Original Research Article

Exploring the Effect of Constructivist Learning Approach on Problem Solving Skills in Mathematics among Pre-Service Teachers at Wiawso College of Education

ABSTRACT

This study aimed to explore the impact of constructivist learning approach to teaching and learning mathematics at Wiawso College of Education. The research design adopted for the study was action research The target population was level 200 students of the College and the population size was five hundred and seventy-nine (579) whilst the sample size was fifty-two (52), comprising one class, which was selected based on purposive sampling. The instrument used for the study was tests and questionnaire. In the pre-intervention stage, a pre-test was used to identify the weaknesses of the students before the interventional strategies were applied. A post-test was conducted to evaluate the intervention strategies. The results of the study showed a significant improvement in students' post-test scores (M=31.1923) compared to the pre-test scores (M=14.1923). A quiz was conducted eight weeks after the post-test using the same test items to check students' retention of the concept, which the result showed no significant improvement in pre-service teachers' post-test scores (M=31.1923) compared to the quiz scores (M=30.6923), indicating pre-service teachers' retention of the math concept had been exceptionally good. The pre-service teachers preferred constructivist learning strategies over the conventional teaching methods since lessons were practical and interactive. The study recommended that teachers should employ constructivist learning approach in teaching mathematics as it shifts the emphasis from teacher-centered to learner-centered and enhance students' interest and performance.

Keywords: *constructivist learning approach; problem solving; learning mathematics; retention of concepts; teaching and learning.*

INTRODUCTION

All of human society pivots around mathematics. Because of its relevance to modern science and technology, it is a popular field of study all across the globe (Atteh et al., 2014). All of human civilization rests on our ability to understand and exploit the natural world, and mathematics and its scientific applications provide the essential groundwork for this endeavor. Math is an essential part of a well-rounded education and a required subject in nearly every country's school curriculum because of its importance and relevance to everyday life (Keith 2000; Asiedu-Addo and Yidana 2004; Atteh et al. 2014). To be ignorant of mathematics is to be ignorant of the other sciences and the things of the world, so its neglect is harmful to all knowledge (Sidhu, 2002). According to Keith (2000), mathematics is a

foundational study not only in and of itself but also because of the numerous other disciplines (including the physical and life sciences, technology, medicine, and the social sciences) with which it is inextricably intertwined. Therefore, it follows that mathematics should be viewed as the foundation for any subject requiring analytical thought and reasoning, and taught to children as the means by which they will learn to think, reason, analyze, and express themselves logically (Ministry of Education, 2002; MOE, 2019). Some people think that mathematics is essential to human survival (Nabie, 2002). According to research by McBride and Silverman (1997), the ability to use mathematics to quantify and explain scientific relationships is a key factor in students' development of a more thorough grasp of scientific concepts. This indicates that solving mathematical problems is an imaginative process involving the generation of original ideas, the formulation of relevant ideal concepts, the generation of pertinent questions, and the intuitive derivation of potential solutions. This proves without a reasonable doubt that pupils will not be able to acquire and apply the necessary abilities and concepts in science and technology if they do not first have a firm grasp of the fundamental principles of mathematics.

Despite mathematics' centrality in a well-rounded education and its status as a foundational subject, many students struggle to find an interest in the subject. Indeed, many schoolchildren avoid mathematics classes because they find the subject too challenging. Some students would even go so far as to make up an illness so they could avoid studying mathematics because they believe it is "too hard" for them to grasp. They believe that mathematics is too challenging for them because it is full of rules and is reserved for students with greater intellectual aptitude (Atteh et al., 2014). This indicates that students have developed negative attitudes towards mathematics, which in turn explains why so many science and mathematics majors in higher education are instead pursuing degrees in the social sciences, including the arts (Nabie, 2002). The National Education Assessment and the Trends in International Mathematics and Science Study (TIMSS) (Anamuah-Mensah, Mereku, and Ghartey-Ampiah, 2008) show that this is why students don't do well in math.

The primary goal of mathematics education is to equip students with the conceptual tools and procedural knowledge necessary to solve real-world mathematical problems of varying complexity (National Mathematics Advisory Panel, 2008). Tools, methods, and approaches that enable practice or the study of practice are of primary relevance to researchers in mathematics education. This is why curriculum materials from all around the globe stress the need to learn proper procedures. Procedural knowledge, as described by Van de Walle

(2001), is "knowledge of the rules and procedures that one uses in carrying out routine and mathematical tasks and also the symbolism that is used to represent mathematics" (p. 31). According to the literature, mathematical literacy requires not only factual recall but also the ability to think and understand abstract concepts (Wilkins, 2000). This promotes critical thinking, argumentation, and communication abilities. It is well-established that students are more likely to gain abilities linked to applicability and obtain a comprehension of associated ideas in mathematics when they acquire both procedural knowledge and conceptual understanding (Hiebert and Carpenter, 1992). Among the many activities that make up the practice of mathematics are the following: expressing circumstances in various forms, conducting research, formalizing patterns and regularities, generalizing, and solving problems. This means that teachers should take part in a process in which they help students get ready to learn by using different strategies and tools and setting up the best conditions for learning (Lal and Malhotra, 2008).

Mathematical instruction is based not just on the facts and techniques students need to solve problems, but also on the methods they might use to learn and improve as they work. Colleges of education in Ghana use a variety of instructional strategies, including face-to-face, practical activities, work-based learning, as well as independent study, to teach mathematics to their students. These modes of delivery aim to instill in pre-service teachers the nation's core values of honesty, integrity, creativity, and responsible citizenship to achieve an inclusive, equitable, high-quality education for all learners in line with Sustainable Development Goal (SDG) Four. Effective mathematics instruction calls for educators to employ appropriate pedagogical practices. When it comes to mathematics education in Ghana's public schools, the new curriculum places an emphasis on a constructivist learning approach (MOE, 2019). As a result, this research aims to investigate the role of constructivist teaching methods in the resolution of pre-service teachers' mathematical difficulties.

Statement of the Problem

The Ghanaian mathematics curriculum emphasizes the importance of using mathematics in everyday life through the identification and use of relevant methods such as teaching through constructivism (Ministry of Education, 2007; MOE, 2019). In order to help their students succeed in high school and beyond, it is imperative that elementary school teachers have strong mathematical backgrounds. According to research by Atteh et al. (2014), "Concept-representation of all mathematical ideas needs to be taught with the help of practical activities

and guidance from the teachers so that students can develop the concepts on their own" (p. 41), and to help students learn how to solve problems in creative ways.

In contrast, theoretical aspects of education receive greater attention than their practical counterparts (Mereku, 2004; Atteh et al., 2014; Andam et al., 2015). Learners' inability to handle non-routine mathematical problems was highlighted in the chief examiners' report (Davis, 2019), and this report suggests that some mathematics teachers exhibit a negative attitude toward questions that require problem-solving skills. The situation was the same in the college of education as well. In a mathematics test, Wiawso College of Education level 200 students performed below expectations. The retention and confidence of the majority of these students to accept or respond to a task involving non-routine math problems was not encouraging; this issue was identified during a review to consolidate some of the mathematics courses taught in the level 100 and 200 first and second semesters. Students' inability to apply suitable problem-solving skills to solve non-routine mathematical problems, as well as a general lack of problem-solving abilities, is, therefore, a reflection of how mathematics teachers conceptualize and conduct teaching. On the other hand, it seems likely that classroom performance improves dramatically when teachers use methods that encourage students to actively participate and share ideas (Atteh et al., 2014; Atteh et al., 2017; Atteh et al, 2020; Boadi et al., 2020; Gyan et al., 2021; Mensah et al., 2022).

Additionally, since the 2018 implementation of the new college of education curriculum, it has been clear that there is a lack of research evaluating the effect of the constructivist learning strategies on the mathematical problem-solving skills of pre-service teachers in the Western North region of Ghana. So, the goal of this study was to find out how using a constructivist approach to learning affected how well future teachers in Sefwi Wiawso Municipality could solve math problems.

Purpose of the Study

The purpose of this study is to explore the impact of constructivist learning approach on students learning outcome in solving mathematical problems at Wiawso College of Education.

Research Questions

The following questions guided the researcher to undertake this study;

1. What is the effect of teaching mathematics using constructivist learning strategies on pre-service teachers' achievement?
2. To what extent will the constructivist learning approach improve the retention of mathematical concept among pre-service teachers in mathematics?
3. What are the views of students about learning mathematics through constructivist learning approach?

LITERATURE REVIEW

The constructivist learning theory that underpins this research may be traced back to the work of cognitive scientists such as Jean Piaget, John Dewey, Jerome Bruner, and Lev Vygotsky. The core tenet of the constructivist approach to education is that students learn best when they actively participate in rather than simply consume the content being presented to them. In a truly democratic classroom, students and teachers work together to enhance student learning. In this setting, new information is built on top of the learner's existing body of knowledge and experience; as a result, learning is seen as a process of rearranging one's schema. A child learns to comprehend, think imaginatively, and reason logically through his interactions with physical experiences and concrete objects. Learners are pushed to take the initiative and take charge of their own learning in a constructivist classroom. The goal of a constructivist teacher is to foster critical thinkers and self-starters in their students. Learning mathematics in a constructivist approach is seen as the social construction of concepts, strategies, and knowledge. Teachers of mathematics at all levels should incorporate into their lessons any concrete manipulative that helps students make connections between mathematics and the real world and provide students with appropriate hands-on activities that discourage rote learning, purely declarative knowledge, and memorization of facts, theorems, formulae, and algorithms. Sometimes there isn't enough coordination between learning theorists and curriculum designers, despite the fact that constructivism may be seen as a dialog between the two, and as a result, the curriculum isn't developed with the learners in mind (Duffy and Jonassen, 2013).

The constructivist perspective of education has been extensively studied in numerous mathematical education papers (Katic, Hmelo-Silver and Weber, 2009; Steele, 1995; andam et al., 2015). It is the belief of constructivists that imparting information to a student without taking into account his or her prior knowledge is inefficient. To paraphrase what Brooks and Brooks (1999) had to say, in a constructivist classroom, the focus shifts from the teacher to

the students. In addition, Brooks and Brooks stressed that the constructivist classroom is no longer one in which the teacher (the "expert") pours information into students (the "empty vessels") who are waiting to be filled. As opposed to traditional lecturing, students in a constructivist classroom are expected to actively engage in the learning process. An educator's role is that of a mediator, providing guidance and assistance to students as they work to refine their knowledge and evaluate their progress. Constructivism is a more modern approach to education than more traditional methods, in which students simply repeat back what their teachers say word for word. Instead, in a constructivist classroom, students bring new perspectives to the table, which are then validated and reinforced through a variety of student-centered methods. Several studies have shown that the constructivist approach to teaching and learning is more effective than traditional methods (Hmelo-Silver, Duncan, and Chinn, 2007; Steele, 1995; Andam et al., 2015; Boadi et al., 2020; Gyan et al., 2021).In a constructivist classroom, students have a lot of control over how they learn and think about math because they learn to build their own understanding.

The commitment made by those who use constructivist approaches in the classroom to foster an atmosphere that promotes students' cognitive activity and sense of self is in keeping with the nature of learning as determined by both behavioral and cognitive perspectives. Constructivist approaches to education have been shown to be successful in a wide range of research settings (Mader, 2009; Nelson-Johnson, 2007; Gatlin, (1998); Bimbola and Daniels, 2010). Over the course of four semesters, with more than a hundred students, Mader (2009) conducted an informal experiment in which she asked them to rate themselves and then provided them with significant advice and input. One survey was taken at the end of each semester. When students weren't concerned about how their teachers would evaluate their work, they were free to focus on learning whatever interested them. Both students and faculty reported greater honesty in these areas. The 30 seventh graders who participated in Nelson-Johnson's (2007) after-school math program benefited from a therapeutic approach to learning through the application of constructivist teaching strategies. Fifteen individuals each comprised the research and control groups. Results from a state-wide standardized test showed that the learners in the experimental group performed significantly better than their peers. The experimental group outperformed the control group, which was taught in the conventional fashion, in terms of both school attendance and students' attitudes toward mathematics.

Gatlin (1998) conducted a similar study, comparing two high school biology classrooms, and found that pupils taught in the conventional manner performed better on the researcher-created examinations than those taught in the constructivist manner. However, on the delayed post-test, students in the constructivist classroom showed improvement while those in the conventional classroom showed a decline. Constructivist pedagogy resulted in improved long-term memory retention for students. Using tests designed by the researchers and based on the content covered in class, Bimbola and Daniels (2010) found that the results for 120 students in junior high school varied. Tests administered immediately after instruction and a few days later revealed that students who had been taught using constructivist strategies fared better than those who had been instructed using traditional lecture approaches. As a result, constructivist approaches led to greater knowledge retention and comprehension than lecturing. Both studies suggested that this type of constructivist instruction might boost students' performance.

Further, Granas (2006) found the same thing when he applied the same quantitative approach to algebra lessons in ninth grade. When comparing the effects of the two approaches on student accomplishment as judged by a standard end-of-course exam, she found no significant difference. It was shown, however, that pupils in student-centered classrooms outperformed those in teacher-centered classrooms on open-ended assignments. When discussing how teachers' lessons should be evaluated, the author brought up the issue of testing. Andam et al. (2015) conducted an analogous study with a sample of 40 high school students in Ghana; their goal was to apply the constructivist learning approach as an intervention to improve students' conceptual knowledge of the concepts of solving linear equations. Based on a descriptive study of test scores, it appears that teaching linear equations with a constructivist approach helps students grasp the concepts behind solving linear equations in one variable. Student academic performance also improved, as evidenced by the findings.

METHODOLOGY

Research Design

For this study, the researchers opted for an action research design. It's a thorough inquiry into school culture, pedagogy, and student achievement that's conducted by educators for educators (Shanks, Miller & Rosendale, 2012). The teacher can assess the success of his or her lessons by engaging in the practices of observation, listening, evaluating, questioning, and

a genuine interest in expanding one's own knowledge (Gyan et al., 2021). The goal of collecting this information is to better understand the learning environment in schools and educational practices in general so that we can make meaningful changes that improve student outcomes.

Population, Sample and Sampling Procedure

The Wiawso College of Education in the Sefwi Wiawso municipal was the site of the study. A purposive sampling technique was used to select the population of the study. There are currently 579 level 200 pre-service teachers enrolled at the college, which served as the population of the research since they have covered a lot of the mathematics courses in the curriculum. Convenience sampling was employed in this study to select the sample. In total, 52 pre-service teachers from a level 200 math/science class participated in the study (41 males and 11 females). All of the students in the single math/science class took part in the study. They were between the ages of 18 and 26, of varying mathematical abilities.

Instruments and Pilot Study

This study relied on a math achievement test created specifically for the purpose of the study. The pre-test, post-test, and quiz were used to collect quantitative data in order to determine the learning outcome of pre-service teachers, while a closed-ended questionnaire was used to collect quantitative data on students' views about the use of constructivist learning strategies. There was a total of 6 questions on the test (same number of questions for the pre-test, post-test, and quiz). The questionnaire consisted of 10 items that solicited information on pre-service teachers' views about teaching mathematics through constructivist pedagogy. Students' test scores were recorded after each test was graded out of a possible fifty (50) marks. The instrument was piloted in a college of education in the Debiso district with 27 pre-service teachers.

Validity and Reliability

An experienced mathematics senior lecturer and two other members of the researcher's department helped verify the accuracy of the test items. The concepts, skills, difficulty level, and clarity of the questions, as well as the language, all played a role in the test's validation. The feedback and suggestions from the experts were used to fine-tune the assessment tools. The reliability coefficient, which was calculated using the Cronbach Alpha method, came out to be 0.82. This rating is excellent, indicating a high degree of instrument reliability.

Data Collection Procedure

After giving out the pre-test, the author noticed that the majority of the pre-service teachers scored below the average on a test measuring their ability to solve mathematical problems based on the content they had already covered. To address the challenges, the author designed a set of intervention activities for the students to participate in using the constructivist learning approach, and then gave them a post-test to evaluate their progress in overcoming the identified difficulties. Their scores in both the pre-test and post-test were recorded for analysis. A quiz was conducted eight (8) weeks after the post-test to measure the pre-service teachers' learning outcomes with regard to solving mathematical problems. The quiz was conducted after several different topics had been covered with the students. The time gap was conceived to find out the retention of the pre-service teachers after learning through a constructivist approach to solving mathematical problems. The results of both the post-test and the quiz were recorded for further analysis. In an effort to get their feedback on the constructivist approach to education, the researcher handed out questionnaires to participants after the test. Forty-five (45) minutes in total were spent on the distribution and collection of the questionnaire.

Intervention Activities

Interventions are design activities implemented on a regular basis by researchers in an effort to accomplish their objectives. Academic success can be enhanced or improved through the use of a wide variety of strategies, and the focus of the research is on constructivist learning approaches such as using video lessons, manipulatives, mix-pair share, think-pair share, and rally tables were implemented to teach different mathematics concepts. The researcher conducted the interventions for one month.

Data Analysis Techniques

The study employed descriptive and inferential analysis techniques in representing the research findings. The pre-test, post-test, and quiz data collected from learning outcomes were analysed using Statistical Package for Social Science (version 20) software, and the findings were presented in frequency, mean, standard deviation, and t-test. All the pre-service teachers participated in the close-ended questionnaire after the quiz, and the results were analysed using the frequencies and percentages.

RESULTS AND DATA ANALYSIS

The pre-service teachers' data was analyzed using the statistical package for social science (SPSS) software version 20. Descriptive statistics and a paired sample t-test were used to analyze the data to determine the level of the impact of the interventions.

The effect of teaching mathematics using constructivist learning approach on pre-service teachers' achievement

Tables 1 shows the frequencies and percentages of the respective scores for the math/science pre-service teachers in both pre-test and post-test.

Table 1: Comparing Pre-test scores and Post-test Scores for Math/Science Class

Scores	Pre-test Frequency	Pre-test Percentage (%)	Post-test Frequency	Post-test Frequency (%)
1 – 10	18	34.6	0	0
11 – 20	24	46.2	11	21.2
21 – 30	8	15.4	13	25.0
31 – 40	2	3.8	19	36.5
41 – 50	0	0	9	17.3
Total	**52**	**100**	**52**	**100**

A careful observation of Table 1 indicated that the pre-service teacher's performance was abysmal in the pre-test, which shows clearly that they lack an understanding of the basic concepts and principles of mathematics, and therefore they were not able to use appropriate strategies and principles in finding solutions to the mathematical problems. However, after the intervention activities, the post-test scores from Table 1 showed a tremendous improvement in the performance of the students in relation to the questions administered to them, and this was evidence of the good use of the constructivist learning approach through the numerous activities that the pre-service teachers were taken through.

The researchers undertook inferential analysis of the pre–test and post–test, and the data used for this analysis were the scores obtained by the students on both tests. Table 2 indicates the mean and standard deviation of the paired samples.

Table 2: Paired Samples Statistics of Pre-Test and Post-Test Scores

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	14.1923	52	6.77376	.93935
	Posttest	31.1923	52	8.88497	1.23212

The results showed that the post-test scores were higher than the pre-test scores. The mean scores of the pre-test and post-test were 14.1923 and 31.1923, respectively, resulting in a mean difference of 17.0, indicating an appreciable difference. This demonstrated that pre-service teachers improved in their learning achievement during the post-test. And this was attributed to the intervention processes the researchers took the students through.

Table 3: Paired T-Test analyses of means of Math/Science class

	Mean	Std Deviation	T	Df	Sig (2-tailed)
Pre-Test& Post Test	-17.0	8.6	-14.3	51	0.0000

A paired-samples t-test in Table 3 indicated a test statistic of -14.1 and a p-value of 0.000 with 51 degrees of freedom. The two-tailed p-value of 0.000 is far less than the conventional 0.05 level of significance. There is therefore enough evidence to conclude that there is a significant difference between the pre-service teacher's pre-test and post-test mean scores. The results suggest that the constructivist learning strategies employed during the intervention increased pre-service teachers' achievement in mathematics.

The retention of mathematical concept among pre-service teachers after learning through constructivist approach

After the pre-test, intervention (using a constructivist learning approach) and the post-test to measure the students' achievement in mathematics, a quiz was conducted eight (8) weeks after the post-test. The quiz was conducted after several different topics had been treated with the pre-service teachers. The idea of the time lapse was to find out the retention of knowledge among the pre-service teachers in the areas treated under the intervention. The post-test items were used for the quiz in order to ensure consistency in the test. Table 4 shows the frequencies and percentages of the respective scores for both the post-test and the quiz.

Table 4: Comparing Post-test scores and Quiz Scores for Math/Science Class

Scores	Post-test Frequency	Post-test Percentage (%)	Quiz Frequency	Quiz Frequency (%)

1 – 10	0	0	0	0
11 – 20	11	21.2	12	23.1
21 – 30	13	25.0	14	26.9
31 – 40	19	36.5	18	34.6
41 – 50	9	17.3	8	15.4
Total	**52**	**100**	**52**	**100**

Table 4 showed no major change in the performance of the pre-service teachers in relation to the solving of the quiz administered to them. This showed that the use of a constructivist learning approach had a positive effect on the retention of mathematical concepts among pre-service teachers at the 200-level. Table 5 indicates the mean and standard deviation of the paired samples (post-test and quiz).

Table 5: Paired Samples Statistics of Post-test and Quiz Scores

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Posttest	31.1923	52	8.88497	1.23212
	Quiz	30.6923	52	6.59497	1.03002

From Table 5, the mean scores of the post-test and quiz were 31.1923 and 30.6923, respectively, resulting in a mean difference of 0.5, indicating no appreciable difference. Since there was no statistically significant difference between post-test and quiz scores, this suggests that students retained a high level of knowledge regarding the mathematical concepts covered during the interventions. This is due, once again, to the researchers' intervention procedures that they made the students go through.

Table 6: Paired T-Test analyses of means of Math/Science class

	Mean	Std Deviation	T	Df	Sig (2-tailed)
Posttest & Quiz	-0.5	6.3	-1.8	51	0.097

A paired-sample t-test in Table 6 indicated a test statistic of -1.8 and a p-value of 0.097 with 51 degrees of freedom. The two-tailed p-value of 0.097 is far greater than the conventional 0.05 level of significance ($p>0.05$). There is therefore enough evidence to conclude that there is no significant difference between the pre-service teacher's post-test and quiz mean scores. There is therefore a clear indication that there is good retention of mathematical concepts among pre-service teachers when they are taught with constructivist learning strategies.

The views of pre-service teachers about using Constructivist approach in learning mathematics

The pre-service teachers' general views about learning through a constructivist approach in solving mathematical problems were collected through the administering of a close-ended questionnaire after the post-test was conducted. The opinions of the pre-service teachers are presented in Table 7 below.

Table 7: Summary of pre-service teachers responses of the questionnaire

Statement	Always	Sometimes	Not at all	Total
	N (%)	N (%)	N (%)	N (%)
The constructivist strategies made the lessons very interesting.	46(88.5)	6(11.5)	0(0)	52(100)
The concepts are well explained in the lessons delivered through constructivism	42(80.8)	8(15.4)	2(3.8)	52(100)
I was able to follow the lessons with understanding	40(76.9)	10(19.3)	2(3.8)	52(100)
I was able to solve the practice question in the lessons	45(86.5)	7(13.5)	0(0)	52(100)
I was able to solve more try questions after the lessons	44(84.6)	6(11.6)	2(3.8)	52(100)
I was able to make contributions during class discussions	38(73.1)	12(23.1)	2(3.8)	52(100)
There were active class discussions that made me understand certain concepts better	40(76.9)	12(23.1)	0(0)	52(100)
The tutor's explanations in class were useful	50(96.2)	2(3.8)	0(0)	52(100)
Learning through constructivism made the	46(88.5)	6(11.5)	0(0)	52(100)

lessons very interactive				
The lessons were enjoyable, and I wish such teaching methods can be employed by other subject tutors	43(82.7)	9(17.3)	0(0)	52(100)

Table 7 provides the summary of responses from the pre-service teachers. The purpose of the questionnaire was to find out how pre-service teachers embraced the constructivist learning approach and the impact it had on their studies. For example, the first five questions revealed that pre-service teachers participate in engaging mathematics classes that enhance their understanding of fundamental mathematical concepts. The responses indicate that learning through a constructivist approach enhanced the mathematical problem-solving skills of pre-service teachers, thereby facilitating their assimilation of the concepts. The final five questions demonstrate how practical and interactive the classroom engagement was. The response demonstrates that pre-service teachers were engaged and contributed to the discussion, in contrast to the traditional approach of teaching, in which the teacher does most of the talking and students are reduced to passive recipients of pre-cooked information.

DISCUSSION OF RESULTS AND FINDINGS

The results of the present study justify that the incorporation of constructivist learning strategies helps students learn mathematics more effectively as they provide students with a conducive environment to learn and practice in stimulating ways. Data collected through the subject achievement of pre-service teachers disclosed that the post-test mean score of 31.1923 was significantly higher than the pre-test mean score of 14.1923, with a mean difference of 17.0000 and a significance value (P) of 0.00. These findings showed that there was an increase in the learning achievement of pre-service teachers in mathematics after the use of constructivist learning strategies. This result is consistent with research by Andam et al. (2015), who discovered that students who were taught using constructivist learning methods had higher test scores and more positive attitudes toward the subject. Similarly, Boadi et al. (2020) conducted research on the constructivist learning approach and concluded that it is effective in teaching students' mathematics, boosting self-esteem, and fostering social and collaborative abilities. This result is in line with the findings of Gyan et al. (2021), who found that the constructivist learning approach was more effective than the conventional teaching method in improving students' performance in the classroom. Also, this shows how important it is for math teachers to use a method called "constructivist learning."

However, a quiz was conducted to measure the retention or long-term impact of the intervention in comparison with the post-test results of pre-service teachers after 8 weeks of the intervention. The data analysed through the subject achievement of pre-service teachers disclosed that the post-test mean score of 31.1923 was not significantly higher than the quiz mean score of 30.6923 with a mean difference of 0.50 and a significance value (P) of 0.097. These findings revealed that there was good retention of mathematics concepts among pre-service teachers after the use of constructivist learning strategies. The findings are in tandem with Gatlin (1998), who compared two classrooms and found that students who were taught in the traditional/conventional way had poor retention of subject concepts, while students taught using constructivist methods had greater learning retention of the concepts. The finding also correlates to the studies conducted by Bimbola and Daniels (2010) and Mensah et al. (2022), which concluded that the teaching methods that promote active interactions among students, such as the constructivist learning approach, are more effective and improve learners' retention of mathematics concepts and academic success. To a similar extent, Arthur, Asiedu-Addo, and Assuah (2017) acknowledged in their research that using innovative pedagogical strategies that engage students in the learning process improves students' conceptual understanding and, in turn, their ability to remember what they've learned. Further, this indicated that the use of a constructivist learning approach has improved the retention level of students, thereby improving students' conceptual understanding.

Finally, the finding from the analysis of results on the close-ended questionnaire reveals that using a constructivist learning approach not only increases students' achievement in general but also motivates them. The majority of the pre-service teachers affirmed that the constructivist learning approach enhanced their motivation to learn mathematics; the lesson was interesting, which got them participating actively; the constructivist approach was effective, which encouraged discussions; the constructivist approach aided them to answer the given examples and additional practice examples correctly; and they wished it would be used in teaching other subjects. This finding corroborates with the findings of Andam *et al.* (2015), who revealed that teaching mathematics through a constructivist approach encourages students' interest, promotes interaction and discussion, which improves students' problem-solving skills. Similarly, studies by Bryant (2009) and Ontario Ministry of Education (2007) revealed that constructivism assists students in developing a variety of methods of solving mathematical problems and, again, it enables students to develop a

positive attitude towards mathematics. So, you could say that a constructivist way of learning encourages both teacher-student and student-student interaction in the math classroom, gives students a better understanding of math and how it can be used in real life, and makes studying math more fun.

Major Findings

1. The constructivist learning approach had a positive impact on pre-service teachers' learning achievement since there was a significant difference between their pre-test and post-test scores in favor of the post-test results.
2. The constructivist learning approach had a positive impact on pre-service teachers by aiding good retention of mathematics concepts among them since there was no significant difference between their post-test and quiz results.
3. The constructivist learning approach gives pre-service teachers benefits such as enhancing active discussions and interactions that encourage their interest and better conceptual understanding, which leads to improved performance in mathematics.

CONCLUSION

The study concluded that the constructivist learning approach enhanced the mathematics performance of pre-service teachers. This is owing to the fact that pre-service teachers taught with a constructivist learning technique achieved significantly higher scores than their pre-test scores prior to the intervention. The statistical analysis revealed that the researchers' intervention actions improved the mathematical competency of the pre-service teachers. The intervention, which shifted from the recall of basic facts to interaction, effective discussions, doing, linking activities to the home, and creating a conducive environment, resulted in the pre-service teachers developing a more positive attitude toward mathematics and a strong ability to retain mathematical concepts in general. The use of constructivist learning strategies helps students understand the subject better compared to conventional learning methods. Thus, better and higher achievement could be continued, and the act of seeing mathematics as a difficult subject will be a thing of the past.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that college of education mathematics tutors should employ a constructivist learning approach in the teaching and learning of mathematics as it will enhance students' interest and performance in mathematics. Furthermore, mathematics teachers are encouraged and expected to explore instructional

strategies such as constructivism in the teaching and learning of mathematics, as it shifts the emphasis from teacher-centered to learner-centered. Lastly, a school-based workshop should be held annually to educate and train tutors on how to adopt and modify a variety of teaching and learning strategies.

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