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THE EFFECT OF ALGEBRA TILES MANIPULATIVE ON PRESERVICE TEACHER'S MATHEMATICS KNOWLEDGE IN TEACHING BASIC ALGEBRA

***Bashiru Amidu [1] Anas Seidu Salifu [2] Josephine Nyarko3**
[1] Tutor, Department of Mathematics & ICT, Atebubu College of Education
Corresponding Author: bashidow@yahoo.com
[2] Senior Tutor, Department of Mathematics & ICT, E.P. College of Education, Bimbilla.
[3]Tutor Department of Mathematics & ICT, St. Monica College of Education

ABSTRACT: *The purpose of the study was to examine the effect of algebra tiles manipulative on pre-service teachers' achievement and also to investigate how the use of algebra tiles influence the pre-service teachers' achievements in basic algebra. The research design was quasi- experimental precisely pretest-post-test design. The population of the study was all level 200 PSTs of Ashanti and Brong-Ahafo Zone colleges of education with a sample of 119 pre-service teachers selected through purposive, convenient and simple random. The instruments used were test and interview for the collection of both quantitative and qualitative data. From the t-test analysis, there was statistically significant difference which favored the experimental group in the pre and post-test. Also, large effect size was noticed from the experimental group pre and post –test analysis. The pre-service teachers had positive views about algebra tiles manipulatives as a teaching material.*

KEYWORDS: Manipulatives, Algebra tiles, achievement, control group, experimental group

INTRODUCTION

The role played by mathematics in almost all areas of development in life cannot be underestimated. Mathematics serves as the backbone to all technological advancement in the world. There can be no meaningful development in this modern world of technological era without adequate and sufficient knowledge of mathematics. The study of mathematics enhances one's understanding of the world through the language of symbols and abstract representation of phenomena. It is a subject that is very important for the academic excellence of people irrespective of programme of study. Algebra is a topic that cuts across the curriculum because of its importance. In algebra, it is necessary to think not only a few numbers, but sets of numbers. For this reason, algebra seems more abstract than arithmetic (Palabıyık & Akkuş, 2011). Since algebra seems less concrete for PSTs, they find it difficult in school mathematics and they encounter serious obstacles in the mathematics learning process (NCTM, 2000). The difficulty comes from working with variables and their notations (Kieran &Chalouh, 1993). Edge and Kant (1992, as cited in Thornton, 1995) stated that words represent something that is touched or experienced, and therefore, learning a language is easy. Therefore, when you see a word like banana or computer, you can visualize it. On the other hand, they stated that learning mathematics is difficult because it is generally taught with no recognizable meaning. You cannot visualize anything when you see 2x or x^2 if you do not

know the meanings of the symbols. In this case, as Edge and Kant addressed, learning mathematics might be described as learning reading without knowing the meanings of the words. Hence, it can be said that "conceptualizing variables and manipulating them are key features of algebra learning" (Akkuş, 2004, p. 7).

Manipulatives could be the tools to make the algebra learning process meaningful and effective for Pre-service Teachers (PSTs) by providing a concrete base for learning. According to Hynes (1986), manipulatives are "concrete models that incorporate mathematical concepts, appeal to several senses and can be touched and moved around by PSTs" (p. 11). Manipulative use enables PSTs to transit from concrete thinking to abstract thinking (Fennema, 1973). Manipulatives enhance learning by providing PSTs with characteristics they can see, hear and touch, increase motivation of PSTs and lessens the rather fewer interesting characteristics of mathematics for PSTs. They are specifically useful when PSTs are introduced to new mathematical concepts (Kober, 1991). One type manipulative which is known to be effective is algebra tiles. Algebra tiles usually come with a small square, an oblong-rectangular strip, and a larger square. The tiles are purposely designed so that the side length of the larger square is not an integral multiple of the side length of the smaller square" (Chappell & Strutchens, 2001, p. 20). They can be used to model several mathematical processes in basic algebra concepts and help PSTs visualize and conceptually understand these processes (Brahier, 2016). Moreover, adding, subtracting, multiplying and dividing integers; completing the square; factoring and distributive property can be taught by using algebra tiles (Leitze & Kitt, 2000).

Algebra tiles are used to visualize operations with mathematical expressions including variables and numbers (Karakırık & Aydın, 2011). They enable PSTs to figure out mathematical problems algebraically. With the help of algebra tiles, PSTs can visualize polynomial operations, solve equations (Heddens & Speer, 2001 as cited in Saraswati, Putri & Somakim, 2016), have a better understanding of the concepts (Thornton, 1995), and learn the concepts meaningfully (Larbi & Okyere, 2016). They are able to reach the formal solution of linear equation with one variable easily with the help of algebra tiles (Saraswati, Putri & Somakim, 2016).

Algebra Tiles are a versatile manipulative that can be used by students to represent algebraic concepts beginning with integer arithmetic, continuing with activities involving linear expressions and equations, and ending with factoring and equation-solving for quadratics. They enable PSTs to state the rules of algebra from their own experiences (Okpube, 2016). Algebra tiles can easily be made by cutting the cardboards (Karakırık & Aydın, 2011). Teachers can create algebra tiles by themselves when resources are inadequate. Creating algebra tiles is inexpensive and they can easily be replicated. Algebra tiles provide geometric interpretation of symbol manipulation and combine algebraic and geometric concepts. Earlier studies about algebra tiles were conducted with middle school PSTs to teach solving linear equations with one variable (Magruder, 2012; Saraswati et al., 2016) or with high school PSTs to teach factoring by using algebra tiles (Sharp, 1995; Thornton, 1995). In addition, there are some studies about using algebra tiles in polynomial multiplication (Goins, 2001; Johnson, 1993).

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LITERATURE REVIEW

Using algebra tiles increase treatment group's scores of PSTs with learning disabilities in Castro's (2017) pretest-posttest control group design experimental study. Using algebra tiles have also been found to assist PSTs when they make geometric connection to factoring polynomials (Schlosser, 2010). In the same way, while teaching solving quadratic equations by completing a square, using algebra tiles help PSTs build connections between algebraic and geometric concepts (Vinogradova, 2007).Use of algebra tiles increase treatment group PSTs' understanding in mathematics learning process compared to control group in Larbi (2011)'s experimental study. Saraswati et al. (2016) found that algebra tiles helped PSTs find the formal solution of linear equation with one variable.

In a study by Goins (2001) which examined the effects of using algebra tiles on students' polynomial multiplication used 30 students as the sample found that there was no significant difference between the non-visual and non-manipulative and the visual methods of instruction. Goins's study concluded that the use of manipulatives had a positive effect on students learning the algorithm of multiplying binomials. Again, Yuan, Lee, and Wang (2010) quasi-experimental study examined physical techniques involving manipulatives and virtual manipulatives in solving polynomials with 68 participants. In their study the treatment group used the virtual manipulatives while the control group used physical manipulatives. Their conclusion was that there was no significant difference between the treatment group and the control group. Similarly, White (2012) results revealed no significant difference in post-test scores between low-achieving control versus low-achieving experimental, high-achieving control versus high achieving experimental when 145 seventh-grade students used hands-on learning and manipulatives with quasi-experimental non-equivalent control-group design. Also, in a study by Cabonneau, Scott, and Selig (2013) in a math retention study found that students who were taught with algebra tiles achieved better performance than those their counterparts who did not use the algebra tiles in the post-assessment but there was no statistically significant difference between the groups. Çaylan (2018) study investigated the effects of using algebra tiles on sixth grade students' algebra achievement, algebraic thinking and views about using algebra tiles. The result of the study revealed that the experimental group performed better than the control group and even though there was no significant difference in their post-test scores means. There was positive effect on the students' algebraic thinking while using the algebra tiles. The students further stated that the tiles helped them learn meaningfully and understand the concepts better because the lessons was enjoyable.

Magruder (2012) study compared concrete and virtual manipulatives in solving simple linear equations with a total of 60 students comprising 20 in the control group, 20 in the virtual group, and 20 in the concrete group. Magruder study used an embedded quasi-experimental mixed methods research and concluded that there was a statistically significant difference in favor of the control group because it takes more time to learn how to operate the manipulative and to learn mathematics content. In a similar study in Nigeria by Aburime (2007) indicated a significant difference between the experimental groups and the control groups which favored the experimental groups. Aburime's study used 287 high school students in a 10-week mathematics manipulatives study. Morris (2014) study used 12 fourth-grade students' as the participants when impact of virtual manipulatives mathematics performance in adding and subtracting three- to six-digit whole numbers was investigated. The study used three groups, one

treatment and two control groups. The treatment group used virtual manipulatives, and of the two control groups used pencil, paper, and worksheets, and the other used concrete manipulatives. The results showed that all the three groups improved in their post-test but the significant improvement came from those who used the virtual manipulative. Akpalu, Adaboh and Boateng (2018) study examined the effects of algebraic tiles on Senior High School (SHS) students' conceptual understanding of a system of two linear equations. Their study used achievement test as the main instrument during the data collection. Their study also used simple random sampling technique in selecting 70 students equally to experimental and control groups. Per the result, there was a statistically significant in the post-test scores in favor of the experimental group who were taught using the algebraic tiles for four weeks.

Doias (2013) used seventh-grade mathematics 44 students as the subjects with 22 both in the experimental and control groups. The study used mixed methods approach to examine the effects of manipulatives (concrete and virtual) on teaching addition and subtraction of fractions over a two-week, eight-day period. The pretest and posttest, and the researcher's observations and student questionnaires were the instruments used to triangulate the data. The results showed that the combination of concrete manipulatives with virtual manipulatives increased students' performance. Allen (2007) study used pattern blocks manipulatives to understand the relationship of interior angles in polygons. The results revealed that students' achievement and understanding of mathematics increased, and their dispositions toward mathematics improved while using manipulatives. The study used 22 fifth-grade as the subjects over a three day period in a program entitled Everyday Mathematics.

Statement of problem

Pre-service teachers face so many difficulties in studying college mathematics where algebra is compulsory course which involves solving linear equations. There are recommendations from the new bachelor of education curriculum for 2018 for teachers to improve upon the usage of manupulatives including algebra tiles because students performance in algebra is poor which has always being highlighted by chief examiners reports from the Basic education certificate examination through to colleges of education level. From the review of the literature there are few studies on the Ghanaian setting about algebra tiles. Hence these gaps must be filled by studies like this present study entitle "the effect of algebra tiles manipulative on pre-service teachers' mathematics knowledge in teaching basic algebra".

Purpose of the study

The purpose of the study was to examine the effect of algebra tiles manipulative on pre-service teachers' achievement and also to investigate the pre-service teachers' views about the use of algebra tiles in Algebra lessons.

Research Questions

The following research questions were formulated to guide the study.

1. Is there any significant difference in pre-test between the control and experimental group in achievement in basic algebra?

2. Is there any significant difference in post-test between the control and experimental group in achievement in basic algebra?
3. Is there any significant effect and difference in pre-test and post-test of experimental group in basic algebra?
4. What are the Pre-service teachers' views about the use of algebra tiles in algebra lessons?

Research Hypotheses

Ho1: There is no significant difference in pre-test between the control and experimental group in achievement in basic algebra?
Ho2: There is no significant difference in post-test between the control and experimental group in achievement in basic algebra?
Ho3: There is no significant effect and difference in pre-test and post-test of experimental group in basic algebra?

METHODOLOGY

The research design used for this study is quasi- experimental design, precisely the pretest-posttest design. The subjects are randomly selected for the groups with the convergence parallel mixed methods approach: this is a form of mixed methods approach in which the researcher converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem (Creswell, 2014). In this design, the investigator typically collects both forms of data at roughly the same time and then integrates the information in the interpretation of the overall results. This method is used because, contradictions or incongruent findings are explained or further probed in this design. The population of the study was all level 200 PSTs of Ashanti and Brong-Ahafo Zone colleges of education. From the population, a sample of 119 pre-service teachers was selected through purposive, convenient and simple random selection of the colleges, year batch, the control and the experimental schools, and classes. In this study, the convenient sampling technique was used in selecting 119 pre-service teachers (60 for control group and 59 for experimental group) sampled from two colleges of Education in the Ashanti and Brong-Ahafo Zone of the colleges of education. The sample composed of 81 (68.1%) females and 38 (31.9%) males. The choice of these colleges from the two different regions was influenced by such factors as proximity and time constraints and also to avoid contamination of treatment. Purposive Sampling technique was employed to select all second-year students offering method of teaching basic school mathematics as the sampling frame from which the sample, two intact-classes in each sampled schools were selected. The simple random sampling technique was used in selecting the experimental and the control groups in each of the schools. Two kinds of instrument were used by the researchers which were Mathematics Achievement Test (MAT) and interview. The Mathematics Achievement Test (MAT) adapted from (Çaylan 2016) composed of pre-test and post–test. The tests were administered to PSTs to collect data for the quantitative analysis while the interview response from 5 pre-service teachers served as the qualitative data. To ensure validity of the instruments, two tutors from each of the selected regions were given copies of the achievement test to assess the quality of each item in the context of clarity, ambiguity and generality. This was done in addition to using the recommended course outline for

colleges of education in Ghana. Suggestions received from the tutors were incorporated to refine the content of the MAT making it more relevant and suitable for the purpose of the study. The refined instruments were then pilot-tested in two different colleges in the northern zone of the colleges of educations in Ghana to estimate the reliability coefficient. The reliability coefficient of the Mathematics Achievement Test using the split-half method was 0.71 which is suitable to use since a classroom test can have a reliability coefficient of 0.7 or higher (Wells & Wollack, 2003).The results from the pilot test showed no significant difference between the two colleges. School A (M=18.59, SD=6.15) and school B (M=16.71, SD=7.62); t (51) =0.982, p=0.331. Since p=0.331> 0.05.

Descriptive statistics such as means, standard deviations, and percentages, were used to describe the general performance of students in both groups in the pre-test and post-test. The paired samples t-test was used to find whether the performance of students within each group improved or not while the effect size (eta statistic square) was used to determine the magnitude of improvement in each group using SPSS version 20. The purpose was to determine whether there were statistically significant difference between each student score in the pre-test and post-test. This is because the difference might occur by chance. According to Pallant (2001), the criterion for interpreting eta squared values are 0.0 = small effect, 0.06 = moderate effect and 0.14 = large effect.

Procedure and Treatment

Four weeks was used for the treatment of this intervention. Participants were given a pre-test during week one and followed by the intervention in week two through to week four.
The Pre-test was on writing of phrase in an algebraic expression, writing a phrase for a given algebraic expression, and evaluating algebraic expressions for different values of variables. This was administered to both the experimental and the control groups during the first week.

During the treatment, the experimental group was given instruction on the use of algebra tiles in solving algebraic problems was given to the students by the researchers before the study. Three objectives were accomplished within three weeks with the help of algebra tiles. These objectives were that, students should be able to:

(i) express the meaning of simple algebraic expressions: The teacher asked students to write different representations of given algebraic expressions individually. Students had difficulty in representing algebraic expressions including fractions. For this reason, the researchers gave some clues and asked leading questions. For example, *"How do we subtract fractions with same denominator?"* and *"How do we multiply fractions?"* After the students completed the activity, different students came to the board and explained results for each item in the activity sheet.

(ii) make addition and subtraction in algebraic expressions

For this objective three hours during the second week was allocated. Lessons included five phases as engagement, exploration, explanation, elaboration and evaluation respectively.
In the explanation part, the teacher explained how to make addition and subtraction in algebraic expressions and gave the definition of term, like term, constant term, and coefficient. The researcher wrote 2x+3 on the board and showed the terms, coefficients, constant term and variable of this

algebraic expression.In the elaboration part, algebra tiles were collected from the students and the activity sheet was distributed to them, and the teacher asked students to fill given table individually. After the students completed, the teacher asked students for correct answer in each blank sheet provided. Students said what they wrote and they discussed with their colleagues.
In the evaluation part, the exit card was distributed to the students. After they completed, they gave exit cards to the teacher while leaving the classroom.

(**iii) multiply an algebraic expression with a natural number respectively**.
Lessons included five phases as engagement, exploration, explanation, elaboration and evaluation respectively. In the exploration part, students were asked to work in pairs and algebra tiles were distributed to the pairs. The teacher stuck algebra tiles on the board to remind them and told students to model 3x by using algebra tiles. After the pairs modelled 3x, the researcher also showed the model on the board by sticking three red rectangle pieces. Next, students were asked to model multiplication of (x+1) by 2 by using algebra tiles. While pairs were modelling with algebra tiles, the researchers walked around the desks and helped students if they needed.

In the explanation part, researcher explained how to multiply an algebraic expression with a natural number. He said *"While multiplying an algebraic expression with a natural number, each term of the algebraic expression is multiplied with the natural number."* In addition, he explained multiplication by drawing arrows on the algebraic representations near the algebra tiles on the board again.

In the elaboration part, algebra tiles were collected from the students and the activity sheet was distributed to them and the teacher asked students to perform given multiplications individually without using algebra tiles. In addition, students were expected to determine whether given representations were correct or not, and to correct the incorrect ones. After the students completed activity for each item in the activity sheet, different students came to the board and explained results. In the evaluation part, the exit card was distributed to the students. After they completed, they gave exit cards to the teacher while they were leaving the classroom.

The control group was taken through the same objectives using the traditional method without the algebra tiles. Three objectives were accomplished within three weeks by regular instruction without using algebra tiles. These objectives were the same as the objectives covered in the experimental group. The objectives were:

(i) express the meaning of simple algebraic expressions
(ii) **solve addition and subtraction in algebraic expressions**
(iii) **multiply algebraic expression with a natural number.**

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RESULTS

Research Question 1: Is there any significant difference in pre-test between the control and experimental group in achievement in basic algebra?

Table1:Pre-test Scores showing the Comparability of the experimental and control group.

Group	N	Mean	Std. Dev.	t-value	df	p-value
Experimental Pre-test	60	8.92	3.855	-1.209	117	0.229
Control Pre-test	59	9.71	3.296			

Table 1 shows the independent samples t-test comparison of both control and experimental groups pre-test. An examination of the group means and standard deviations in the pre-test indicate that the control group (*M* =9.71, *SD* = 3.296) performed significantly higher on the pre-test than the experimental group (*M* =8.92, *SD* = 3.855), with $(t(117) = -1.209,\ 0.229 > 0.05)$. The difference favored the control group in basic algebra but it is insignificant, hence the null hypothesis is upheld. This implied that the mean pre-test score of the pre-service teachers in the experimental group is not significantly different from that of the students in the control group before the treatment. This could also be due to the criterion used in selecting students for programs and the methods used in teaching the leaners in the college.

Research Question 2: Is there any significant difference in post-test between the control and experimental group in achievement in basic algebra?

Table 2:1Results of Independent sample t-test of Pre-Service teachers post-test

Group	N	Mean score	Std. Dev.	t-value	*df*	P-value
Experimental post-test	60	24.60	1.669	21.37	86.573	0.00
Control post-test	59	14.47	3.170			

Table 2 indicates the means and standard deviations of the post-test scores of the two groups, which indicates a statistically significant difference in favour of the experimental group when the means were compared. The details of the Experimental group achievement after the treatment for 4 weeks is (M = 24.60, SD = 1.669) compared with control group achievement without the usage of the algebraic tiles with (M = 14.47, SD = 3.170). There was statistically significant difference because t (86.573) = 21.37, $p<0.05$. The null hypothesis is rejected because the difference in means is 10.13 which is enough to suggest that the treatment with algebra tiles had a positive effect on the experimental group that is by comparing it to their pre-test scores.

Research Question3: Is there any significant effect and difference in pre-test and post-test of experimental group in basic algebra?

The results of analysis of the effect of Algebra teaching approach on students' performance is presented in Table 3.

Table 3: Descriptive statistics of students Taught with Algebra tiles Teaching Approach

	Minimum	Maximum	Mean	Std. Deviation
Experimental Pre-test	3	19	8.92	3.86
Experimental Post-test	21	28	24.60	1.67

Table 3 compares the pre-test and post-test results of the PSTs within the experimental group. In the experimental group the results showed an improvement in Pre-service teachers understanding of basic algebra in the post-test. The minimum score students obtained in the pre-test was 3, while the maximum score was 19 out 30. However, in the post-test, the minimum score was 21, while the maximum score was 28. The mean score of PSTs in the pre-test was 8.92, while that of the post-test was 24.60, an increase of 15.68. This is an indication that in the post-test, every PSTs' performance had increased in the experimental group. This improvement in scores might be due to the use of the Algebra tiles approach of teaching basic algebra. To ascertain whether or not the difference observed in the means are statistically different, a paired samples t-test was conducted to compare the pre-test and post test scores to test the null hypothesis that there is no significant difference between the pre-test and post-test performance of PSTs taught with Algebra tiles method. Table 3 presents the results of the paired samples t-test on the pre-test and post-test performance of students taught with Algebra tiles method.

Table 4: Results of the paired samples t-test on the pre-test and post-test performance of experimental group who were taught with Algebra tiles method

	Mean	Std. Deviation	Std. Error Mean	*T*	*df*	Sig.	Eta square
Post-test – Pre -test	17.100	5.024	0.649	26.363	59	.000	0.935

A paired sample t-test was conducted to compare the pre-test and post test scores for the pre-service teachers taught with the Algebra tiles teaching approach (experimental group). The paired sample t-test was examined to find out if the mean score difference (M = 17.100, SD = 5.024) between the post-test and the pre-test of the experimental group was statistically significant. This was done to evaluate the effect of Algebra tiles on pre-service teachers' achievement in Basic Algebra. The results from Table 4 indicated a statistically significant increase in the pre-service teachers' achievement from the pre-test (M

= 8.92, SD = 3.86) to the post-test (M = 24.60, SD = 1.67), t (59) = 26.363, $p < 0.05$. The eta squared statistics (0.935) indicate large effect size. This means that 93.5% of the variance in the scores is the Mathematics Knowledge Test that is, the pre-test and the post-test of the experimental group was elucidated by the teaching method (Use of algebra tiles) for teaching. Also, the results imply that after the pre-service teachers had gone through the intervention, it had a large effect, meaning they improved massively in their understanding and achievement of the concept on basic algebra. Thus, Algebra tiles as an instructional tool had a positive impact on the Pre-service teachers' achievement in basic algebra.

Research Question 4: What are the pre-service teachers' views about use of algebra tiles in Algebra lessons?

Pre-service teachers' views about use of algebra tiles in Algebra lessons during the interview process

Researcher: What are your views about use of algebra tiles in Algebra lessons?

PST1: "Hmmm*, before the intervention I encountered a lot of* difficulty *at the beginning in solving linear equations, but as of now, I understand the concept better*. *Algebra tiles are significant manipulatives that can be used during field practicum to enhance pupil's performance in mathematics. I have enjoyed the intervention activities, so I can predict that pupils at the basic level will enjoyed better."*

Researcher: What are your views about the use of algebra tiles in Algebra lessons?

PST2: "Great, I *learnt better with the introduction of the algebra tiles because complicated operations were made easier for me during the intervention period, because I remember concepts easily. I know the value of manipulatives such as algebra tiles. For me using the algebra tiles did not only created fun, but helped me in comprehending the topic*".

Researcher: What are your views about use of algebra tiles in Algebra lessons?

PST3: *"For me learning with the algebra was slower. I still enjoyed the lessons by working with my colleagues in groups.* The use of the tiles *helped me and my group to understand the concepts and making algebra tiles for teaching is not difficult. I will make my algebra tiles right away for my on campus teaching practice.*"

Researcher: What are your views about the use of algebra tiles in Algebra lessons?

PST4: " Sir, learning i*n groups with algebra tiles helps a lot, because those who understood it will help we those perceived as slow learners. Hmmm, I was surprised that there is manipulative that can help me learn linear equations during on and off-campus teaching practice. Algebra tiles usage throughout the intervention has motivated me to like mathematics now. If all tutors were using manipulatives like this one then mathematics would have been seen as a practical subject than abstract. The algebra intervention introduction motivated me to participate actively during the sessions.*

Researcher: What are your views about use of algebra tiles in Algebra lessons?

PST5: *"*Algebra tiles *are amazing sir, it has increased my love for mathematics most especially algebra. I did not know that there was such an excellent manipulative. I must also say that it is more simper than Cuisenaire rods. The inventor of algebra tiles I guess was a great mathematician. Using algebra tiles helped me find more tricks, tactics, and methods and erase my misconception and perception about mathematics*. *The lessons were practical and every group participated actively hence the concepts were easily understood."*

From the interview interaction, the pre-service teachers generally stated that they had fun and enjoyed the usage of the algebra tiles. They again stated that it helps them in understanding the concepts of algebra and hence they were ready to use it during on and off campus teaching practice.

DISCUSSION OF RESULTS

For research question one, when the test statistics of the pretest of both the experimental and the control group was found, it revealed that the achievements scores of the Pre-Service teachers was below the average score of 10 which indicates that PSTs had some difficulty in understanding the basic concept of algebraic expression. This finding is in agreement with the works of Norton and Irvin (2007) and Seng (2010) who found that PSTs have difficulties in the use of the distributive property. However, the results in the study shows that PSTs in the experimental group performed better than their control group counterparts indicating that continual exposure of the PSTs to the use of algebra tiles in learning could alleviate their difficulty in the understanding of the concepts of basic algebra.

In reference to research question two, there was significant difference in achievement in post-test which favored the experimental group. This finding is consistent with previous studies by Akpalu, Adaboh and Boateng (2018), Aburime (2007), and Morris (2014) whose studies showed that experimental group outperformed the control group because of the usage of manipulatives in those studies. The experimental group learned concepts faster and remembered concepts easily during the intervention activities.

For the third research question, the achievement of the experiment group pre-test and post–test revealed a significant difference with a large effect size, meaning the algebra tiles has helped in improving the performance of the pre-service teachers greatly. This finding also corroborates with Akpalu, Adaboh and Boateng (2018), Aburime (2007), and Morris (2014) studies where students performances were enhanced with the usage of algebra tiles. Pre-Service teachers in the present study had never seen or used algebra tiles before. For this reason, they were surprised at first. At the beginning, some of them were confused which color-tile represented negative and which color-tile represented positive, and also which piece represented x and which piece represented 1. After they learned these representations, they did not have any difficulty in using them. In addition, Pre-Service teachers were willing to participate in the lessons and they were active while they were using algebra tiles. Even rather passive participants tried to model given algebraic expressions by using algebra tiles. These Pre-Service teachers participated in group works and pair works, and they also showed their models on the board. Most of the Pre-Service teachers

seemed to be having fun while using algebra tiles and they enjoyed through the lessons. They concentrated on learning algebraic expressions with algebra tiles.

From the interview interaction with the five pre-service teachers they indicated that the algebra tiles helped them to understand the concepts easily and hence they were ready to replicate the skills acquired during on and off campus teaching practice.

CONCLUSION

The usage of the algebra tiles helped the experimental group to outperform their control group counterparts in the post-test. Also, there was a massive improvement in achievements of the experiment group pre and post–test scores with large effect size. Finally, the pre-service teachers view on the algebra tiles usage was positive from the interview.

RECOMMENDATIONS

This study was conducted using only two colleges. This makes it difficult to generalize the results. However, the results and findings can be inferred to students of the same characteristic and to a large extent to improve on the method of instruction as far as teaching and learning of mathematics is concerned.

The following recommendations are made to guide the teaching of algebra and mathematics:

1. Algebra tiles should be used in teaching the distributive property to all students to enable them discover the discernable pattern in removing brackets from an expression. In doing this, emphasis must be laid on “process” and not “product”.

2. As much as possible, mathematics educators should use manipulatives such as algebra tiles for effective teaching of all the units in algebra in the school curriculum.

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