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Effectiveness of the Symbolab Calculator in Improving Second Year Science and Mathematics Students Ability to Solve Trigonometric Equations

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Abstract: Trigonometry is a challenging area of mathematics for many students, especially for pre-service primary teachers in TTCs. The Symbolab calculator, software developed to assist mathematicians in solving complex problems, is used to improve students' performance and understanding. This study investigated the effectiveness of using the Symbolab calculator on second-year student-teachers, comparing their performance with those without the calculator. The data was analysed using the t-test. The findings showed that the integration of the Symbolab calculator significantly improved students' performance and understanding, reducing the time taken to solve trigonometric equations. It is recommended that further research be conducted on the effectiveness of combining different instructional methods in trigonometry instruction. There is a need to encourage teachers to adopt various pedagogical strategies for improved learning outcomes.

Keywords: Effect; Symbolab; trigonometric equations; pre-service primary teacher; performance.

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Introduction

Mathematics is a systematic application of matter that affects all aspects of human life. It occupies a crucial and unique role in human societies and represents a strategic key in the development of mankind. The powers of mathematics in human beings are observed in reasoning, creativity, abstract or spatial thinking, critical thinking, problem-solving ability and even practical communication skills (Jayanthi, 2019). Mathematics is therefore an important subject because it plays a big role in the development of all areas of knowledge and the modernization of society. I

Children are educated to acquire mathematical competences because mathematics is a discriminating element in their future academic pathways (Melchor et al., 2020). However, students believe that mathematics is a difficult subject, an attitude often inherited from their parents and from the society Mabena et al., 2021). In African countries, learners' performance in mathematics has consistently been poor and their inferior

performance has been caused by various factors (Tran et al., 2020). One of the factors is that learners are not motivated and their behaviour leads them to perform poorly in mathematics (Fokuo et al., 2022). Reports of various national and international bodies, such as the International Mathematics Union (IMU) indicate that primary and secondary level mathematics education is weak in most African countries, reducing the potential population of talented students who choose mathematics majors at university level (IMU, 2020). The proper solutions to improve learners' performance in mathematics depend on knowing the causes of poor performance in the subject (Mabena et al., 2021).

In Ghana, it was found that low arithmetic performance is caused by a lack of covering of maththematics curriculum material, lack of interest in mathematicss and the view that mathematics is difficult to grasp (Fokuo et al., 2022). According to Kamau (2020), poor performance in Kenya is caused by insufficient teaching staff, students' absenteeism, low admission scores, bad evaluation methodologies and poor teaching practices. In Uganda, both internal and external constraints such as financial limitations, lack of teaching resources and qualified teachers affected the application of implementation of the mathematics curriculum in Ugandan secondary education. Furthermore, it is stated that the biggest barrier to students applying their understanding of mathematics in Rwanda is traditional teaching methods used by teachers, which lower students' motivation (Dorimana et al., 2021).

At the present time, the way mathematics is understood and taught in many schools around the world is undergoing remarkable changes as a result of governments' initiatives and African countries joining the trend (Rakes et al., 2022). The practice of mathematics has changed considerably due to technological development and the availability of powerful information and computer technology (ICT) (Sampaio & Coutinho, 2021). ICT helps to teach mathematical facts, skills, knowledge and concepts and recovers the learners' mathematical understanding more effectively. It also helps to increase the capability of students and teachers. It encourages individuals to organize, present, treat their mechanisms and transfer their inferences to others (Das, 2019).

Das (2019) stated that effective use of ICT helps learners to visualize and represent mathematical concepts and facilitates calculations instead of spending much time on tedious computations. The integration of ICT in teaching and learning of mathematics has been proved to help in most areas of mathematics, especially in trigonometry (Alrwaished et al., 2017). Trigonometry is considered as part of mathematics which is an interesting world of ratios, angles and transcendental functions and is taught in every high school mathematics curriculum (Abdul Rahman & Puteh, 2017). This field emerged during the 2nd century, Before the Common Era (BCE), from applications of geometry to astronomical studies. Trigonometry formulae have an application in various fields such as construction, design and other branches of engineering (Sreeja, 2017).

Trigonometry is also taught in teacher training colleges, where research indicates that students perform unsatisfactorily in the operation with real numbers of trigonometric expressions used frequently in trigonometry (Karthikeyan, 2017). Two different types of errors that the freshman Calculus students make in solving trigonometric problems were identified to be the lack of knowledge about trigonometry functions and the students' lack of knowledge in solving trigonometric equations (Ferrer & Maynila, 2017). Ferrer and Maynila further argued that the trigonometric expression to an equivalent trigonometric identity is a big problem. The most common operational breakdown is the inability to find the sum of two trigonometric fractions and clear the resultant fraction. Moreover, it was observed that students find it hard to identify, recall and use the appropriate trigonometric identity. This leads to students' poor performance in solving trigonometric equations (Sánchez et al., 2023). The above observation is in line with the research conducted on students attending secondary schools dedicated to training primary teachers (TTCs), which serve only pre-service primary teacher and in-service teacher training programs. The observation wasvmade on how students perform in trigonometry topic indicates that TTC pre-services teachers perform poorly in this topic (Kanamugire et al. 2019).

Today, science and technology is one of the areas of priority in the Rwanda education sector and well trained student-teachers by science and mathematics tutors at TTCs are highly needed to enhance the teaching of Science and Technology at the primary education level. Student-teachers enrolled in Science and Mathematics Education combination (Kanamugire et al, 2019). The advantage of using ICT is that the educator can save times and observe the students' performance easily, especially in a large quantity of students. Some of technological tools and programs are made to facilitate works and help in solving complex problem found in mathematics.

There are various online programs that have been indicated by researchers to be efficient in helping students to learn trigonometry. These include Symbolab calculator, e-MathHelp, integral calculator and derivative calculator, among others (Brown, 2017). The Symbolab provides automated step-by-step solutions to algebraic, trigonometric or calculus topics covering middle schools through college. Symbolab offers a wealth of smart calculators for simultaneous equations, inequalities, integrals, derivatives, limits, tangent lines, trigonometric equations and functions (Amponsah et al., 2022). Symbolab is also an educational app that provides users with answers to complicated algebra, calculus and trigonometry problems. It is used to solve simple addition and subtraction problems and it is a more useful app for tweens and teens, where students of year two in TTCs belong. Students can benefit from using the app to check their worked-out trigonometric equations (Hadjinor et al., 2021).

In order to cultivate conceptual and geometrical knowledge and promote a more profound styles of learning, the integration of technology into mathematics teaching and learning is essential. The most well-known mathematics programs include Microsoft Math, GeoGebra, and Symbolab, which enabled learners to visualise materials in ways that were previously difficult. Technology implementation requires a variety of resources in terms of ICT tools and appropriate infrastructures in the schools. Mathematics is taught in Rwandan Teacher Training Colleges with some concepts (trigonometry, logarithm, combinatory and calculus) that very few students like and succeed at, and which most students do not like and struggle with (Mensah, 2017). The common complaint of students is that they will never make use of the trigonometry they learn in schools (Sulistyaningsih et al., 2021). However, they forget that trigonometry is an area of mathematics that, in fact, they will use in their lifetime and whose applications are numerous (Maknun et al., 2022). In addition, pre-service science and mathematics primary teachers in TTCs believe that trigonometry is difficult and abstract compared with the other mathematics topics taught in TTCs. They take it as a complex topic and a deep understanding of it requires relations and transitions between similar concepts to be made (Nabie et al., 2018). This causes poor performance of many students in solving trigonometric equations. In response, this study sought to explore the effects of using Symbolab on pre-service primary teachers' performance in solving trigonometric equations.

Literature Review

By examining the existing research findings and scholarly works, this section sought to provide insights into the impact of utilising the Symbolab calculator as a tool for improving students' proficiency in this specific area of mathematics.

The Use of Symbolab Software in Solving Mathematical Equations

Many scholars over the last few decades have concentrated on employing digital technology to teach and study mathematics in order to capture students' interest. As a result, clever pedagogical strategies have been used to deliver lectures successfully and enhance pre-service primary teachers' comprehension, knowledge, involvement and engagement (Maknun et al., 2022). Agyei and Voogt, (2017) asserted that it is important to give instructors the chance to expand their understanding of cutting-edge pedagogies and teaching techniques. In order to build imaginative links between subject, pedagogy and the proper instruments, they added, educators must employ novel teaching techniques for mathematics. Teachers' professional development is also required in terms of which methods work better to adapt technologies in the Mathematics classrooms for

the efficacy of helping student-teacher learn conceptually (Benning et al., 2018)

Symbolab software is a free, interactive and exclusive resource. According to Makhdum et al. (2023), Symbolab is the most often used mathematics program since it provides results in the step-by-step approach. This is a complex search engine designed exclusively for mathematical difficulties; it is not just a clever calculator. It uses a variety of computational methods and algorithms to analyse, decompose and resolve a wide range of mathematical issues (Makhdum et al., 2023). Although it is typically regarded as the fundamental strategy at all educational levels, the chalkboard method is one of the most traditional and widespread in teaching Mathematics techniques (Sánchez et al., 2023).

The development of current technology can speed up the study of mathematics by allowing both quick input and quick calculation of results. Enhancing the input will speed up the computation of the output (Williams, 2020). The Symbolab Calculator offers automatic, step-by-step answers to algebraic, trigonometric and calculus concepts. According to Shahriari (2019),conversions, it is particularly helpful for conversions, simultaneous equations, equations, graphs, inequalities, integrals, derivatives, limits, as well as linear and quadratic equations. With its comprehensive functionality, the Symbolab Calculator provides students and learners with valuable assistance in tackling these mathematical areas, facilitating a deeper understanding and proficiency in mathematics. Functions and many other subjects were proven to be easy by using the Symbolab calculator. Simultaneous equations are also made easier to perceive and comprehend when they are solved visually (Parrot & Leong, 2018).

Advantages Symbolab in Solving Mathematical Equations

Obina et.al, (2022) said that Mathematics is one of the most difficult and challenging subjects to learn and due to the rising of CODIV-19 pandemic, there have been significant worries over the education of young people. To address this issue, technology has the potential to reduce the pandemic-related educational problems by incorporating its benefits and addressing its drawbacks (Obina et al., 2022). This assertion is confirmed by Makhdum (2023) who said that learners can use mathematical applications anytime and anywhere, encouraging their performance. According to Williams (2020), with the use of Symbolab, which works best as a supplement to classroom materials, pre-service primary teachers and tutors may work through solutions to a range of equations from easy to challenging. Students can practice a range of skills, especially with a premium membership.

The ability to create content that is specific to what their class is learning right now or to let students practice supplemental materials-filling in any gaps of extending their skills to topics that are not being covered- is provided by paid accounts, which allow students access to pre-made or custom quizzes. The Symbolab recommendations are helpful for helping student-teacher who might be struggling, but they do not take pace of in-person instruction (Obina et al., 2022). The Symbolab helps learners to assess their capacities independently while using the independent learning approach. They are in charge of the progression and method of their learning (Vijayalaksmi, 2021). Given that each student has a unique way of developing their abilities and knowledge, an opportunity for exploration would result in the identification of learning styles that is best suited to each particular learner (Kit et al., 2023).

The Role of Computer, Mobile Phone and Internet in Symbolab

Symbolab is an online Mathematics solver that interprets and simplifies user queries, applies mathematical rules and algorithms to solve problems and it provides thorough explanations for each step of the problem-solving process using Symbolab computation, natural language processing and profound understanding of the mathematical principles. To be used, the user has to be equipped with computer or smart phone and the internet connection to facilitate the access on it (Admission Sight, 2023). There is a free and a paid edition of Symbolab. The paid version allows access to the solver but has less detailed solutions. By offering thorough, step-by-step solutions, Symbolab is an effective tool that may aid pupils in understanding the complex world of mathematics (EdQual, 2017).

It shouldn't be used as a stopgap to avoid studying because this might result in a shallow level of interest and a disjointed comprehension of arithmetic. Instead, students should concentrate on utilising the Symbolab appropriately if they want to get the most out of it (Agyei & Voogt, 2017). A popular international computer network called "the internet" provides access to information, music, movies and communication. It is a well-liked application with affordable access, which makes it a useful tool for education, entertainment and socialising (Amponsah et al., 2022). "The internet" is the most practical technology we have today, assisting us in our personal and professional lives. It is frequently used for educational purposes to gather data, carry out research or increase information on a variety of subjects.

"The internet" plays a vital role in education (Delaporte & Bahia, 2021). Both teaching and learning now heavily rely on the internet. By posting their teaching aids (notes, videos and photos) on the school websites or other forums, teachers can use it as a teaching resource (Danden, 2020). Using instructional clips and notes makes learning more engaging in a variety of ways. To keep learners interested, instructors use PowerPoint slides, animations, and images when teaching. Thus, using the internet opens consumers' eyes to the enormity of the world outside of them. It collects a variety of data that secondary school students and college students use. Internet use thus opens consumers' eyes to the enormity of the world outside of them. It collects a variety of data that senior high school students and college students use (Dogruer et al., 2017). Internet use will continue to grow as long as users are not denied the accessibility. This is because people access data sites like social networking sites and online gaming as shown by recent information, which is made achievable by internet service suppliers (Olatokun, 2013).

Literature shows that mathematics software and applications can improve learning and motivation for learners. Symbolab is the most popular software for solving linear and simultaneous equations. However, it has not been explored how it can help solve trigonometric equations, particularly in trigonometric tests. This study aimed at addressing this gap to help pre-service educators teach trigonometric equations.

Methodology

Design

The study utilised the quasi-experimental design. Pre-tests and post-tests were used as instruments to establish the effectiveness of the intervention on students' learning outcomes.

Population and Sampling

The target population was the entire aggregation of respondents that meet the designated set of criteria (Garg, 2016). The population for this study involved 112 years two pre-service teachers doing science and mathematics in two TTCs. The TTCs were purposively selected from four TTCs in the Southern Province. Mbuga TTC was randomly assigned as control group and Save TTC was as an experimental group.

Table 1: Target Population

School	Number of year two pre- service primary teachers	%
TTC Mbuga	47	41.6
TTC Save	65	58.4
Total	112	100%

The researchers used census to select respondents. The approach was the best way to ensure that the selected sample represented the population (Ansari et al., 2022). The sample size study was 112 pre-service primary teachers of year two doing science and mathematics in two TTCs composed of 65 members from Mbuga TTC and 47 members from Save TTC.

Research Instruments

Pre-tests and post-tests were employed as research instruments to evaluate the impact of the intervention on pre-service primary teachers' proficiency in solving trigonometric equations. The pre-test served to assess 112(100%) students' initial level of knowledge before the intervention, while the post-test measured their knowledge after the

intervention had been implemented. Both tests contained identical content, with the post-test administered following the intervention. These pre-test and post-test assessments functioned as the primary instruments for data collection. The term "test" under this study referred to a set of stimuli presented to individuals to elicit responses, which are subsequently used to calculate numerical scores (Malik & Alam, 2019). The pre-test was administered to both groups before the treatment to obtain initial scores, which were then utilised as data. Following the treatment, the post-test was conducted as the final data collection procedure.

Administration of Data Collection

Before attending to the participants, the researcher requested an appropriate arrangement with the deputy principal and the principal of the TTCs sampled. The African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS) provided a to Whom It May Concern letter to the researchers allowing them to carry out the study. The researchers wrote another letter requesting for the permission to collect data and attached the To Who it May Concern letter to the concerned TTC principals to seek for their permission to collect data in their institutions.

The pre-test was administered for both groups to solve trigonometric equation. The pre-test was given at the first meeting with the pre-service science and Mathematics primary teachers. The experimental group was given the treatment by solving trigonometric equations up to the end of the unit using Symbolab and the control group used the chalkboard method (traditional method) to solve the same. After the treatment, a post-test was administered to both groups. The post-test was administered in the two last periods of the unit.

Validity and Reliability

Reliability was established using the test-retest approach, which involved administering the same set of questions to the same group of individuals at two different time points and comparing their responses. The goal was to assess whether the research instruments consistently and reliably produced similar outcomes under different conditions. In terms of the test results, reliability was demonstrated by conducting pre and post-tests twice with the same groups of participants. The mean scores of the pre-test for the control and experimental groups were 10.012 and 10.83, respectively, indicating consistent and nearly identical results. This study sought to establish the effectiveness of Symbolab in improving student performance and the validity of pre and post-tests as indicators of intended variables, ensuring meaningful, accurate, and applicable conclusions

Statistical Treatment of Data

Students' works were marked and results were coded and entered in the computer system for analysis, cleaning and computation through the Statistical Package for Social Science.

Ethical Considerations

The participants in this study were treated with respect and were given their rights to privacy and confidentiality. The researchers adhered to ethical principles that guide academic research, ensuring an equitable distribution of risks and benefits, ensuring a scholarly approach and adhering to royal protocols for data collection. The study's permissions were obtained and used for the intended purposes.

Results and Discussion

This section presents the results of the study and discusses the findings in comparison with those from previous studies. Table 2 shows the demographic characteristics of respondents.

Demographic Information of Respondents

The table 2 indicates that the gender composition among the participants was 66 (58.9%) female and 46 (41.1%) males. The number of females was slightly greater than the number of males.

Table 2: Demographic information for Respondents

Variable		Frequency	Percent
Gender	Female	66	58.9
	Male	46	41.1
	Total	**112**	**100.0**
Age group	10-20 years	85	75.9
	21-25 years	27	24.1
	Total	**112**	**100.0**

The data summarized in Table 2 reveals that the majority of the respondents (75.9%) fell within the age range of 15 to 20 while a smaller proportion (24.1%) belonged to the age range of 21 to 25.

These findings indicate that a significant number of pre-service primary teachers in the TTCs (which are secondary educational institutions focused on equipping secondary students with the necessary knowledge and skills for a teaching career in the near future) were in their adolescent years. It is important to note that adolescence is a developmental stage characterised by creativity, where individuals often showcase their ideas and talents. However, it is also a period where they can easily become discouraged if they do not receive appropriate support (Sun, 2013).

Research Question: What is the impact of utilizing the Symbolab calculator on the enhancement of pre-service primary teachers' performance in solving trigonometric equations?

Descriptive and inferential statistics were used to analyse the mean scores obtained from the pre- and post-tests. The means of the two groups were calculated and compared using the t-test. Prior to solving trigonometric equations, both the control and experimental groups took the pre-test to establish their prior level of understanding. During the intervention, both groups received instruction on how to solve trigonometric equations but with difference approaches: the experimental group using the Symbolab Calculator while the control group using the conventional method. Thereafter, a post-test was administered to establish the difference in the participants' conceptual grasp of the subjects under evaluation.

Table 3: Descriptive Statistics for pre-test and post-test

Descriptive Statistics	Control group (N=65)		Experimental group (N=47)	
	Pre-test	Post-test	Pre-Test	Post-Test
Mean	10.015	13.723	10.830	20.521
Std. Dev	3.597	3.947	3.082	2.686

Table 2: Comparison of Pre-test and Post-test scores of subjects in both groups

Variables	Teaching Using Symbolab (Experimental)		Teaching Without Symbolab (Control)		N	Df	T-computed	P-value
	Mean	SD	Mean	SD				
Pre-Test	10.830	3.082	10.015	3.597	112	111	-28.305	.0001
Post-Test	20.521	2.686	13.723	3.947	113	111	-35.651	.0001

Paired sample statistics

Table 3 and 4 present results of the trigonometric equations solved using the Symbolab and normal instruction methods. In table 4, there is a significant variation in the pre-test mean scores (10.015, 13.723) but the difference is lower (3.708). Furthermore, there is a significant variation (10.830, 20.521) in the post-test mean scores and the difference is higher (9.691). The control group's mean score was significantly lower, suggesting that the Symbolab Calculator approach made it easier for pre-service primary teachers in the experimental group to solve trigonometric equations. The results are similar to the study findings *by* Makhdum et al.(2023) *where the experimental group that used Symbolab calculator performed higher than the control group that used traditional approach in teaching and learning.*

Conclusions and Recommendations

Based on the findings, it was concluded that the utilisation of the Symbolab calculator has a positive impact on the academic performance of pre-service primary science and mathematics teachers in the southern province of Rwanda. The study demonstrated that incorporating the Symbolab calculator into trigonometry instruction led to significantly higher post-test scores compared to the traditional methods. This highlights the potential of integrating technological tools like Symbolab to enhance the learning outcomes of pre-service primary teachers. In light of these conclusions, the study recommends that further research should be

conducted to explore the effectiveness of combining different instructional methods in trigonometry instruction. This may involve integrating Symbolab with other pedagogical approaches to optimize the leasrning experience for pre-service primary teachers. Additionally, teachers are encouraged to explore and adopt various pedagogical strategies that incorporate different instructional methods and technological tools like Symbolab, Mathlabs and MicrosoftMaths.

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