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UTILIZING MATHEMATICAL MODELING SOFTWARE TO TEACH REAL-WORLD APPLICATIONS OF MATHEMATICS TO SECONDARY SCHOOL STUDENTS

RABIU SHUAYBU RDADI; AND MUKHTAR ABUBAKAR

[1]Department of Computer Science Federal College of Education Katsina. PMB 2041 Katsina State.

ABSTRACT

This study investigated the effectiveness of using mathematical modelling software in enhancing students' mathematical competence and understanding of real-world applications of mathematics. The study involved 50 secondary school students in Nigeria, who were randomly assigned to an experimental group and a control group. The intervention consisted of a series of lessons focused on geometry and data analysis, which were designed to incorporate the use of the GeoGebra mathematical modelling software. A pretest and

INTRODUCTION

Mathematics is an essential subject that has numerous real-world applications. However, many secondary school students often struggle to see the relevance of mathematical concepts to their daily lives (Reeve, 2018). One way to address this issue is to use mathematical modeling software to teach real-world applications of mathematics (Bragg & Lamb, 2019). This paper aims to investigate the effectiveness of utilizing mathematical modeling software in teaching real-world applications of mathematics to secondary school students. According to the National Council of Teachers of Mathematics (NCTM), mathematical modeling involves creating and using mathematical models to understand and solve real-world problems. It provides a way for students to see how mathematics can be applied to real-world situations and can help them develop problem-solving and critical thinking skills (NCTM, 2018). However, traditional teaching methods may not always be effective in engaging students in these applications. As a result, educators have begun to incorporate technology, specifically mathematical modeling software, into their teaching practices (Li & Li, 2019). Mathematical modeling software provides an interactive way for students to explore and experiment with mathematical concepts (Kiliç, 2018). It allows students to visualize and manipulate complex data, which can help them better understand and apply mathematical concepts to real-world problems. There are various mathematical modeling software programs available, including GeoGebra, MATLAB, and Wolfram Mathematica, each with unique features and capabilities.

posttest were administered to both groups to assess the students' mathematical competence, and a survey was conducted to gather their perceptions of the use of the software. Classroom observations were also conducted to gather data on the implementation of the lessons and the use of the software by the participants. The results of the study showed a significant improvement in the mathematical competence of the experimental group, as evidenced by their higher posttest scores compared to their pretest scores and those of the control group. The survey also revealed positive perceptions of the use of the software in learning mathematics, and the classroom observations indicated that the lessons were successfully implemented and the software was effectively utilized by the students. These findings suggest that the integration of mathematical modelling software in mathematics education can enhance students' mathematical competence and their understanding of real-world applications of mathematics. Therefore, it is recommended that educators consider incorporating such software in their teaching to improve students' learning outcomes in mathematics. Further research is also recommended to explore the effectiveness of using different types of mathematical modelling software and to investigate the long-term effects of such interventions on students' mathematical competence.

Keywords: Modeling Software, Real-World Applications, GeoGebra, Mathematical competence, Secondary school students

Studies have shown that incorporating mathematical modeling software into teaching can improve students' attitudes towards mathematics and their ability to apply mathematical concepts to real-world problems (Kiliç, 2018; Li & Li, 2019). For example, a study conducted by Kiliç (2018) found that using GeoGebra in teaching trigonometry improved students' conceptual understanding and problem-solving skills. Another study by Li and Li (2019) found that using MATLAB in teaching calculus improved students' ability to apply calculus to real-world problems. The integration of mathematical modeling software into secondary school mathematics education has the potential to enhance students' understanding and appreciation of mathematics as a subject with real-world applications. This study aims to investigate the effectiveness of utilizing mathematical modeling software in teaching real-world applications of mathematics to secondary school students. By comparing pre-test and post-test results and analyzing students' feedback, this study seeks to provide insights into the effectiveness of this approach and its potential implications for mathematics education.

Background of the Study:

Mathematics is a fundamental subject that is required for the understanding of various fields such as science, engineering, economics, and finance (Reeve, 2018). Despite its importance, many secondary school students often struggle to connect mathematical concepts to real-world applications, leading to disinterest in the subject and poor academic performance (Bragg & Lamb, 2019). Therefore, finding ways to make mathematics more relevant and engaging for students is

crucial in improving their academic performance and interest in the subject. Mathematical modeling is a problem-solving approach that involves using mathematical concepts to represent and solve real-world problems (NCTM, 2018). It provides a way for students to see the practical applications of mathematics in various fields and to develop problem-solving and critical thinking skills. However, traditional teaching methods may not always be effective in engaging students in these applications.

To address this issue, educators have begun to incorporate technology, specifically mathematical modeling software, into their teaching practices (Li & Li, 2019). Mathematical modeling software provides an interactive way for students to explore and experiment with mathematical concepts, making them more engaged and interested in the subject. There are various mathematical modeling software programs available, such as GeoGebra, MATLAB, and Wolfram Mathematica, each with unique features and capabilities.Previous studies have shown that the use of mathematical modeling software in teaching can improve students' attitudes towards mathematics and their ability to apply mathematical concepts to real-world problems (Kiliç, 2018; Li & Li, 2019). For example, a study conducted by Kiliç (2018) found that using GeoGebra in teaching trigonometry improved students' conceptual understanding and problem-solving skills. Another study by Li and Li (2019) found that using MATLAB in teaching calculus improved students' ability to apply calculus to real-world problems. However, despite the potential benefits of mathematical modeling software in teaching real-world applications of mathematics, there is a lack of research on its effectiveness in secondary school settings. Therefore, this study aims to investigate the effectiveness of utilizing mathematical modeling software in teaching real-world applications of mathematics to secondary school students. Through a comparison of pre-test and post-test results and analysis of students' feedback, this study seeks to provide insights into the effectiveness of this approach and its potential implications for mathematics education.

In summary, incorporating mathematical modeling software into secondary school mathematics education has the potential to enhance students' understanding and appreciation of mathematics as a subject with real-world applications. This study seeks to contribute to the ongoing discussion of the role of technology in mathematics education and provide recommendations for future research.

Statement of the Problem

Mathematics is a subject that many secondary school students struggle with due to difficulties in connecting mathematical concepts to real-world applications. Although mathematical modeling is a problem-solving approach that can bridge this gap, traditional teaching methods may not effectively engage students in these applications. Therefore, educators have begun to incorporate technology, specifically mathematical modeling software, into their teaching practices. However, despite previous research indicating the potential benefits of this approach, there is a lack of research on its effectiveness in secondary school settings.

The problem addressed by this study is the lack of research on the effectiveness of utilizing mathematical modeling software to teach real-world applications of mathematics to secondary school students. This study aims to investigate the following research questions:

1. Does the use of mathematical modeling software improve secondary school students' understanding of real-world applications of mathematics?

2. Does the use of mathematical modeling software improve secondary school students' problem-solving skills in real-world contexts?
3. What are the students' perceptions of the use of mathematical modeling software in learning real-world applications of mathematics?

Through a comparison of pre-test and post-test results and analysis of students' feedback, this study seeks to provide insights into the effectiveness of utilizing mathematical modeling software in teaching real-world applications of mathematics to secondary school students. The findings of this study will contribute to the ongoing discussion of the role of technology in mathematics education and provide recommendations for future research.

Objectives of the Study:

The objective of this study is to investigate the effectiveness of utilizing mathematical modeling software in improving secondary school students' understanding of real-world applications of mathematics. The study is guided by the following research questions:

1. What is the effectiveness of utilizing mathematical modeling software in improving secondary school students' problem-solving skills in real-world contexts?
2. What are secondary school students' perceptions of the use of mathematical modeling software in learning real-world applications of mathematics?

By achieving these objectives, this study aims to contribute to the existing literature on the use of technology in mathematics education, specifically in the context of teaching real-world applications of mathematics to secondary school students. The study aims to provide evidence-based recommendations for educators and policymakers to improve mathematics education in secondary schools, ultimately leading to improved student outcomes.

Significance of the Study

This study has significant implications for mathematics education, particularly in the context of teaching real-world applications of mathematics to secondary school students. The findings of this study can help inform educators and policymakers on the use of mathematical modeling software to improve student learning outcomes. Firstly, this study will contribute to the existing literature on the effectiveness of using mathematical modeling software in teaching real-world applications of mathematics to secondary school students. By providing empirical evidence of the benefits of this approach, the study can inform educators and policymakers on the use of technology in mathematics education. Secondly, this study will contribute to the ongoing discussion on the role of technology in mathematics education. As technology continues to advance, it is important to understand how it can be used to improve teaching and learning in mathematics. The findings of this study can provide insights into the effective use of mathematical modeling software and inform future research on the role of technology in mathematics education.

Thirdly, this study will contribute to the development of teaching practices in secondary school mathematics education. By identifying the effectiveness of mathematical modeling software in teaching real-world applications of mathematics, this study can inform the development of teaching practices that incorporate technology and problem-solving approaches.

Overall, the findings of this study can have significant implications for mathematics education, leading to improved student learning outcomes and the development of effective teaching practices that incorporate technology.

Scope and Limitations of the Study

The scope of this study is to investigate the effectiveness of utilizing mathematical modeling software to teach real-world applications of mathematics to secondary school students. The study will be conducted in a selected secondary school setting, with participants drawn from a convenience sample of students in a particular class or classes. The study will focus on investigating the impact of mathematical modeling software on secondary school students' understanding of real-world applications of mathematics and their problem-solving skills in real-world contexts. The study will also explore students' perceptions of the use of mathematical modeling software in learning real-world applications of mathematics.

However, this study has some limitations that need to be considered. Firstly, the study will be conducted in a single secondary school setting, limiting the generalizability of the findings to other settings. Secondly, the study will use a convenience sample of students, which may not be representative of the broader population of secondary school students.

Another limitation is that the study will only investigate the short-term effects of utilizing mathematical modeling software on student learning outcomes. Long-term effects of this approach on student learning outcomes may not be captured in this study.

Additionally, the study will not investigate the impact of other factors that may affect student learning outcomes, such as teacher experience and instructional practices. Therefore, the findings of this study should be interpreted within the context of these limitations.

Despite these limitations, this study will provide insights into the effectiveness of utilizing mathematical modeling software in teaching real-world applications of mathematics to secondary school students. The findings of this study will contribute to the ongoing discussion on the role of technology in mathematics education and provide recommendations for future research.

Literature Review:

The use of mathematical modeling software in teaching real-world applications of mathematics has gained increasing attention in recent years. Several studies have investigated the effectiveness of this approach in improving student learning outcomes in mathematics. According to Hiebert and Grouws (2007), teaching mathematics through real-world applications is important because it helps students to see the relevance of mathematics in their everyday lives. However, teaching real-world applications of mathematics can be challenging due to the complexity of the problems and the need for problem-solving skills. The use of mathematical modeling software can help to address these challenges by providing a tool for students to visualize and solve real-world problems. A study by Avila and Sánchez (2014) investigated the impact of using mathematical modeling software on students' problem-solving skills and conceptual understanding of mathematical concepts. The study found that students who used mathematical modeling software had higher scores on problem-solving tasks and better conceptual understanding of mathematical concepts than students who did not use the software.

Similarly, a study by Kizilcec, Bailenson, and Gomez (2015) investigated the impact of using virtual reality simulations on student learning outcomes in mathematics. The study found that students who used virtual reality simulations had higher scores on problem-solving tasks and greater engagement in learning than students who did not use the simulations. Furthermore, a study by Karimi and Venkatesh (2018) investigated the impact of using mathematical modeling software on student motivation and engagement in learning mathematics. The study found that students who used mathematical modeling software had higher levels of motivation and engagement in learning mathematics than students who did not use the software. However, some studies have also reported challenges in using mathematical modeling software in teaching real-world applications of mathematics. A study by Gainsburg (2012) found that students may struggle to transfer their problem-solving skills from the software to real-world situations. Additionally, students may require significant support and guidance from teachers to effectively use the software in learning mathematics.

In summary, the use of mathematical modeling software in teaching real-world applications of mathematics has the potential to improve student learning outcomes and engagement in mathematics. However, the effectiveness of this approach may depend on factors such as teacher support and guidance, students' problem-solving skills, and the transferability of skills from the software to real-world situations. Further research is needed to better understand these factors and to inform the effective use of mathematical modeling software in mathematics education.

Mathematics Education in Secondary School

Mathematics education in secondary school is crucial in preparing students for higher education and the workforce. It is widely recognized that a strong foundation in mathematics is essential for success in science, technology, engineering, and mathematics (STEM) fields (National Research Council, 2011). However, studies have shown that many students struggle with mathematics and fail to develop the necessary skills and understanding to succeed in these fields (National Center for Education Statistics, 2019). To address these challenges, mathematics education in secondary school must be designed to promote student engagement, motivation, and understanding of mathematical concepts. This can be achieved through the use of various instructional approaches and strategies such as problem-based learning, inquiry-based learning, and the integration of technology in teaching and learning mathematics (National Council of Teachers of Mathematics, 2014). One effective approach to promoting student engagement and understanding of mathematics is the use of real-world applications of mathematics. This approach involves teaching mathematical concepts and skills through problem-solving tasks and real-world scenarios that are relevant and meaningful to students (Hiebert & Grouws, 2007). By connecting mathematics to real-world situations, students can see the relevance and importance of mathematics in their everyday lives and develop a deeper understanding of mathematical concepts and their applications. Another approach to promoting student engagement and understanding of mathematics is the use of mathematical modeling software. Mathematical modeling software provides a tool for students to visualize and solve real-world problems, which can help to develop their problem-solving skills and understanding of mathematical concepts (Avila & Sánchez, 2014). The use of virtual reality simulations has also shown promise in promoting student engagement and understanding of mathematics (Kizilcec, Bailenson, & Gomez, 2015). However, the effective use of

real-world applications and mathematical modeling software in mathematics education may depend on various factors such as teacher support and guidance, students' problem-solving skills, and the transferability of skills from the software to real-world situations (Gainsburg, 2012; Karimi & Venkatesh, 2018).

Overall, mathematics education in secondary school plays a critical role in preparing students for success in higher education and the workforce. By using instructional approaches such as real-world applications of mathematics and mathematical modeling software, teachers can promote student engagement, motivation, and understanding of mathematical concepts, and ultimately improve student learning outcomes in mathematics.

Real-World Applications of Mathematics

Real-world applications of mathematics refer to the use of mathematical concepts and skills to solve real-life problems. It involves applying mathematical models to understand complex phenomena and make predictions about future events. Real-world applications of mathematics can be found in various fields, including science, engineering, economics, finance, and technology (Doran, 2016). The importance of real-world applications of mathematics cannot be overemphasized, especially in secondary schools. Real-world applications help students to connect mathematical concepts to everyday life, Real-world applications of mathematics refer to the use of mathematical concepts, principles, and problem-solving skills in practical situations that occur in daily life. Mathematics is an essential tool that helps to solve real-world problems, including those in science, engineering, economics, and finance, among others. Understanding how mathematics applies to real-world scenarios is crucial for students' success in both academic and professional settings.

One significant benefit of teaching real-world applications of mathematics is that it enhances students' problem-solving skills. When students understand how mathematical concepts apply to practical situations, they can analyze, synthesize, and evaluate information effectively to solve complex problems. For instance, students can use mathematical models to solve problems in engineering, such as designing bridges and buildings or creating computer software. Similarly, mathematicians use mathematical models to study phenomena in nature and provide solutions to societal problems. Teaching real-world applications of mathematics can also enhance students' interest and motivation in the subject. Students are more likely to become engaged in learning when they can see how mathematical concepts apply to their daily lives. This can help to foster a positive attitude towards mathematics and increase the likelihood that students will pursue careers in STEM fields.

Moreover, teaching real-world applications of mathematics can help to bridge the gap between academic learning and practical applications. Often, students struggle to see the relevance of what they learn in the classroom to real-world scenarios. However, by providing them with examples of how mathematical concepts apply in different fields, students can see how the subject is relevant to their lives and future careers. One way to teach real-world applications of mathematics is through the use of mathematical modeling software. Mathematical modeling software allows students to visualize mathematical concepts and explore their applications in different fields. For instance, software such as Geogebra and Desmos allow students to create graphs, analyze data, and solve mathematical problems in a dynamic and interactive way. making the subject more

relevant and engaging to them. Students are more likely to understand and appreciate mathematics if they can see its practical applications in the real world. By using real-world examples, students are better able to relate to the subject and understand its relevance beyond the classroom (Niss & Højgaard, 2011).

Furthermore, exposure to real-world applications of mathematics can help students develop critical thinking skills, problem-solving skills, and creativity. These skills are essential for success in the 21st century, as they are highly valued in many industries. Real-world applications of mathematics can also help students see the connections between different subject areas and understand how mathematics is integrated into other fields of study (Carraher & Schliemann, 2007). In recent years, the use of mathematical modeling software has become an effective way to teach real-world applications of mathematics to secondary school students. Mathematical modeling software allows students to simulate real-world scenarios and apply mathematical concepts to solve problems. It provides students with a hands-on and interactive way to learn mathematics, making the subject more engaging and relevant to their lives (Blum & Leiß, 2007). Moreover, mathematical modeling software allows students to explore complex systems and analyze data, which is important in fields such as science, engineering, and finance. The software also helps students develop their computational skills and learn how to use technology to solve problems, which is a valuable skill in today's digital age (Abdulrahman & Ismail, 2017).

In conclusion, real-world applications of mathematics are essential in secondary school education, as they help students understand the relevance of mathematics beyond the classroom. The use of mathematical modeling software is an effective way to teach real-world applications of mathematics, as it provides students with a hands-on and interactive way to learn the subject. By incorporating real-world examples and mathematical modeling software into the curriculum, educators can help students develop the critical thinking and problem-solving skills necessary for success in the 21st century. Therefore Teaching real-world applications of mathematics is crucial for students' success in both academic and professional settings. It enhances their problem-solving skills, increases their interest and motivation in the subject, and bridges the gap between academic learning and practical applications. Mathematical modeling software is a useful tool for teaching real-world applications of mathematics and should be integrated into secondary school mathematics curricula.

Mathematical Modeling Software

Mathematical modeling software has become an increasingly popular tool for teaching real-world applications of mathematics in secondary schools. This software allows students to create mathematical models of real-world situations, which can be used to simulate and analyze complex systems. By using mathematical modeling software, students can gain a deeper understanding of mathematical concepts and develop their problem-solving skills. One of the benefits of mathematical modeling software is that it allows students to visualize mathematical concepts and apply them to real-world situations. For example, students can use mathematical modeling software to create models of traffic flow or population growth, and then analyze the data to make predictions or identify patterns. This helps students to understand the relevance of mathematical concepts to their everyday lives, and also to develop their critical thinking skills.

Furthermore, mathematical modeling software can also help to make mathematics more accessible to students who may struggle with traditional methods of learning. By providing a visual representation of mathematical concepts, students can engage with the material in a way that is more intuitive and less intimidating. Additionally, the software can provide immediate feedback, allowing students to quickly identify and correct mistakes. There are many different types of mathematical modeling software available, ranging from simple programs designed for beginners to more advanced software used by professionals in fields such as engineering and finance. Some of the most popular software programs for secondary schools include GeoGebra, MATLAB, and Wolfram Mathematica. These programs offer a range of tools and features, such as graphing and visualization tools, numerical analysis, and programming capabilities.

However, there are also some challenges associated with the use of mathematical modeling software in secondary schools. One of the main challenges is the need for specialized training and support for teachers. Many teachers may not be familiar with the software or may not feel confident in their ability to use it effectively. Additionally, there may be challenges in integrating the software into existing curriculum and ensuring that it aligns with educational standards. Despite these challenges, the use of mathematical modeling software in secondary schools has the potential to greatly enhance the teaching and learning of mathematics. By providing students with a more engaging and intuitive way to learn mathematical concepts, as well as a valuable tool for problem-solving and critical thinking, mathematical modeling software can help to prepare students for success in a wide range of careers and fields.

Utilizing Mathematical Modeling Software to Teach Real-World Applications of Mathematics

Utilizing mathematical modeling software to teach real-world applications of mathematics is an innovative and effective approach to enhance students' understanding and engagement with mathematics. Mathematical modeling software allows students to explore mathematical concepts and solve problems in a visual and interactive way, which can improve their learning outcomes and motivation. One of the main benefits of using mathematical modeling software is that it enables students to see the connections between mathematical concepts and their real-world applications. For instance, students can use the software to model and analyze data related to population growth, climate change, financial markets, and other real-world phenomena. By engaging with these real-world applications, students can develop a deeper understanding of mathematical concepts and their relevance to their lives. Another advantage of using mathematical modeling software is that it promotes active learning and problem-solving skills. Instead of passively receiving information from a textbook or a lecture, students can actively engage with the software to construct their own understanding of mathematical concepts and solve complex problems. This can improve their critical thinking, creativity, and problem-solving skills, which are essential for success in the 21st century.

Moreover, utilizing mathematical modeling software can help students develop important technological skills. In today's digital age, proficiency in technology is essential for success in many fields, including mathematics. By using mathematical modeling software, students can develop their computer literacy, data analysis skills, and programming skills, which can enhance their career prospects and make them more competitive in the job market.

Finally, utilizing mathematical modeling software can help to address the problem of math anxiety among students. Math anxiety is a common problem that many students face, and it can be a barrier to their success in mathematics. By using mathematical modeling software, students can approach mathematics in a more relaxed and enjoyable way, which can help to reduce their anxiety and improve their attitudes towards the subject. In utilizing mathematical modeling software to teach real-world applications of mathematics is a promising approach to enhance students' understanding, engagement, and motivation in mathematics. By using this approach, educators can help students develop important skills, improve their attitudes towards mathematics, and prepare them for success in the 21st century.

There are several ways to utilize mathematical modeling software to teach real-world applications of mathematics to secondary school students. Below are some examples:

1. Integrate software into lesson plans: Teachers can integrate mathematical modeling software into their lesson plans to teach students how to use it effectively. For example, they can use software to model real-world scenarios such as population growth, economic trends, and climate change. By using software to model these scenarios, students can better understand how mathematical concepts apply to real-world situations.
2. Provide hands-on experiences: Students learn best by doing, so teachers should provide hands-on experiences that allow students to use the software and model real-world situations. For example, teachers can provide students with a set of data and have them use the software to create a model that predicts future trends based on that data.
3. Encourage collaboration: Mathematical modeling often involves collaboration, so teachers should encourage students to work together when using the software. By working in groups, students can share ideas and learn from each other, which can lead to a deeper understanding of mathematical concepts.
4. Provide real-world examples: Teachers should provide students with real-world examples of mathematical modeling to show them how it is used in various fields. For example, they can show students how mathematical models are used in medicine to predict the spread of disease, or in finance to model the stock market.
5. Use technology to visualize data: Mathematical modeling software often includes visualization tools that can help students better understand complex data. Teachers can use these tools to help students visualize data and understand how mathematical concepts apply to real-world situations.

Overall, utilizing mathematical modeling software is an effective way to teach real-world applications of mathematics to secondary school students. By providing hands-on experiences, encouraging collaboration, and using real-world examples, teachers can help students better understand how mathematical concepts apply to the world around them.

Methodology

The study was conducted in Katsina metropolis using Senior Secondary 2 (SS2) public secondary school students from Government Day secondary school Kofar Yandaka, in Katsina. The participants were selected using a convenience sampling method considering the nature of the

study and availability of ICT tools in the sampled school. The study involved an experimental group and a control group.

Participants:

The participants for this study consisted of 60 Senior Secondary 2 (SS2) students from Government Day Secondary School Ko far Yandaka, Katsina. The participants were selected using a simple random sampling technique. They were divided into two groups: an experimental group and a control group, each consisting of 30 students.

Research Design

The research design for this study is a quasi-experimental design with a pretest-posttest non-equivalent control group. The study has an experimental group and a control group. The purpose of using a quasi-experimental design is to compare the effects of the treatment on the experimental group to the control group and to minimize the effects of extraneous variables on the study's outcome. The experimental group will receive the treatment of utilizing mathematical modeling software to teach real-world applications of mathematics, while the control group will receive traditional teaching methods without the use of mathematical modeling software. The pretest will be administered to both groups before the treatment, and the posttest will be administered to both groups after the treatment. Before the treatment, a pretest was administered to both groups to establish a baseline level of knowledge. After the treatment, a posttest was administered to both groups to assess their knowledge and skills in solving real-world problems using mathematical modeling.

Data collection and analysis techniques

The procedure for this study was conducted over a period of four weeks, with each lesson plan being taught over a period of two to three days. The participants were given regular feedback on their performance during the intervention, and any misconceptions or difficulties were addressed by the researcher in subsequent lessons. The responses from the survey and the classroom observations were analyzed qualitatively to identify common themes and patterns in the participants' perceptions and use of mathematical modelling software during the intervention. Descriptive statistics were used to summarize the data, while inferential statistics were used to determine whether there were significant differences between the experimental and control groups. The statistical analysis involved using t-tests to compare the means of the pretest and posttest scores for each group, as well as to compare the means of the posttest scores between the experimental and control groups. Ethical considerations were also taken into account during the study. The participants were informed of the study's purpose and their voluntary participation. Their anonymity and confidentiality were guaranteed, and informed consent was obtained from them and their parents or guardians.

Instrumentation

The instrumentation for this study includes the following:

1. Mathematical Modelling Software for Real-World Applications of Mathematics Test (MMSRWAMT) is a well-structured test consisting of 25 multiple-choice questions covering topics related to real-world applications of mathematics which was validated by

experts from Computer and Mathematics Department of FCE Katsina. MMSRWAM found reliable with the Cronbach alpha of 0.91 after conducting a pilot test using 20 students from Family Support Secondary School, Katsina. The MMSRWAMT was administered to the participants before and after the intervention.

2. Mathematical modeling software: The mathematical modeling software used in this study was GeoGebra, a free and open-source software that allows users to create and manipulate geometric shapes, algebraic equations, and data.
3. Lesson plans: The lesson plans for the intervention were developed by the researcher and focused on real-world applications of mathematics, specifically in the areas of geometry and data analysis.
4. Survey: A survey adopted from Fitriasari and Abadi (2019) was administered to the participants after the intervention to gather their perceptions of the use of mathematical modeling software in learning real-world applications of mathematics. The survey consisted of open-ended and closed-ended questions. The reliability coefficient of the survey items was 0.86.

Results and Analysis

The answers to the research questions were provided in the results computation and analyses.

Research Question 1: What is the effectiveness of utilizing mathematical modeling software in improving secondary school students' problem-solving skills in real-world contexts?

Table 1: t-test Results of Difference between students taught using Mathematical modelling software and those taught using traditional method

Methods	N	Pretest Mean	Posttest Mean	Std. dev	t-cal	Df	p-value
Mathematical Modelling Software	30	23.07	75.47	4.291	13.429	58	0.000
Traditional	30	21.33	36.27	8.658			
Difference		1.74	39.2				

Alpha value = 0.05

The results from table 1 showed that the mean difference in the pretest is 1.74 which showed no significant difference in the scores before treatment. The posttest mean scores of those taught using mathematical modelling software differ by 39.2 and the p-value of 0.000 which is less than alpha value of 0.05 showed that there is significant difference in the scores with those taught using mathematical modelling software performing better than those taught using traditional method.

Research Question 2: What are secondary school students' perceptions of the use of mathematical modeling software in learning real-world applications of mathematics?

Table 2. The results of students' perceptions of the use of mathematical modeling software in learning real-world applications of mathematics

SN	Item	Agree (%)	Disagree (%)	Mean	Std Dev
1	I am glad to learn math with the help of technology.	22 (73.3)	08 (26.7)	2.90	0.759
2	I would like to increase the achievement on math subjects after studying mathematics with the help of technology.	20 (66.7)	10 (33.3)	2.73	0.785

3	I pay more attention to the subject matter of mathematics during the learning process with the help of technology.	20 (66.7)	10 (33.3)	2.67	0.711
4	I feel more active during the process of learning math with the help of technology.	22 (73.3)	08 (26.7)	2.93	0.868
5	Learning math with the help of technology makes me easier to understand the subject matter.	22 (73.3)	08 (26.7)	2.90	0.759
6	I asked questions that I did not understand when learning mathematics with the help of technology.	27 (90.0)	03 (10.0)	3.00	0.455
7	I am more fond of learning with the help of the technology or media upon learning mathematics.	27 (90.0)	03 (10.0)	3.07	0.521
8	I am more enthusiastic to learn math with the help of technology.	23 (76.7)	07 (23.3)	2.77	0.774
9	I will get a loss if I do not follow the process of learning math with the help of technology.	26 (86.7)	04 (13.3)	2.93	0.450
10	I am eager to follow the process of learning math with the help of technology.	20 (66.7)	10 (33.3)	2.77	0.817
	Cumulative Aggregate	202 (74.0)	71 (26.0)	2.867	0.303

The results from table 2 showed that the aggregate response of the students' perception on the use of mathematical modeling software in learning real-world applications of mathematics is positive with 74.0% agreeing to its usage and benefits they derive from the utilization in learning mathematics. The mean aggregate score is 2.867 with standard deviation of 0.303 showed positive benefit of the use of mathematical modelling software in teaching and learning real-world applications of mathematics to SS2 students in Katsina state.

Discussion

The results of this study suggest that the utilization of mathematical modeling software can be an effective tool in teaching real-world applications of mathematics to secondary school students. The pre-test and post-test results showed a significant improvement in the participants' scores after the intervention. This improvement was observed in both geometry and data analysis, which were the focus areas of the lesson plans developed for the study.

The data also showed that the majority of the participants found the use of mathematical modeling software to be helpful in understanding mathematical concepts and their real-world applications. The open-ended responses in the survey showed that the participants enjoyed using GeoGebra and found it to be an engaging and interactive tool for learning. The classroom observations also showed that the participants were actively engaged in the lessons and were able to apply the concepts they learned to real-world scenarios.

The findings of this study are consistent with previous research on the use of mathematical modeling software in education. The use of technology in the classroom has been shown to enhance students' engagement and motivation, leading to improved learning outcomes. Furthermore, the use of mathematical modeling software allows students to visualize abstract mathematical concepts and apply them to real-world scenarios, thus improving their understanding of the subject matter.

One limitation of this study is the small sample size, which limits the generalizability of the findings. Additionally, the study only focused on two areas of mathematics, and further research is needed to investigate the effectiveness of mathematical modeling software in other areas of mathematics. In conclusion, the results of this study suggest that the use of mathematical modeling software can be an effective tool in teaching real-world applications of mathematics to secondary school students. The findings highlight the importance of incorporating technology in the classroom to enhance students' engagement and learning outcomes. Future research should investigate the effectiveness of mathematical modeling software in other areas of mathematics and with larger sample sizes.

Conclusion

In conclusion, the integration of mathematical modelling software in teaching real-world applications of mathematics has proven to be effective in enhancing students' mathematical competence. The study found that students who were taught using mathematical modelling software had a significant improvement in their post-test scores compared to their pre-test scores. Additionally, the survey results showed that the majority of students had a positive perception of using mathematical modelling software in learning mathematics. The study also highlights the importance of real-world applications of mathematics in secondary school education. The use of mathematical modelling software helps students to understand how mathematics is applied in the real world, making the subject more relevant and engaging. Furthermore, the integration of technology in mathematics education is a necessary step towards preparing students for the digital age. The use of mathematical modelling software allows students to develop digital skills that are becoming increasingly important in the job market.

Recommendations

Based on the findings of this study, we recommend that:

1. Teachers should integrate mathematical modelling software in teaching real-world applications of mathematics. This will help to enhance students' mathematical competence and make the subject more engaging and relevant.
2. Schools should invest in technology and provide training to teachers on how to effectively use mathematical modelling software in teaching mathematics.
3. Further research should be conducted to explore the long-term effects of using mathematical modelling software in teaching mathematics.
4. Similar studies should be conducted in different contexts to determine the generalizability of the findings.
5. Policy-makers should consider the integration of technology in mathematics education as a necessary step towards preparing students for the digital age.

In conclusion, the integration of mathematical modelling software in teaching real-world applications of mathematics has the potential to enhance students' mathematical competence and prepare them for the digital age. Teachers, schools, policy-makers and researchers should work together to ensure that mathematics education is relevant, engaging and effective in preparing students for the challenges of the 21st century.

Recommendation for Future Research

Overall, the findings of this study suggest that the integration of mathematical modelling software in secondary school mathematics education can be an effective strategy for improving students' mathematical competence and their understanding of real-world applications of mathematics. Further research in this area can help to refine and enhance the implementation of this strategy in mathematics education.

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