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RESEARCH ARTICLE

The Role of Symbolab Calculator Usage to Enhance Pre-Service Primary Teachers' Conceptual Understanding in Trigonometry Through Community of Inquiry

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ABSTRACT

This study investigated the role of Symbolab Calculator software usage in enhancing pre-service Science and Mathematics Education (SME) primary teachers' conceptual understanding of trigonometry through community of inquiry. The research used a quasi-experimental design with control and experimental groups. Thus, purposive sampling techniques was used to select pre-service primary teachers in the option of Science and Mathematics Education (SME) taken from two schools randomly selected from Southern Province of Rwanda. Thus, the selected sample was 99 pre-service primary teachers from two classes of Year One. Besides, the interview guide was used with seven pre-service primary teachers to explore their perception towards Symbolab Calculator software. Qualitative data was analyzed analytically and thematically. To analyze quantitative data, a t-test statistical analysis tool was used to compare means of the two groups. Although the results from a t-test revealed that there was no statistically significant difference between the control and experimental groups ($p>0.5$), the treatment group made a significant increase in scores compared to the control group. In addition, the results from pre-service primary teachers' conceptual understanding solutions analysis and those from pre-service primary teachers' interviews, showed that using Symbolab Calculator helped to develop a collaborative skill and more understanding of trigonometry. It recommended the tutors to integrate a Symbolab Calculator software in their instructions for an effective teaching and learning mathematics.

INTRODUCTION

The community of inquiry (CoI) approach has been applied successfully in a range of educational contexts, including mathematics education (Hannula, 2006; Harris et al., 2006). The CoI is a collaborative learning model that encourages active participation, critical thinking, and reflection. It involves three interdependent elements - social presence, cognitive presence, and teaching presence. In this approach, students work together to construct knowledge, share ideas, and engage in meaningful discussions (Garrison et al., 2001). The CoI approach was found to be effective in promoting conceptual understanding of mathematics in general, and the units of trigonometry in particular (Yiğit Koyunkaya & Boz-Yaman, 2023); (S. Kaymak et al., 2021).

Through CoI, the instructor plays a key role in facilitating the learning process, by designing activities and guiding discussions that promote cognitive and social presence (Garrison et al., 2001). In a CoI approach to learning trigonometry, students are encouraged to engage in collaborative problem-solving activities, discussions, and reflective practice (Koyunkaya & Boz-Yaman, 2023). By promoting collaboration and critical thinking, the community of inquiry approach can help students to develop a deep and thorough understanding of trigonometric functions and their applications. The approach can also help to address common misconceptions and difficulties that students may encounter when learning trigonometry (Koyunkaya & Boz-Yaman, 2023). In addition, the CoI approach was found effective in promoting conceptual understanding, critical thinking, and collaborative learning (Kaymak et al., 2021; Koyunkaya & Boz-Yaman, 2023). The CoI approach is a promising way to support the development of conceptual understanding in trigonometry.

Trigonometry is a mathematical branch that involves the study of angles, sides, and trigonometric functions like sine, cosine, and tangent (America et al., 2018). In Rwanda, trigonometry is taught in secondary schools (GS) and Teacher Training Colleges (TTCs) as part of the mathematics curriculum, alongside subjects like algebra, geometry, and calculus (Murungi, 2019). In the TTC mathematics curriculum, trigonometry is taught from Year One through Year Three, in the option of Teaching Science and Mathematics (TSM). Trigonometry was found to be an essential tool in mathematics since it equips students with essential mathematical tools applicable to various fields such as physics, engineering, architecture, computer graphics, and navigation (Romero-Hall, 2020). In trigonometry education, students explore trigonometric functions, their graphs, and their practical applications in solving triangle-related problems. They learn about trigonometric ratios, inverse trigonometric functions, as well as trigonometric identities and equations (Dugopolski, 2018).

Despite its role played by trigonometry as a mathematics tool used in different fields, pre-service primary teachers continue to face challenges in developing a profound conceptual understanding of some mathematical topic. One of the topic areas highlighted where secondary students and pre-service teachers have challenges is trigonometry (Chapman, 2011). For instance, the study conducted by (James, 2023) showed that trigonometry is difficult since students still have problems related to making invalid references, having conceptual misunderstanding on trigonometric ratios and equations, and in solving word problems. The abstract nature of trigonometry makes it difficult for pre-service teachers which leads to poor performance and the inability to successfully complete their training. For cultivating conceptual understanding of trigonometry and promoting a more innovative way of learning, the integration of technology into mathematics teaching and learning is essential (Paulin, 2023). One of the potential solutions to address the problem was thought to be the integration of Symbolab Calculator software alongside the community of inquiry approach since it was found that the use of Symbolab Calculator software enhances pre-service primary teachers' conceptual understanding (Paulin, 2023)

The Symbolab Calculator software is an online tool that provides step-by-step solutions to mathematical problems, including trigonometry. Studies suggest that the use of Symbolab Calculator software can be effective in enhancing students' learning outcomes in mathematics education. Symbolab Calculator has four main advantages such as being interactive and visual learning (Ozturk & Guven, 2013), enhancing collaborative learning (Yiğit Koyunkaya & Boz-Yaman, 2023), providing immediate feedback (Kaymak et al., 2021); and being flexible and accessible online (Chapman, 2011). These advantages contribute to the creation of a supportive and challenging learning environment that fosters deep and meaningful learning (Akpan et al., 2023). In addition, by working collaboratively and using the Symbolab Calculator software to explore trigonometric concepts, pre-service teachers are engaged in meaningful discussions and gain a better understanding of the subject matter (August, 2002). Thus, the proposed approach suggests the use of Symbolab Calculator software in conjunction with the CoI approach to help pre-service teachers develop a deeper conceptual understanding of trigonometry. Therefore, this proposed approach aimed to improve the pre-service primary teachers' understanding of trigonometry using the Symbolab Calculator through the CoI approach. Using the Symbolab Calculator software through CoI enhanced pre-service primary teachers' deeper understanding of the trigonometry topic area, through collaborative problem-solving, discussion, and reflection (Hannula, 2006). Therefore, Symbolab Calculator software is helpful in addressing the common misconceptions and difficulties that pre-service primary teachers may encounter when learning trigonometry (Koyunkaya & Boz-Yaman, 2023).

Despite the existing research showing the potential of Symbolab Calculator software, through the CoI approach to enhance pre-service teachers' conceptual understanding of mathematics there is a lack of comprehensive study on the effectiveness of Symbolab on pre-service teachers' conceptual understanding of trigonometry within TTCs of Rwanda. Thus, the research gap drives the need for conducting further studies to provide a more nuanced understanding of the use and effectiveness of Symbolab Calculator software through the CoI approach in trigonometry instruction for SME students within TTCs of Rwanda. It was hypothesized that using the Symbolab Calculator software through the CoI approach can effectively enhance pre-service primary teachers' conceptual understanding of trigonometry.

Objectives

1. To enhance pre-service primary teachers' conceptual understanding of trigonometry through Symbolab and the community of inquiry approach.
2. To investigate pre-service teachers' perceptions and acceptance of the Symbolab Calculator software used in teaching and learning trigonometry.
3. To compare the mean scores of pre-service primary teachers who received instruction in trigonometry with the use of the Symbolab Calculator software through community of inquiry approach. and those exposed to traditional teaching approaches.

Hypothesis

H0: There is no statistically significant difference in the mean scores between students who received instruction in trigonometry with the support of the Symbol Calculator and those who received instruction without the support of the Symbol Calculator.

H1: There is a statistically significant difference in the mean scores between students who received instructions in trigonometry with the support of the Symbol Calculator and those who received instructions without the support of the Symbol Calculator.

Study's theoretical framework

This study is grounded on the community of inquiry theoretical framework. With its foundations the CoI theoretical framework offers an organized method for comprehending and guiding online learning environments (Garrison et al., 2001). It was created by Garrison, Anderson, and Archer in late 1990 and consists of the following three interrelated components: teaching presence, social presence, and cognitive presence. The process of creating meaning through extended conversation, analytical thought, and investigation is referred to as cognitive presence. The ability of users to portray themselves as actual individuals online is known as social presence as it promotes trust and human interactions. A supportive and collaborative environment is fostered while guiding students through the process of inquiry through the design, facilitation, and direction of educational experiences. This is known as teaching presence (Vaughan & Lawrence, 2013). Thus, to design meaningful and successful online learning experiences, the CoI theoretical framework model highlights the significance of striking a balance between these three presences to comprehend the influence of using the Symbolab Calculator software through the community of inquiry approach on pre-service teachers' conceptual understanding of trigonometry.

Figure 1: Community of inquiry theoretical framework model (Vaughan & Lawrence, 2013)

This study also recognizes the role of technology, specifically the Symbolab Calculator software, this study incorporates the Technology Acceptance Model (TAM) as a guiding theoretical framework (Milly et al., 2021). The TAM provides valuable insights into how individuals perceive and adopt technology. By investigating pre-service teachers' perceptions and acceptance of the Symbolab Calculator software, the study aimed to understand the impact of technology integration on trigonometry learning. This theoretical perspective helps shed light on the factors that influence pre-service teachers' acceptance and utilization of the Symbolab Calculator software within the context of trigonometry education. These theoretical frameworks collectively contribute to the understanding of the impact of using the Symbolab Calculator software and the community of inquiry approach on pre-service teachers' conceptual understanding and attitudes towards trigonometry. They provide a robust theoretical foundation for the study, guiding the research design and analysis to explore the complex interplay between technology, collaborative learning, and cognitive processes in trigonometry education.

RESEARCH METHOD

Research design

The study employed a quasi-experimental design (Jelatu et al., 2019), utilizing pre-test and post-test measures, with both treatment and control group. This research design was considered suitable for examining the effectiveness of integrating the Symbolab Calculator through the community of inquiry approach in enhancing pre-service primary teachers' conceptual understanding of trigonometry (Aljermawi et al., 2024; Jelatu et al., 2019). Participants' conceptual understanding of trigonometry was assessed using both a pre-test and a post-test. The pre-test was conducted before the instruction, while the post-test was conducted after the instruction.

Population, sample size, and sampling technique

The target population for this study consisted of pre-service primary teachers in Year One, specializing in the option of Science and Mathematics Education (secondary students preparing for the future teachers of science and mathematics in primary schools), from the Southern Province of Rwanda. The selection of a sample from the target population, aimed to achieve greater accuracy and efficiency compared to considering the entire population, as explained by (Garg, 2016). In Rwanda, there are 16 TTCs among which 2 TTCs were randomly selected. At each school, Year One SME class was purposely selected. Thus, the obtained participants are 99 including 49 and 50 students that formed the experimental and control group respectively. Besides, the researcher used the cluster sampling technique to sample students for an interview. Cluster sampling is a widely used sampling technique that involves dividing the population into clusters or groups that are representative of the overall population (II et al., 2001). Thus, seven students were obtained and called for an interview for pre-service teachers' perceptions on using Symbolab Calculator through the CoI.

Data collection

The study involved the use of pre-test and post-test measures to assess participants' conceptual understanding of trigonometry. The pre-test was administered prior to the instruction, while the post-test was administered after the instruction. The same trigonometry test was used for both the pre-test and post-test to ensure that any changes in participants' scores can be attributed to the intervention (Aljermawi et al., 2024). The test was designed to assess participants' knowledge of key concepts in trigonometry, such as converting degrees into radian, trigonometric ratios of special angles and identities.

In this study, data collected from pre-test and post-test measures analyzed the role of the intervention in enhancing pre-service primary teachers' conceptual understanding of trigonometry and their attitudes towards mathematics. Descriptive and inferential statistics were used to determine whether there were significant differences between the experimental and control groups. The collected data were used to summarize the participants' attitudes towards mathematics and the instruction they received. The data collection procedures were designed to provide comprehensive and reliable data to assess the effectiveness of the intervention.

Research instruments

Two instruments; a conceptual understanding test of trigonometry and an interview guide were adapted and employed. The test was composed of four questions for calculations. The test was marked out of forty-five marks. It underwent a pilot study and was given to40 students. The purpose of the pilot study was to assess the reliability of the instrument and identify any potential issues or areas for improvement. The internal consistency was calculated using Cronbach's alpha. The obtained value was $\alpha=0.8$ showing the higher internal consistency among the questions. Therefore, the instrument was reliable to be used. Besides, the interview guide was subjected to the two external experts to assess its validity and reliability.

Intervention

The experimental group used the Symbolab Calculator software to complete the trigonometric equations tasks. Students in the experimental group cooperated in groups to complete in-class exercises. In addition, they were given assignments that piqued their desire to learn more about the topics discussed in class using Symbolab Calculator software software in mathematics. The teachers were knowledgeable in the use of the Symbolab Calculator software software for teaching their lessons. The students in the control group received traditional teaching strategies. A step-by-step procedure for solving trigonometric equations. was provided. Since the researcher wanted to also develop the pre-service teachers' skills in writing symbols used in trigonometry, given assessments were done using a pen and paper.

Data analysis procedure

Qualitative data collected from interviews were entered into the computer for further cleaning, analysis, and computations. Thus, thematic analysis was conducted after creating codes. In addition, The interview and the document data, a narrative analysis approach was adopted to analyze qualitative data from the students' solutions from the test. Quantitative data from the conceptual understanding test was analyzed using both descriptive and inferential statistics. This was accomplished by utilizing the Statistical Package for Social Science (IBM SPSS, version 21) where percentages and means were calculated. In addition, for inferential statistics, an independent t-test was run to compare mean scores from the control and experimental groups.

FINDINGS AND RECOMMENDATIONS

Findings presentation

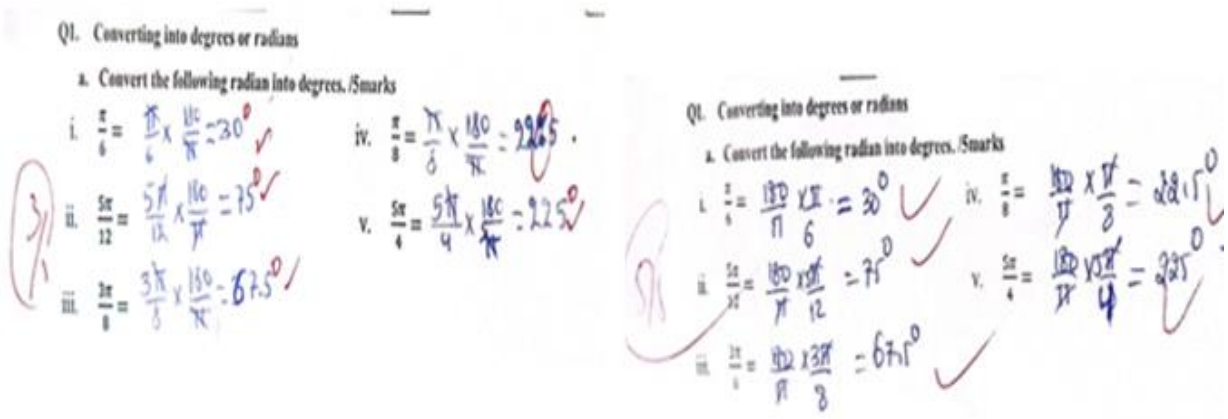
The results are from pre-service primary teachers who were enrolled in Year One in science and mathematics education (SME) at TTC Save and TTC Mbuga. The results are presented following the objectives of the study. These involve, (1) pre-service primary teachers' conceptual understanding of trigonometry through Symbolab

and the community of inquiry approach, (2) pre-service teachers' perceptions and acceptance of the Symbolab Calculator software used in teaching and learning trigonometry, and (3) to compare the mean scores of pre-service primary teachers who received instruction in trigonometry with the use of the Symbolab Calculator software through community of inquiry approach and those exposed to traditional teaching approach.

1) Pre-service primary teachers' conceptual understanding of trigonometry through Symbolab and the community of inquiry approach.

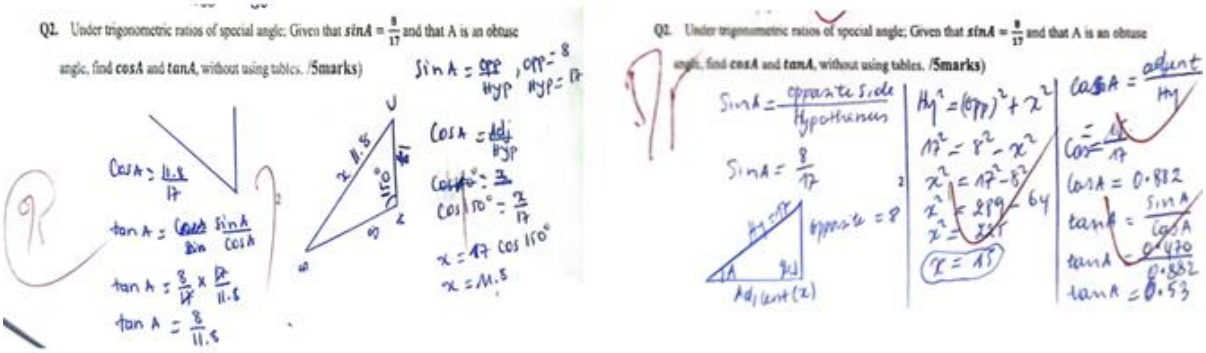
To investigate the effect of Symbolab Calculator on pre-service primary teachers' conceptual understanding of Trigonometry, the solutions provided by pre-service teachers in both pre-and post-conceptual tests were compared and analyzed. The analysis and comparison of the solutions permitted researchers to see how the randomly sampled pre-service teachers (four teachers) answered the questions and challenges met while showing their work towards the right answer. The analyzed solutions are for Question1, Question2, Question3, and Question4, respectively corresponding to Teacher A, B, C, and D for anonymous reasons. Questions 1, 2, 3, and 4 were considered for analysis, since they showed a significant shift of pre-service teachers' score performance from pre-to post-test. It was therefore clear for the researcher to identify how and why the particular pre-teacher answered the way s/he answered and the journey made to provide an improved solution in the post-test. As shown for each worked question, the first circled marks in red (on the left-hand side) are for the pre-test, while the second circled marks (towards the right-hand side) are for the post-test. The following are the presented solutions with the corresponding analysis.

The solution for Question 1:



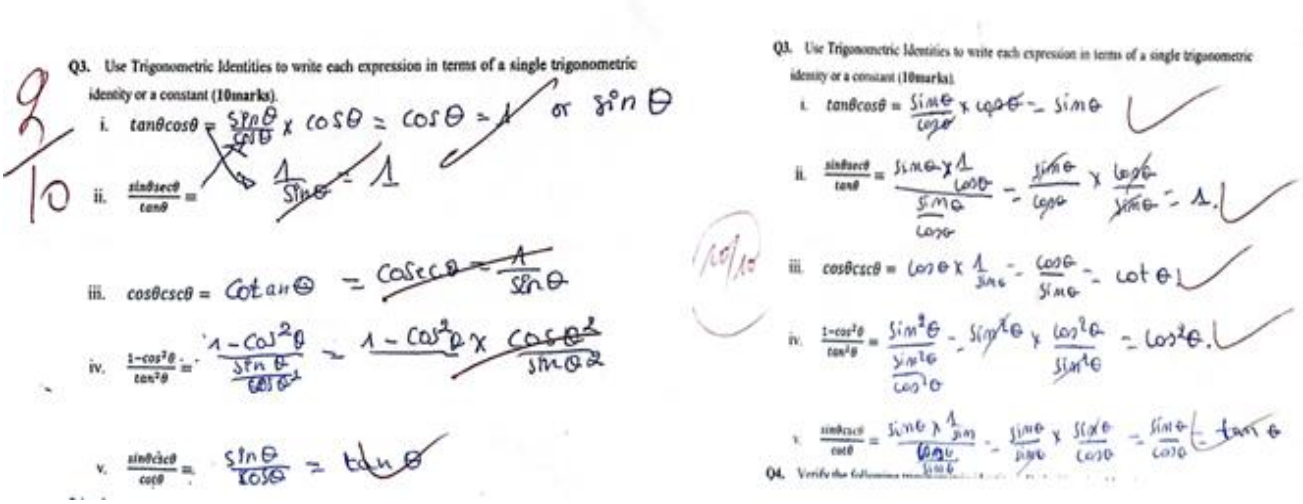
For Question 1, teacher A obtained 3 and 5 out of 5 in the pre-and post-test respectively. The answer sheet illustrates that prior to the intervention, learner A on the left side had the knowledge on how to convert radian into degrees but with a limited grasp of degree notation. However, through the implementation of Symbolab and the community of inquiry approach, the learner successfully developed a conceptual understanding of degree notation. As a result, on the right side, the pre-service primary teacher demonstrated improved performance in trigonometry.

The solution for Question 2:

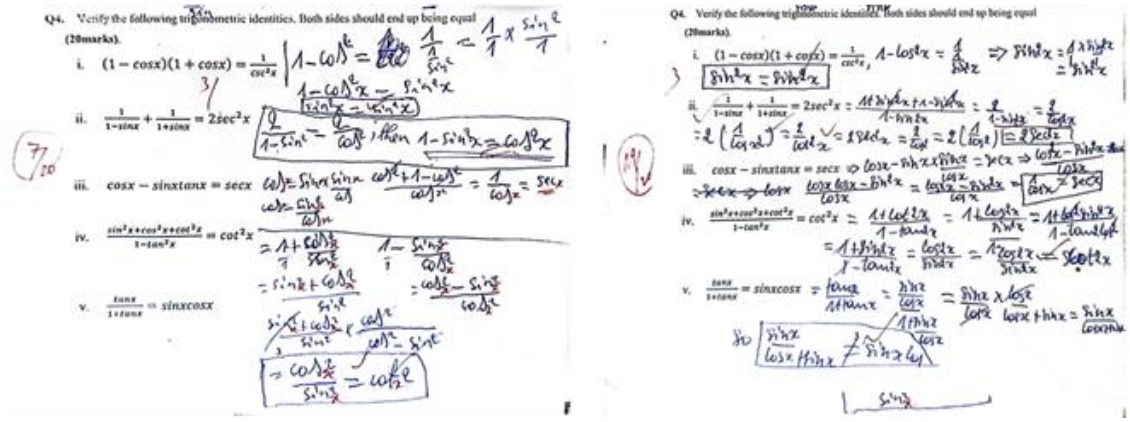


The solution for Question 2, teacher B obtained 0 and 5 out of 5 in the pre-and post-test respectively. Initially, pre-service primary teachers encountered difficulties in accurately drawing the required triangles for problem-solving see figure in the last hand side). However, by employing the community of inquiry approach and effectively utilising the Symbolab calculator, teacher B experienced a notable enhancement in their comprehension of right triangle shapes and angle relationships. Despite initial hesitation, teacher B showcased improvement in solving questions pertaining to the ratios of special angles.

Solution for Question 3:



For Question 3, teacher C obtained 2 and 10 out of 510in the pre-and post-test respectively. It is evident that pre-service primary teacher C initially demonstrated a limited understanding of trigonometric identity simplification. The left side of the figure illustrates confusion between cosx=1 and sinx=1, indicating a lack of clarity regarding these concepts. However, through collaborative efforts and a commitment to improvement, the performance and conceptual understanding of these concepts, the pre-service teacher C showed significant progress. This positive development is clearly depicted in the right side, which highlights the benefits of working together and the positive impact it has on learning outcomes.



The solution for Question 4:

For Question 4, teacher D obtained 7 and 10 out of 10 in the pre-and post-test respectively. Upon examining the solutions provided for Question 4, it becomes apparent that pre-service primary teacher D had a grasp of the trigonometric functions concept before the Symbolab Calculator-supported instruction. However, there was a recurring issue with the accurate representation of these functions in written form, as the respondent often omitted the parameter "x". This oversight indicated a lack of confidence and a tendency to overlook essential mathematical principles. Notably, when attempting question number four in the pre-test, the pre-service teacher D, displayed a weak concentration and struggled to apply the necessary attention to detail the solution. The presented results show that after the intervention there is significant improvement in the pre-service teacher D's conceptual understanding of simplifying trigonometric identities. These interventions likely played a crucial role in enhancing teacher D's attention to detail, allowing for a more comprehensive understanding of the subject matter.

The findings from this study revealed that the integration of Symbolab Calculator through the community of inquiry approach significantly enhanced pre-service primary teachers' conceptual understanding of trigonometry. Through active engagement in inquiry-based discussions and the use of Symbolab Calculator software as a tool for problem-solving, participants demonstrated a deeper comprehension of trigonometric concepts and their applications. In addition, the collaborative nature of the CoI approach fostered meaningful discussions and critical thinking, allowing pre-service primary teachers to construct and refine their understanding of trigonometry. The use of Symbolab Calculator software further facilitated the visualization and exploration of trigonometric principles, supporting the development of a solid conceptual foundation among the participants.

2) Pre-service teachers' perceptions of the Symbolab Calculator software used in teaching and learning trigonometry.

To answer the second research objective, we asked individually the seven pre-service teachers if they got a chance to interact with Symbolab Calculator and if they have enjoyed it. The majority of the pre-service teachers (five out of seven) revealed that they interacted with it and they provided their insights about the tool. The provided responses highlighted the positive impact of the Symbolab calculator on their understanding of trigonometry. According to their explanations, the Symbolab calculator provides a valuable tool for solving trigonometric equations efficiently. Many questions could be answered within minutes, and the calculator provided step-by-step guidance to obtain all possible solutions, thereby simplifying the process of solving tedious problems. For example, one pre-service teacher 5 said: “The Symbolab Calculator allowed me to tackle challenging trigonometric equations and obtain prompt solutions. Additionally, three pre-service teachers who were interviewed emphasized that the calculator facilitated their revision process and enabled them to correct their exercises more effectively (Interview with the pre-service Teacher 5).”

In addition, two interviewed teachers affirmed the usefulness of employing the Symbolab calculator to solve trigonometric equations. They also noted that its usage stimulated their interest in utilizing ICT software while teaching mathematics.

Although pre-service teachers acknowledged the effectiveness of Symbolab Calculator in teaching and learning Trigonometry, they also acknowledged some challenges to learn some topics in Trigonometry. For example, pre-service teachers said that the topic of trigonometric equations is a challenging one for them, as they often struggle to recall trigonometric operations, particularly when confronted with trigonometric identities.

The respondents proceeded to answer to the question, asserting that they faced numerous obstacles such as a lack of familiarity with computers (insufficient background in ICT tool utilization), difficulties in typing mathematical equations, unreliable network connectivity, and limited knowledge regarding the usage of Symbolab Calculator software in classroom.

One interviewed pre-service teacher 3 reveals that the school has an internet connection problem, proposed some suggestions and said: "Our school is suffering from inadequate internet connectivity. The provided resources by the Rwanda Education Board are not functioning properly. Consequently, I suggest that schools should engage in further advocacy efforts to secure more computers and enhance internet connectivity in Teacher Training Colleges (TTCs) (Interview with the pre-service Teacher 3)."

In general, the interviewed pre-service teachers provided their input mentioning that incorporating the Symbolab Calculator into their classroom was a novel experience for them though it required them time to familiarize themselves with its functioning.

3) **To compare the mean scores of pre-service primary teachers who received instruction in trigonometry with the use of the Symbolab Calculator software through the community of inquiry approach and those exposed to traditional teaching approaches**.

To answer the third research question, a descriptive and inferential statistics t-test was used to compare pre-service teachers' performance (for both control and experimental groups) in pre- and post-test. The purpose was to investigate the effectiveness of the Symbolab Calculator software and the community of inquiry approach in enhancing pre-service primary teachers' conceptual understanding of trigonometry. Table 1 and 2 show the descriptive and inferential results of the control and experimental groups test scores in both pre- and post-test.

Table 1: A descriptive table comparing pre-test and post-test scores

	Group	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Pre-test	Treatment Group	49	16.735	5.5482	.7926
	Control Group	50	25.480	4.5636	.6454
Post-test	Treatment Group	49	34.959	6.2013	.8859
	Control Group	50	35.500	4.3916	.6211

The findings presented in Table 1 shows that there is a prominent difference in the mean scores between the pre-test and post-test of the treatment and control groups at the baseline. The table provided a comparison of the pre-test and post-test mean scores for conceptual understanding of trigonometry using the Symbolab Calculator software and the traditional method of teaching trigonometry. The results demonstrated a

significant difference in the mean scores between the pre-test and post-test of both the control group with 25.48% and 35.5% respectively and the experimental group got 16.735% in pre-test and 34.959% in post-test. Notably, the pre-test mean score for the treatment group was 16.735% lower than the control group's pretest with the mean score of 25.48%. However, after the intervention, the treatment group's mean score increased significantly from 16.735% in pre-test to 34.959% in the post-test. These results indicate a substantial improvement in performance in the post-test. These findings highlighted the effectiveness of the Symbolab Calculator software and the community of inquiry approach in enhancing pre-service primary teachers' conceptual understanding of trigonometry.

Table 2: An independent samples t-test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre-test	Equal variances assumed	.891	.348	-8.573	97	.000	-8.7453	1.0201	-10.7699	-6.7207
	Equal variances not assumed			-8.556	92.792	.000	-8.7453	1.0221	-10.7751	-6.7155
Post-test	Equal variances assumed	7.827	.006	-.502	97	.617	-.5408	1.0783	-2.6809	1.5992
	Equal variances not assumed			-.500	86.344	.618	-.5408	1.0819	-2.6915	1.6098

The study employed an independent sample t-test to test the hypothesis. The table presented above illustrates the tested equal variances of the pre-test results and they showed that there is a significant difference since the significance level (2-tailed) value was 0.000 and it is less than 0.05. The results indicated that there was a statistically significant difference in pre-test mean scores between the two groups' background on trigonometric concepts. For the post-test, the significance level (2-tailed) was calculated using IBM-SPSS and the results was 0.618, which is greater than the significance level of 0.05. Consequently, based on the results, there is no statistically significant difference between the utilisation of the Symbolab Calculator software and the traditional teaching methods. Thus, the alternative hypothesis was rejected and the null hypothesis (H0) was accepted. It was therefore concluded that there is no significant difference between the two approaches for the Year One Science and Mathematics Education pre-service teachers. It is important to note that though the findings did not indicate a statistically significant difference, it is still essential to consider the potential benefits of using Symbolab Calculator to enhance pre-service conceptual understanding of trigonometry. This is explained by the significant rise of mean scores from the pre-test to the post-test for pre-service teachers who had 16.9% in pre-test, while they got 34% in the post-test. Pre-service teachers in the experimental group made a difference of only 9.6% from pre to post-test, while the treatment group made a difference of 18.2% from pre to post-test (see Table 1).

DISCUSSION

The findings from the analysis of the pre-service teachers' conceptual understanding were found through the analysed scripts about four pre-service primary teachers' solutions in both pre- and post-test. As presented in the study's results, the teaching of trigonometry, supported by Symbol Calculator, contributed in enhancing pre-service primary teachers' conceptual understanding of trigonometry. Indeed, (Garrison et al., 2001)

asserted that the Symbolab Calculator software allows students to input trigonometric equations, explore graphical representations, and obtain step-by-step solutions, thereby facilitating a deeper understanding of trigonometric principles. The results from this study also agree with (Ndagijimana, 2024) who found that the integration of the Symbolab calculator significantly contributed to students' performance and understanding. It was also found the time taken to solve trigonometric equations was reduced when Symbolab Calculator was used during trigonometry instructions. Through Symbolab Calculator-supported instructions, students can explore real-life applications of trigonometric concepts enhancing their understanding and mathematical reasoning skills. Indeed, the Symbolab was found flexible in way that it allows users to work together to solve problems and explore the relationships between different trigonometric functions (Koyunkaya & Boz-Yaman, 2023) in addition to providing immediate feedback on calculations and solutions, which can help pre-service teachers to identify and correct misconceptions and errors (Ozturk & Guven, 2013). Therefore, the integration of the Symbolab Calculator software into geometry instructions can further enhance the learning experience by providing a valuable tool for trigonometric calculations and problem-solving.

Symbolab Calculator has many advantages when integrated effectively while learning Geometry. This is because it allows users to input and solve complex trigonometric equations, making it a valuable resource for pre-service teachers in TTCs of Rwanda who struggle with the abstract nature of trigonometry (Munyaruhengeri et al., 2023). The same observation was made by (Akpan et al., 2023) who reported that use of the Symbolab Calculator software in the context of a community of inquiry approach has several advantages in enhancing pre-service primary teachers' conceptual understanding of trigonometry. When used in the context of a CoI approach, the Symbolab Calculator software fields several advantages in enhancing pre-service primary teachers' conceptual understanding of trigonometry. For instance, a study by (Aljermawi et al., 2024) found that the use of Symbolab Calculator software was effective in improving college students' mathematical achievement and attitudes towards mathematics in an algebra course. Similarly, a study by (Makhdum et al., 2023) showed that the use of Symbolab Calculator software improved Saudi students' mathematical achievement and attitudes towards mathematics.

The use of Symbolab calculator through participating in a community of inquiry approach, was perceived playing a profound positive impact on their performance. It was found that through the community of inquiry approach, Symbolab Calculator enabled pre-service primary teachers to actively engage in problem-solving, develop critical thinking skills, and engage in collaborative discussions, which ultimately facilitated the development of a deeper conceptual understanding of simplifying trigonometric identities. We therefore agree with Garrison et al. (2000) who reported that discussions, and peer-to-peer interactions, educators can create a supportive environment where students can exchange ideas, perspectives, to deeply understand trigonometric principles while utilizing the Symbolab Calculator software as a shared resource. As is also supported by the theory of acceptance (Davis, 1989) guiding this study, there should be a pre-service acceptance interaction and use of the Symbolab Calculator software in their learning. Indeed, Baki, Bilgin, and Karakirik (2017) showed pre-service mathematics teachers with positive attitudes towards using technology in mathematics education, including the community of inquiry approach, are likely to use that technology. Thus, there is a hope that pre-service teachers will integrate the Symbolab Calculator software in their mathematics instructions since this ICT tool was found to be effective in promoting students' mathematical achievement and attitudes towards mathematics when applied effectively through the community of inquiry approach (Liao & Lin, 2021). Indeed, by implementing this approach, tutors can create a collaborative and interactive learning environment that caters specifically to the needs of adolescent pre-service primary teachers (Garrison et al., 2001). While comparing the pre-service primary teachers who used the Symbolab Calculator software of inquiry approach and those exposed to traditional teaching approaches, the results showed that there is no difference in their mean scores in score means of the post-test. Although, while comparing the pre-test and post-test scores, the results show that students have made a significant performance due to the software used. The results from the study agree with (Aljermawi et al., 2024) who found that the flipped classroom approach combined with the use of Symbolab Calculator software was effective in improving students' achievement in mathematics. The results from the study were also found by (Gholami, 2022) who investigated the impact of using a technology-based intervention, including Symbolab Calculator software, on college students' achievement in trigonometry. In their study, (Gholami, 2022) also found that the technology-based intervention was effective in improving students' trigonometry achievement.

It is important to note the added value brought by the community of inquiry enhancing students' active learning and collaboration. Indeed**,** the community of inquiry approach is a pedagogical framework that emphasises the importance of social presence, cognitive presence, and teaching presence in online and blended learning environments (Martin et al., 2022). We also agree with (Lee & Lee, 2019) who reported that pre-service mathematics teachers' perceive the community of inquiry model to be effective in promoting the students' collaboration, engagement and critical thinking in mathematics education. Secondly, the social presence component recognizes the importance of fostering a sense of community and collaboration among students (Garrison et al., 2001). Through group work, discussions, and peer-to-peer interactions, educators can create a supportive environment where students can exchange ideas, perspectives, and collectively build a deeper understanding of trigonometric principles while utilizing the Symbolab Calculator software as a shared resource. Indeed, the utilization of the Community of Inquiry approach holds great significance when it comes to teaching trigonometry to adolescent students in teacher training colleges (Çakiroğlu, 2019). Therefore, it was suggested that the community of inquiry approach can be effective in enhancing pre-service teachers' engagement and critical thinking in mathematics education.

Although Symbolab Calculator was found to contribute significantly to Mathematics education, its exploitation in schools has some challenges. The revealed challenges include the insufficient ICT tools in schools, limited teachers' knowledge to use ICT tools, and poor internet connection in TTCs. Similarly, Nzayisenga et al., (2023) found that teachers perceived technology as a valuable tool to effectively enhance mathematics instruction by making it more engaging, interactive, and conducive to student-centered learning. However, challenges such as mathematics teachers' knowledge to incorporate technology into their teaching practices was noted. We therefore agree with (Nzayisenga et al., 2023) who recommended that there is a need for sustainable policies and investments in educational technology infrastructure and teacher training to maximize the benefits of technology integration.

CONCLUSION

The study investigated the role of Symbolab Calculator software in conjunction with the community of inquiry approach to enhance pre-service primary teachers' conceptual understanding of trigonometry. The findings from the study demonstrated a significant improvement in the pre-service primary teachers' conceptual understanding of trigonometry Similarly, the results from the interview showed that pre-service primary teachers perceive Symbolab Calculator as a tool greatly contributing in enhancing their conceptual understanding through discussion and collaboration. While the statistical analysis did not reveal a significant difference between the Symbolab Calculator software and traditional teaching methods, the study highlights the importance of the community of inquiry approach in creating a collaborative and interactive learning environment.

Implications for further studies and recommendations

Based on the findings, several recommendations can be made for practitioners and researchers in the field of mathematics education. Within this regard, tutors should consider incorporating the Symbolab Calculator software as a supplementary tool in trigonometry instruction. The calculator can assist students in exploring real-life applications, visualizing concepts, and providing step-by-step solutions, thereby enhancing their understanding and problem-solving skills. TTC tutors should prioritize the integration of the community of inquiry approach in trigonometry instruction. It is very important to provide professional development opportunities for teachers to familiarize themselves with both the Symbolab Calculator software and the community of inquiry approach. Training and support will equip teachers with the necessary skills and knowledge to effectively implement these strategies in the classroom.

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