AN INVESTIGATION INTO THE EFFECTIVENESS OF THE MASTERY LEARNING STRATEGY IN TEACHING THE PROPORTION CONCEPT IN NIGERIAN SCHOOLS

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Abstract
The effectiveness of the Mastery Learning approach in enhancing the teaching and learning of the proportion concept in the schools was investigated. A pretest-posttest control group design was used for the study. The subjects for the study were four Hundred and twenty Junior Secondary I (JSSI) students drawn from six randomly selected schools in Ilesa area of Osun State. The experimental group was taught the proportion concepts using Bloom's Model of the Mastery Learning Technique, while the control group was taught using the non-mastery traditional method. The main instrument used in data collection was a 30-item multiple choice objective test called the Proportion Skill Test. The reliability coefficient of the instrument was calculated to be 0.74 using the Kuder-Richadson formula 21. A t-test Analysis of the post-test scores revealed that the mastery learning group performed significantly better than the non-mastery learning group in the test of competency in proportion concept both at the lower levels of cognition and the higher levels of cognition. Based on these findings, useful recommendations were made for the improvement of mathematics and science teaching in schools.

Introduction

The knowledge of proportion is crucial to every individual in nearly all facets of life, such as agriculture, economy, business navigation, building, and engineering. A farmer, for instance, may need the knowledge of proportion in calculating the number of seedlings needed for a plot of land or estimating the expected number of young ones from a breed of farm animal. In the business sector, proportional reasoning is indispensable in price systems. Market women and petty traders engage in proportional arithmetic frequently.

Besides the four basic operations that are fundamental to every other calculation, proportion is perhaps the most widely used mathematical concept. The mathematics students need to know proportion to understand different aspects of the mathematics curriculum. Knock (2017), for instance, found that students' varying capacity to reason in terms of proportion was closely related to their placement in Algebra and noted that students' proportional reasoning capacity could be enhanced in the context of algebra. The work of Knok is collaborated by that of Vanluydt et al. (2021), who opined that the proportion concept is an important aspect of the elementary mathematics curriculum, which serves as the foundation for the learning of advanced mathematical skills such as algebra, geometry, and statistics, among others.

The knowledge of proportion is not only useful in understanding other mathematics concepts but also important to understanding many other topics, especially science topics, both at the elementary and advanced levels. Indeed, the students of science are perhaps in greater need of the knowledge of proportion than any other group of its users. Topics such as Boyle's and Charle's laws and calculations involving volumetric analysis, etc., either directly or indirectly require the knowledge of proportion. Lee(2020), particularly in his work for the Doctor of Philosophy degree at Columbia University, noted the importance of proportion reasoning to learning the chemistry topic Stoichiometry.

Works such as those by Calisici (2018) in Turkey, among others, have shown that students have difficulties in understanding the ratio and proportion concept and consequently have difficulty transferring the knowledge of the topics to other subject areas. Calisici (2018) specifically observed that students often have misconceptions about solving ratio and proportion problems by confusing the direction of the operation while reducing or expanding the number involved in the proportion. On the other hand, the mastery learning system of instruction has been found to be effective in enhancing the performance of students. Tan (2023), for example, found out that the mastery goal improved both the self-regulation and academic performance of Hong Kong secondary school students. Wang (2022) noted, particularly for mathematics, that mastery learning improved problem-solving skills and retention abilities among students, while Jones and Smith (2023) investigated mastery learning and found that it not only impacted positively on Science, Technology, Mathematics, and Engineering but enhance understanding of concepts in general. Indeed, the importance of mastery learning is not limited to science and mathematics alone but to

other areas, including arts and social sciences. Ramos et al. (2023), for example, found that the mastery learning system of instruction enhanced comprehension and long-term retention in Languages.

Works have been done generally by authors on ways by which the teaching and learning of mathematics could be improved (e.g., Akanmu et al. (2014), Iyamuremye et al. (2021), Godfrey et al. (2023). However, only a few have been specifically directed toward enhancing the teaching of the (ratio) and proportion concept. Those few, such as Tan (2023), Calisici (2018), Izzatin (2020), and Almond (2023), are even outside Nigeria. Furthermore, the mastery learning method of instruction as an effective method of imparting knowledge has also been verified by works such as Wang (2022) and Toheed and Ali (2019), all of which are outside Nigeria. The few works, such as those by Reuben and Ogheneakoke (2021) and Oginni et al. (2021), which are on mastery learning by Nigerian authors, are either not on mathematics or not mathematics topic specific. For example, the work of Oginni et al. (2021) was on the effect of mastery learning strategy on the performance of students in mathematics. Still, it did not have as its objective improvement of teaching and learning of any specific topic. The present traditional method of instruction does not take into consideration the individual differences in learners, which include differences in emotion and rate of learning, among others. Considering the foregoing background, it is therefore important that efforts be geared towards effective teaching of the concept in schools. The present study seeks to find out the effectiveness of the mastery learning technique in enhancing the performance of students in the mathematics topic, proportion in the Nigeria senior secondary schools

The Mastery Learning Approach

The mastery learning approach is a teaching-learning strategy that, through appropriate procedures, obtains feedback using the formative test mechanisms and applies immediate corrective measures to ensure a high level of mastery of the concepts at hand. There are different forms of the approach, but the most widely used is Bloom's Mastery Learning, which is based on Carrol's (1963) model that the degree of learning acquired by a learner is directly proportional to learning divided by the time needed for the learning.

Kadiri (2004), referencing the work of McNeil, noted the following as the basic elements of blooms mastery learning

1. The learner must understand the nature of the task to be learned and the procedure to be followed in learning it.
2. The specific instructional objectives relating to the learning task must be formulated
3. It is useful to break a course or subject into small units of learning and to test at the end of each unit

4. The teacher should provide feedback on the learner's errors and difficulties after each test.
5. The teacher must find ways to alter the time some students have available to learn.
6. It may be profitable to provide alternative learning opportunities
7. Student effort is increased when small groups of two or three students meet regularly to review their test results and to help one another overcome the difficulties identified through the results of the tests.

Bloom summarized details of the Carol model by stating that if aptitude can be predicted from the rate at which a learner learns rather than the level to which he could learn, then it should be possible to fix the degree of learning expected of learners at some mastery level.
In the mastery learning system, instructional contents are broken into small units with specific objectives to achieve in each unit clearly stated. Mastery levels for each unit are also set (e.g., 70%) such that students are allowed to move to the next unit only after attaining the mastery level set for the current units. Frequent diagnostic testing, guidance by the teacher, and ability grouping are some of the other varying features of the mastery learning technique. Oginni et al (2021) also noted that integrating into teaching, moving from simple to complex, concrete to abstract, and real to imaginary are parts of the features of the mastery learning instructional system.
The mastery learning approach to teaching is systematic, uses sequencing of learning, is diagnostic, and task-orientated. Hence, it is reasonable to expect that the mastery learning approach would enhance the teaching of the proportion concept in schools.

The mastery learning technique is an instructional strategy that has been widely used to enhance students' performance, mostly in the cognitive domain of learning. Isarameiya and Agbonghale (2018), for example, found out that Nigerian school students who were taught using the mastery learning strategy (MLS) performed better in a basic technology course than those taught by the direct instruction strategy (DIS). The duo also found that the female students taught by the MLS performed significantly better than their male counterparts taught by the same method. Yildiran and Aydin (2005), comparing the mastery learning techniques with the cooperative, competitive, and individualistic approach also found among others that the mastery learning strategy enhanced the attitude towards mathematics of junior high school students in Turkey.

Statement of the Problem

Works have been done generally by authors on ways by which the teaching and learning of mathematics could be improved (e.g., Akanmu et al. (2014), Iyamuremye et al. (2021), Godfrey et al. (2023). However, only a few have been specifically directed toward enhancing the teaching of the (ratio) and proportion concept. Those few, such as Tan (2023), Calisici (2018), Izzatin (2020), and Almond (2023), are even outside Nigeria. Furthermore, the

mastery learning method of instruction as an effective method of imparting knowledge has also been verified by works such as Wang (2022) and Toheed and Ali (2019), all of which are outside Nigeria. The few works, such as those by Reuben and Ogheneakoke (2021) and Oginni et al. (2021), which are on mastery learning by Nigerian authors, are either not on mathematics or not mathematics topic specific. For example, the work of Oginni et al. (2021) was on the effect of mastery learning strategy on the performance of students in mathematics. Still, it did not have an objective to improve teaching and learning of any specific topic.
The present study is carried out in Nigeria and investigates, specifically, the effect of the mastery learning instructional strategy on the performance of students in proportion concept.

Objectives

The specific objectives of the study are to
i. Determine the mean difference in the achievement scores of students taught using the mastery learning approach and the non-mastery traditional method
ii. find out the mean difference in the achievement scores of students taught using the mastery learning approach and the non-mastery traditional method at the different levels of cognition

Research Questions

The questions this study seeks to answer are:

i. What is the mean difference between the achievement scores of students taught using the mastery learning approach and the traditional non-mastery method?
ii. What is the mean difference in the achievement scores of students taught using the mastery learning approach and the non-mastery traditional method at the different levels of cognition?

Hypotheses

Two main hypotheses were formulated for the study.

Ho1: There will be no significant difference in the mean achievement scores of students taught using mastery learning approach and the non-mastery traditional method

Ho2: There will be no significant difference in the mean achievement scores of students taught using mastery learning approach and the non-mastery traditional method at the different levels of cognition.

Methodology

A pretest post-test control group design was used for the study. The design allowed the determination of the background of the subjects in the proportion content by analysing the student's performance in the pretest. Using the control group with the experimental group

also enables the determination of the mean difference in the post-test performance of the experimental group by comparison with the control group. The subjects consist of 420 Junior Secondary School1 [JSS1] students drawn from six randomly selected schools in Ilesa in Osun State, Nigeria. The sample was obtained by simple random sampling technique. To obtain the sample size of 210, the twenty-one existing Junior secondary schools in Ilesa were given code numbers on pieces of paper. These papers were then kept in a box, thoroughly mixed and six of them were picked at random one at a time. The six schools selected were, by a further process of simple random sampling, randomly assigned into two groups of three schools each. One group was randomly chosen as the experimental group and the other as the control group. Using the balloting procedure, two JSS I classes were selected for each school. With the assistance of the regular teachers in the schools, the purpose of the exercise was discussed with the students. This was intended to allay their fear as well as to encourage their seriousness with the exercise. Thirty-five students were randomly selected from each class This gave seventy students from each school so that each control and the experimental group had 210 subjects.

Instrument

The major instrument used in the study was a 30-item multiple-choice objective test called the Proportion Skill Test (PST). The PST was designed and validated by the researcher. It was made up of two sections. Section A consists of 20 questions that test mainly the lower level of cognition (knowledge and comprehension of the concept and simple applications). Section B consists of 10 questions that test the higher level of application of the idea of proportion but include the ability to solve proportion problems, make logical deductions, and interpret results from graphs of direct and inverse relations. The difficulty index of each item was calculated and found to fall around 0. 5, a value within the range of moderate difficulty index. This uniform difficulty index for the 30 items is an important condition for using the Kuder- Richardson formula 21. Hence, the reliability coefficient of the proportion skill test was calculated using the Kuder- Richardson formula 21 and was found to be 0.74.

Procedure

The researchers used the teachers of the experimental and the control group's schools. Each teacher was either a degree holder in mathematics Education or about to complete the part-time B.Ed degree. The teachers were given the content guides showing the unit areas around which teaching of the proportion concept was to be built. The teachers for the experimental group were trained in using the Mastery Learning Approach. Each period of instruction was to be composed of the sequence: introduction, the teaching of the unit at hand (with opportunity for class activities, including questions and answers), to be followed by the time allowed for questions from pupils in the area yet unclear, and finally time for practice

exercise in the area taught. The mastery test for each unit is taken after the unit. This usually was at the end of one or two instructional periods. The performance in the mastery test was assessed against a 75% minimum pass level. If less than 70% of the class attains this minimum pass level, the instruction cycle is repeated on identified areas of difficulties as may be prescribed by the diagnostic test. Progress is made to the next unit upon attaining the minimum pass level set. Even then, extra assignments, as well as on-the-lesson attention, are given to the weak students who are noted to be weak. The mastery test taken on each unit by all the experimental subjects was predesigned by the investigator and made available to the teachers. The non-mastery learning group (the control group) was taught using the usual traditional method. Each instructional period for this group also lasted 80 minutes and was similarly sequenced. The instruction, however, was devoid of mastery testing. The control group was kept occupied by practice exercises and assignments during the time of mastery testing of the experimental group.

Three instructional periods were spent per week. The experiment was carried out during the first three weeks of the students in JSI class when they were yet to learn new topics in mathematics. The period was also good for the study as it normally takes at least two weeks after resumption before the regular school work actively commences. On the first day of the three weeks, the 30-item Proportion Skill Test was administered to the subjects in all six schools as the pretest. The same test was administered as the post-test at the end of the three weeks of instruction. All the scripts in each case were collected and marked immediately after they were taken, and records of scores were kept. The summary of the results is shown in Tables 1, 2, 3, and 4.

Analysis and Results

The pre-test scores of the control and experimental group in the PST were subjected to t-test analysis to determine whether there were possible differences in the two groups' backgrounds. The result is presented in Table 1 below.

Table 1 ***Difference Between the Means of the Pretest of the Experimental and the Control Group in the PST***

Group	No of student	Mean	S.D	Computed t-value	Df	p
Experimental group	210	9.86	4.82	0.64*	418	>0.05
Control Group	210	10.13	3.69			

*Not significant at 0.05 level

The table shows that there is no significant difference between the means of the pretest scores of the control and experimental groups. That is, the two groups had the same background in proportion concepts prior to the study. The mean scores of 9.86 and 10.13 out of the maximum obtainable scores of 30 also indicate the two groups' poor background in the topic.

To test the first hypothesis, the post-test scores of the subjects in the PST were analysed using t-test statistics. The results are shown in Table 2. To test the second hypothesis, the difference in mean performance of the two groups was compared separately for sections A and B of the PST. The results are presented in Tables 3 and 4, respectively.

Table 2 ***Comparison of the Mean Post-Test Scores in the PST of the Experimental and Control Group***

Group	No of students	Mean	S.D	Computed t-value	Df	p
Experimental Group	210	18.42	4.20	9.87*	418	<0.05
Control Group	210	14.60	3.72			

*Significant at 0.05 level

The table shows a significant difference between the performance of the experimental and the control group taught using the mastery learning approach. That is, the students taught using the mastery learning performed better than those taught with a non-mastery approach.

Table 3 ***Comparison of the Mean Score of the Experiment and Control Group at the Lower Level of Cognition of the PST***

Group	No of students	Mean	S.D	Computed t-value	Df	P
Experimental Group	210	12.40	4.89	5.34*	418	<0.05
Control Group	210	10.08	3.97			

*Significant at 0.05 level

Table 4 Comparison of the Mean Score of the Experimental and Control Group at the Higher Level of Cognition of the PST

Group	No of student	Mean	S.D	Computed t-value	df	P
Experimental Group	210	6.02	3.80	4.00*	418	<0.05
Control Group	210	4.52	3.87			

*Significant at 0.05 level

Tables 3 and 4 indicate significant differences in the mean scores of the two groups. That is, the groups taught the proportion concept using the mastery learning approach performed better at both the lower and the higher levels of cognition than the group taught using the non-mastery approach.

Discussion of Findings

The study has shown that the mastery learning approach is very practical in teaching the proportion concept. It has proved to be significantly better than the traditional approach. This finding is similar to that of Vanluydt, Supply, Verschaffel, and Dooren (2021), which shows that students' mastery of mathematical language relating to the proportion concept before its teaching significantly enhances their understanding of the proportion concept. The finding also agrees with that of Oginni et al (2021), who found that the mastery learning strategy produced significantly better performance in mathematics than the conventional method of instruction.

Conclusion and Recommendations

The mastery learning approach enhanced students learning at higher levels of the cognitive domain. This finding is particularly significant as applying the concept of proportion at the various fields is more relevant to those higher levels. The knowledge of the proportion concept has been shown as one that the pupils would continuously need whether the JSS becomes their terminal education or they progress to further studies. It is, therefore, suggested that all teachers use the Mastery Learning Approach as a self-mandatory method in teaching the topic. The approach, because of its being time demanding (but not because of its technicalities) may not be plausible for every subject in the syllabus. It is, however, suggested for the use by mathematics and science teachers in teaching some vital topics or as a fall-back-upon whenever teaching objectives prove challenging to be achieved.

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