Effects of Mastery-Based Learning Approach on Pre-service Mathematics Teachers’ Geometry Performance in Volta Region Colleges of Education, Ghana

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Abstract This study investigated the effect of mastery-based learning approach on pre-service mathematics teachers’ performance in geometry in Volta Region Colleges of Education, Ghana. Two research questions and two hypotheses, evaluated at the level of .05 alpha, guided the analysis. The study had adopted a quasi-experimental approach for testing. Two colleges were sampled on purpose. Participated in this study was a group of 87 first years of the four year bachelor of education pre-service mathematics teachers program. Data was collected for the research before and after the treatment using multiple choice test items. The validated instrument had a reliability of 0.80. Data analysis was carried out using descriptive statistics (mean and standard deviation) and Covariance Analysis (ANCOVA). The study found that the use of mastery-based learning approach had a positive effect on the learning achievement of pre-service teachers as compared with the traditional method of teaching geometry and there was a slightly higher mean achievement scores in favor of the male. There was a significant disparity between the mean achievement scores of students exposed to mastery-based learning approach and traditional approach of teaching elementary geometry, both pre- and post-test. Also, the achievement score of male and female pre-service teachers taught using mastery-based learning methodology was not significantly different. The study recommended among others the adoption of mastery-based learning approach in teaching geometry, since it has proven to aid improved pre-service teachers’ learning achievement in geometry.

Keywords: mastery-based learning, geometry, traditional teaching approach, pre-service mathematics teachers


1. Background to the Study

Mathematical knowledge is an indispensable concept for meaningful development of every nation scientifically and technologically. According to [1], Mathematics is an essential instrument in the study of humanities, sciences and technology. Mathematics concepts are applied daily in our real-life situations to solving mathematical, scientific and technological problems. Mathematics serves as a foundation for other disciplines such as engineering, science, technology and others [2]. Mathematics is also a body of knowledge which opens the minds of individuals to rational reasoning, critical thinking, and creative thinking ability, deep focusing, accuracy and clarity of thought [3]. This points to the fact that the significance of mathematics can never be over emphasized in the total meaningful development of an individual. Similarly, [4] asserted that scientific and technological advancement of a country largely depends on the mathematical knowledge attainment of the citizens, which implies that pre-service teachers’ academic achievement remains incomplete without mathematical knowledge. Mathematics has also been described as a subject which affects all aspects of human life at different degrees [5]. Mathematics has also been recognized as an intellectually stimulating field affecting every facet of human activity such as politics, economics, science and technology [6].

Despite the importance accorded to mathematics due to its relevance and a subject that helps to develop all-round activities of mankind, students have continued to exhibit nonchalant attitude towards the subject. This nonchalant attitude towards mathematics was attributed to the method of teaching which mathematics teachers employ during classroom instruction [7]. This may suggest why [8] pointed out that the poor performance of students in mathematics has to do with non-concept mastery and the use of non-standard instructional techniques by mathematics teachers. The teaching and learning of
Mathematics involves concepts which are hierarchical in nature and most of these concepts are abstract. Mastery of mathematical concepts is very vital for success to be recorded in subsequent mathematical endeavor. Thus, a systematic building up of such a hierarchy of concepts and ideas are needed to be understood and linked together in order to build on one another. It is the mastery of mathematical concepts that paves way for integrated and spiral curriculum implementation.

Mastery-based learning approach (MLA) is an instructional approach in which learners are taught in order to demonstrate a deep understanding of a concept before proceeding to the next higher concept. MLA also entails that the instructor instructs units of learning and conducts formative test(s) to learners. This formative test is done at the end of instructing each unit to determine the readiness of the students for the next unit. Students who are adjudged to have mastered the unit of learning are provided with enrichment activities. On the contrary, students who are measured to have failed the formative test are supported with remedial instruction and tested again at the end of the instruction to determine their level of learning achievement on the specific concept(s). Researches [9,10] indicated that this cyclical process continuous until all students obtained a criterion of 80% and above scores in the formative test. This instructional approach in view of [11] puts emphasis on the perception that all students are potential achievers if provided with the appropriate time and an instructional approach that best suits their learning style. This further revealed that varied instructional approaches and time or durations of teaching are employed in mastery learning approach, depending on the outcome of the formative test.

Additionally, [12] noted further that mastery learning approach was found to have consisted of feedback on progress of learning through regular formative assessments, corrective activities for students which guides on how to remedy students’ learning difficulties, enrichment activities for students who mastered the unit learned to broaden or expand their knowledge and instructional alignment. The results from a research [9] on mastery learning strategy and learning retention, indicated that the mastery learning approach improved students’ learning retention and achievement as compared to the traditional method of instruction.

Findings also showed that the mastery learning approach had a positive impact on the learning output and retention of students compared with the traditional teaching approach [6,13]. Finally, [14] stressed that the mastery learning approach is not only effective in various levels of cognitive domain but also useful for maintaining concepts better than traditional teaching methods. Furthermore, the findings of [6] concluded that mastery learning approach was beneficial to both males and females students.

Geometry is a branch of mathematics that studies the various shapes or figures and their properties [15], it covers the study of plane and solid forms and their properties [16]. The study of geometry offers a rich source of representation for understanding arithmetic, algebraic and statistical concepts [17], it also provides a full comprehension of the universe in which we live, it appears natural in the structure of the solar system, a geological formation, rocks and crystals, plants, flowers and animals. Also, geometry forms part of synthetic world such as architecture, arts, machines and others [18]. It was further revealed that geometry develops students’ spatial awareness, intuition, and visualization as well as enhances students’ problem-solving abilities [19]. This branch of mathematics plays a crucial role in the development of students’ problem-solving skills and critical thinking [20] of which pre-service teachers should not be exempted. Geometrical knowledge therefore is applied in different professions such as engineering, architect, carpentry, building construction and others in taking critical decisions. This therefore makes it imperative that the mastery of the geometrical contents should be given priority in mathematics pre-service teachers’ education. Even though the usefulness of geometry cannot be undermined, researches have shown that students’ learning achievement in it is not satisfactory. Some of the factors responsible for students’ unsatisfactory learning achievement includes teachers’ method of teaching, non-availability of instructional materials and students’ inability to visualize [21,22,23]. It is against this background of students’ unsatisfactory learning achievement in geometry that the researcher investigates the effect of Mastery Learning Approach (MLA) on pre-service mathematics teachers’ achievement in geometry.

2. Statement of the Problem

The instructional approach employed in teaching mathematics in Colleges of Education contributes to the extent of pre-service teachers learning achievement in geometry. The instructional strategy adopted by most mathematics tutors in Colleges of Education, Volta Region is traditional approach. The most frequently used instructional strategy according to [24] was the traditional teaching approach of teaching in Colleges of Education. In the traditional teaching approach, the teacher is considered as the expert and authority in presenting information as well as the centre of classroom activities [25]. It is an approach that often does not allow students to express themselves and direct their own learning [26]. It was emphasized that the traditional teaching approach is such that students passively receive information from the teacher, whereas teacher focuses on transmission of knowledge which does not support the students’ personal growth [27]. The success of understanding mathematics concepts depends on the mastery of the pre-requisite mathematics concepts. It therefore becomes crucial that instructional approaches other than the traditional teaching approach should be employed to ascertain the efficacy of such approaches especially in teaching pre-service teachers who will go into the labor market in future to teach students mathematics at the primary and junior high school levels. The traditional teaching approach was also noted to have failed to meet the learning style of most students [28]. According to [29], students have not been performing satisfactorily in geometry. Considering the context of the study, there is an indication that many research work has been done on the use of mastery learning approach in mathematics teaching and learning,
and their results demonstrate the efficacy of the teaching and learning approach. However, very little or no research work of such has been done in Volta region Colleges of Education, Ghana.

Hence, there was therefore the need to consider an alternative instructional strategy such as mastery learning approach (MLA) in teaching mathematics (geometry) to most probably improve the learning achievement of pre-service teachers in Colleges of Education in Volta Region, Ghana.

2.1. Purpose and Objectives of Study

The study was aimed to investigate the effect of the mastery-based learning approach on pre-service mathematics teachers’ learning achievement in geometry. The study's key objectives were to;

1. Find out whether there is any difference between the performance mean score of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach.
2. Ascertain if there is any difference between the performances mean scores of the male and the female pre-service teachers taught geometry with mastery-based learning approach.

2.2. Research Questions

The research was driven by the following investigative questions;

1. What is the difference between the performance mean score of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach?
2. What is the difference between the performance mean scores of the male and the female pre-service teachers taught geometry with mastery-based learning approach?

2.3. Hypotheses

The researcher tested the following null hypotheses at 0.05 alpha level:

\[ H_{01}: \text{There is no significant difference between the performance mean score of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach.} \]

\[ H_{02}: \text{There is no significant difference between the performance mean scores of the male and the female pre-service teachers taught geometry with mastery-based learning approach.} \]

2.4. Design of the Study

In this research a quasi-experimental design has been employed. The design included the control group pre-test, post-test, non-randomized, and non-equivalent. The Mastery-based Learning Approach (MLA) and performance in geometry were the independent and dependent variables respectively. Table 1 illustrates the design of the research as shown below.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>EG</td>
<td>Q1</td>
<td>MLA</td>
<td>Q2</td>
</tr>
<tr>
<td>CG</td>
<td>Q1</td>
<td>TTA</td>
<td>Q2</td>
</tr>
</tbody>
</table>

Where:
\( EG = \) Experimental Group, \( X_{MLA} = \) Treatment with Mastery-based Learning Approach
\( CG = \) Control Group, \( X_{TTA} = \) Treatment with Traditional Teaching Approach
\( Q1 = \) Pre - Geometry Achievement Test
\( Q2 = \) Post - Geometry Achievement Test.

2.5. Population

The target population of the study consisted of all first-year pre-service mathematics teachers of the four-year Bachelor of Education (B.Ed) program for the Five (5) Education Colleges in the Volta Region, Ghana. The accessible population was made up of eighty-seven (87) pre-service teachers consisting of fifty-eight (58) males and twenty-nine (29) females.

2.6. Sample and Sampling Technique

Two (2) Colleges of Education were selected purposefully from the five (5) Colleges as the accessible population for the study. The two (2) Colleges were purposefully selected to enhance accessibility and proximity as well as willingness of participants to participate in the study. The simple random technique was used to obtain the control and the experimental groups for the study. The experimental group was made up of forty-six (46) pre-service teachers consisting of 31 males and 15 females. On the other hand, the control group was made up of 41 pre-service teachers consisting of 24 males and 17 females.

2.7. Instrument for Data Collection

The instrument used to gather study data was a performance measure created by a researcher. A 20 multi-choice test item was used to gather data before and after the treatments. The "Geometry Achievement Test (GAT)" instrument was entitled. Institute of Education, University of Cape Coast (UCC), Ghana, was the institution from which the GAT items were adopted. The University (UCC) is the organization of external examination of the chosen educational colleges. Each test item had three distracters and only one correct answer from the four options lettered A to D.

2.8. Validity of Instrument

The validity of the instrument was ensured through measuring geometrical concepts within the elementary geometry course outline, specified by UCC, Ghana for the selected students pursuing elementary geometry in the College of Education. The validity (face and content) were ensured by exposing the instruments to the head of mathematics and Information and Communication department and one other mathematics tutor.
2.9. Reliability of Instrument

The instrument’s reliability has been checked with test-retest process. The test-retest approach employed a sample from the target population rather than the accessible population. The test items were administered to the sample twice at an interval of two weeks. When the results of the tests were subjected to the test-retest reliability test, a reliability coefficient of 0.80 that indicates the instrument was reliable was obtained.

2.10. Data Collection Procedure

Detailed lesson plans were written by the researcher in geometry (precisely, geometrical construction). The mathematics tutor in the experimental group was trained on the theoretical and practical aspects of mastery-based learning approach to teaching geometry before the treatment began in the group. The mathematics tutors in both the experimental and the control groups used the same lesson plans developed by the researcher but implored different methods of teaching. Whereas the experimental group’s mathematics tutor used the mastery-based learning approach, the mathematics tutor for the control group used the traditional teaching approach. The test items (Pre-GAT) were administered at one time to both the experimental and the control groups to prevent leakage of the questions between the two groups under relatively the same condition of examination. The two different groups were treated with the two methods by their mathematics tutors at different times. Implementation of the lesson plans were undertaken at various times to allow the researcher to be in the company of the mathematics tutors in both the experimental and the control groups at the treatment sessions to ensure that the preferred methods (thus mastery-based learning method and traditional instructional method) and the lesson plans were conducted as expected. After the treatment the two groups were examined using the Post-GAT. The scripts of the PRE-GAT and POST-GAT of the pre-service teachers were marked over one hundred, collated and subjected for analysis using the Statistical Package for Social Sciences (SPSS) version 24.

2.11. Method of Data Analysis

The data collected was evaluated descriptively and inferentially from the pre-test and the post-test. Descriptive statistics (mean and standard deviation) were used to address the research questions and Covariance Analysis (ANCOVA) was used to evaluate the hypotheses at the level of .05 alpha.

3. Results

Research question 1: What is the difference between the performance mean score of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach?

Table 2 showed the mean and standard deviation on the performance of pre-service mathematics teachers taught geometry with and without mastery-based learning approach.

Table 2. Mean and standard deviation on the difference in the performance of pre-service mathematics teachers taught geometry with and without mastery-based learning approach.

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test Mean</th>
<th>Pre-test SD</th>
<th>Post-test Mean</th>
<th>Post-test SD</th>
<th>Gain Mean</th>
<th>Gain SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLA</td>
<td>36.20</td>
<td>14.22</td>
<td>89.67</td>
<td>15.05</td>
<td>53.47</td>
<td>16.43</td>
</tr>
<tr>
<td>TTA</td>
<td>34.15</td>
<td>12.13</td>
<td>58.90</td>
<td>14.07</td>
<td>24.75</td>
<td>8.09</td>
</tr>
</tbody>
</table>

Research question 2: What is the difference between the performance mean score of the male and the female pre-service teachers taught geometry with mastery-based learning approach?

Table 3 showed the mean and standard deviation on how the performance of the pre-service mathematics teachers taught in the experimental group differ by gender.

Table 3. Mean and standard deviation on the performance of male and the female pre-service mathematics teachers taught geometry using MLA in the experimental group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Gender</th>
<th>Pre-test Mean</th>
<th>Pre-test SD</th>
<th>Post-test Mean</th>
<th>Post-test SD</th>
<th>Gain Mean</th>
<th>Gain SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>37.10</td>
<td>14.21</td>
<td>91.13</td>
<td>15.21</td>
<td>54.03</td>
<td>18.45</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>34.33</td>
<td>14.50</td>
<td>86.67</td>
<td>14.40</td>
<td>52.34</td>
<td>14.10</td>
</tr>
</tbody>
</table>

Table 3 showed the mean and standard deviation on how the performance of the pre-service mathematics teachers taught in the experimental group differ by gender. From Table 3, it was revealed that the male pre-service teachers in the experimental group that were taught geometry with mastery-based approach had a mean gain performance of 54.03, SD = 18.45 while their female counterpart in the same group had a mean gain performance of 52.34, SD = 14.10. This result indicated that the male pre-service teachers performed better than the female pre-service teachers in the experimental group.

H_0: There is no significant difference between the performance of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach.

Table 4 showed the summary of ANCOVA on the difference in the performance of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach. The result in Table 4 showed that there was a significant difference in the performance of pre-service mathematics teachers that were taught geometry with mastery-based learning approach and those that were taught with traditional teaching approach (F1, 84 = 65.573, p<.05). The null hypothesis one, H_0 was therefore rejected at 0.05 alpha level.
Table 4. Summary of ANCOVA on the difference in the performance of pre-service mathematics teachers taught geometry with MLA and those taught with TTA

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>15917.616⁶</td>
<td>2</td>
<td>7958.808</td>
<td>51.679</td>
<td>.000</td>
</tr>
<tr>
<td>Intercept</td>
<td>14880.985</td>
<td>1</td>
<td>14880.985</td>
<td>96.627</td>
<td>.000</td>
</tr>
<tr>
<td>PRETEST</td>
<td>5215.051</td>
<td>1</td>
<td>5215.051</td>
<td>33.863</td>
<td>.000</td>
</tr>
<tr>
<td>GROUP</td>
<td>10098.471</td>
<td>1</td>
<td>10098.471</td>
<td>65.573</td>
<td>.000</td>
</tr>
<tr>
<td>Error</td>
<td>12782.384</td>
<td>84</td>
<td>154.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>288850.000</td>
<td>87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>28700.000</td>
<td>86</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table 5. Summary of ANCOVA on the difference in the performance of the male and the female pre-service teachers taught geometry with mastery-based learning approach

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>2125.035⁶</td>
<td>2</td>
<td>1062.518</td>
<td>5.589</td>
<td>.007</td>
</tr>
<tr>
<td>Intercept</td>
<td>21035.979</td>
<td>1</td>
<td>21035.979</td>
<td>110.648</td>
<td>.000</td>
</tr>
<tr>
<td>PRETEST</td>
<td>1504.459</td>
<td>1</td>
<td>1504.459</td>
<td>7.913</td>
<td>.007</td>
</tr>
<tr>
<td>SEX</td>
<td>626.910</td>
<td>1</td>
<td>626.910</td>
<td>3.297</td>
<td>.076</td>
</tr>
<tr>
<td>Error</td>
<td>8745.373</td>
<td>43</td>
<td>190.117</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>215950.000</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>10870.408</td>
<td>45</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. GROUP = PB

**H₀₂:** There is no significant difference between the performance of the male and the female pre-service teachers taught geometry with mastery-based learning approach.

Table 5 showed the summary of ANCOVA on the difference in the performance of the pre-service mathematics teachers in the experimental group that were taught geometry with mastery-based learning approach by gender. The result from Table 5 revealed that there was no significant difference in the performance of the pre-service mathematics teachers in the experimental group taught geometry with mastery-based learning approach by gender (F₁, 43=3.297, p>.05). The null hypothesis two, H₀₂ was therefore retained at 0.05 alpha level.

4. Discussion of Findings

**Performance of pre-service mathematics teachers taught geometry with mastery-based learning approach and those taught with traditional teaching approach**

The result in Table 2 indicated that the pre-service mathematics teachers in the experimental group who were taught geometry with mastery-based learning approach outperformed those who were taught with the traditional teaching approach. The finding specifically revealed that those taught using mastery-based learning had learning gain of 28.72 more than those taught with the TTA. This showed that the MLA had the capability of improving the performance of pre-service teachers in geometry. When put to statistical test, the finding in Table 4 indicated that there was a significant difference between the performance of pre-service teachers taught geometry with MLA and those taught with TTA. This led to the rejection of null hypothesis one (H₀₁) at .05 alpha level. This present finding is in agreement with the previous finding of [6,13] which examined the relative effectiveness of mastery-based learning on students’ academic performance and retention in mathematics and established that the mastery-based learning approach was more effective than the traditional teaching approach. It is also in agreement with the previous findings of [9].

**Performance of the male and the female pre-service teachers taught geometry with mastery-based learning approach**

The finding in Table 3 showed that the male pre-service mathematics teachers that were taught geometry using MLA in the experimental group performed better than their female counterpart in the same group. The finding specifically revealed that the male teachers had learning gain of 1.69 more than the female pre-service teachers. This difference in the learning gain of the male and the female pre-service teachers indicated that the MLA had the capability of improving the performance of both group of teachers in geometry. The finding in Table 5, when put to statistical analysis of the data, indicated that there was no significant difference between male and female pre-service mathematics teachers who were taught geometry using the MLA. Null hypothesis two (2), H₀₂ was therefore retained at an alpha level of .05. This
finding is in line with the earlier findings of [30,31,32,33] which investigated the impact of mastery learning approach on the academic performance and retention in circle geometry of senior school students and found the MLA to be very effective in improving performance and retention in mathematics. Also in line with this finding are the result of [6,30] which concluded that mastery learning approach was beneficial to both males and females students.

5. Conclusion

This study concluded that the mastery-based learning approach has proven to be significantly effective in the enhancement of the performance of both the male and the female pre-service mathematics teachers in geometry.

6. Recommendations

The following recommendations were derived from the findings of this study:

1. Mathematics teachers may adopt the mastery-based learning approach in the mathematics classroom instruction. This is because the mastery-based learning approach helped the pre-service mathematics teachers to improve their performance in mathematics (geometry).

2. The pre-service mathematics teachers in Colleges of Education in Volta region specifically or Ghana in general may be trained on how to employ the mastery-based learning approach in their mathematics classrooms so that when they graduate from the College and get employed to teach in schools, they will be in a better position to teach using the approach to improve their students’ learning achievement in mathematics.

3. In-service training may be organized for college mathematics teachers to probably adopt mastery-learning approach as one of the alternative instructional strategies of teaching mathematics in Colleges of Education in Volta region of Ghana, since the approach has improved the learning achievements of pre-service mathematics’ teachers in geometry.

References


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