Effects of Mastery Learning Instructional Strategy on Senior School Students' Achievement in the Mole Concept

Bashirat T. Lamidi
University of Ilorin, Nigeria

Oloyede S. Oyelekan
University of Ilorin, Nigeria

Adekunle S. Olorundare
University of Ilorin, Nigeria

Abstract

Nigerian students have not been performing up to expectation in public chemistry examinations. One of the causes identified as being responsible for this is the teachers' use of inappropriate instructional strategies. This study was conducted to determine the effects of mastery learning instructional strategy on secondary school students' achievement in mole concept, a topic that has been empirically identified as contributing to the poor performance of candidates in School Certificate Chemistry. The study used a quasi-experimental design and followed the non-randomized, non-equivalent pre-test and post-test group design. Data were obtained from two intact classes in two purposively selected secondary schools in Ilorin South Local Government Area of Kwara State, Nigeria. The experimental group was taught the mole concept using mastery learning instructional strategy while the control group was taught using the conventional teaching method. The data obtained were analyzed using t-test and Analysis of Covariance (ANCOVA) with the pre-test and post-test scores as covariates. It was found that students taught using the mastery learning instructional strategy performed better (mean score 15.50) than their counterparts in the control group (mean score 7.04). Furthermore, gender had no significant effect on the achievement of the students taught using the mastery learning instructional strategy. Results also showed a statistically significant covariance between scoring level and group. Based on the findings of this study, it is recommended that teachers should consider using mastery learning instructional strategy for chemistry instruction to improve the performance of their students in chemistry examinations.

Correspondence concerning this article should be addressed to Dr. O. S. Oyelekan, Department of Science Education, University of Ilorin, Ilorin, Kwara State Nigeria. solomonoyelekan@hotmail.com

Key words: mastery learning; senior school students; achievement; mole concept

Introduction

The mole concept in Chemistry is a quantitative unit that provides a description of the amount of substances reacting together, and the amount of their corresponding products in a reaction medium. An understanding of the mole concept is pre-requisite to the understanding of many topics in School Certificate and Advanced Level Chemistry. It is also crucial to the ability of students in solving stoichiometric problems in Chemistry (Dori & Hameiri, 1998).

The idea of the mole dated back to 1900 when it was first introduced by Wilhelm Ostwald in an attempt to provide an alternative to the explanation of the laws governing stoichiometry (Jensen, 2004). Since then, the mole has been defined in various ways by different authors. An example of such is the definition provided by Guggenheim (1986). According to him,

> A mole is an amount of substance of specified chemical formula, containing the same number of formula units (atoms, molecules, ions, electrons, quanta, or other entities) as there are in 12 grams (exactly) of the pure nuclide ^{12}C. (p3).

As a unit of quantitative measurement, the use of this term is overwhelming and this underscores its importance not only in quantitative chemistry, but in the physical sciences in general.

The responsibility of the classroom teacher is to help students attain maximum achievement in their learning tasks. Some of the competencies expected of a teacher include ability to use appropriate instructional strategies in teaching. Zayum (2008) noted that the instructional format provided by the teacher seems to be the medium of effective learning and that good teaching helps the learner, while poor teaching leads to poor learning and poor performance. Oloyede and Demide (2000) attributed the cause of the prevalence of poor performance and negative attitudes towards chemistry by secondary school students in Nigeria to teaching problems. In view of this, it was suggested by Owolabi (2000) that the government should find all possible means to retain veteran and experienced teachers who are still willing to serve so that they can contribute their wealth of experience to improving the education system.

Educators are incessantly concerned about the need to improve students' academic achievement especially in the sciences. The plethora of research on students' academic achievement in the sciences is a testimony to this concern (Ayot & Patel, 1987; Lee, 2004; Olatoye, Aderogba & Aanu, 2011; Samuel, 2007; Wilson, 2004). The issue of teaching methods and their effect on secondary school students' achievement has been a

very important issue in recent times. It is apparent that science and technology cannot thrive without using the appropriate instructional strategies to teach the students. The future development of any nation in the field of science depends on how well the subjects are taught. Hence, the need to conduct researches that put various instructional strategies to test.

Mastery learning is an instructional strategy in which learners are provided with the opportunity to master a particular unit of lesson before proceeding to the next. Most modern applications of mastery learning stem from the writings of Benjamin S. Bloom even though the idea of the instructional strategy dated back to earlier years. Bloom (1968) hypothesized that a classroom with a mastery learning focus as opposed to the traditional form of instruction would reduce the achievement gaps between learners of varying degrees of academic abilities (Guskey, 2007).

Mastery learning instructional strategy divides subject matter into units that have predetermined objectives or unit expectations. Students, alone or in groups, work through each unit in an organized fashion. The teacher assesses and grades the students after each unit to determine who has mastered the content and who needs more help. Students must demonstrate mastery on unit exams, typically 80%, before moving on to new material (Anderson, 2000; Davis & Sorrell, 1995). Students who have mastered the material are given enrichment opportunities which could be in the form of projects or problem solving tasks. Students who do not achieve mastery receive remediation through tutoring, peer monitoring, small group discussions, or additional assignment. Additional time for learning is prescribed for those requiring remediation and students continue the cycle of studying and testing until mastery is achieved after which they can proceed to more advanced learning tasks.

Nigerian candidates have been performing below expectations in the School Certificate Chemistry Examinations conducted by the West African Examinations Council (Olorundare, 2014). A proper understanding of the mole concept could assist in improving students' performance in Chemistry since the mole concept finds application in many Chemistry topics. It has however been pointed out that difficulties exist in the teaching and learning of this concept (Oyelekan, 2006; Stromdahl, Tullberg & Lybeck, 1994). This makes it imperative to seek for appropriate instructional strategies that could alleviate these difficulties. Available empirical evidences presented in the literature review section of this paper reveal that studies conducted on mastery learning over several decades show that mastery learning produces better students' achievement than non-mastery learning approaches. Such studies are not common in Nigeria and particularly in Chemistry and with specific emphasis on the mole concept. Furthermore, the authors of this paper have found no such studies conducted in the locality in which this particular study was conducted.

Theoretical Framework

The concept of mastery learning is rooted in the behaviourism principles of operant conditioning (Skinner, 1984). According to the operant conditioning theory, learning occurs when an association is formed between a stimulus and response. In line with the behaviour theory, mastery learning focuses on overt behaviours that can be observed and measured (Baum, 2005). Mastery learning as a theoretical approach goes back to the work of Bloom (1968), who came up with "learning for mastery" method. Bloom was interested on how he could improve traditional classroom instruction by examining what it was about individual tutoring that made it an effective instructional approach. Bloom contended that most instructors were dividing their instructional materials into smaller units of instruction, but the way the students' progress was assessed was not helpful for their learning. He observed that instructors typically had the students take an assessment at the end of the instruction, which served to give the students a grade for their performance, but regardless of how the students did, he or she continued on into the next unit of instruction not minding his or her grade.

Mastery learning as a school of thought presumes that all children can learn if they are provided with the appropriate learning conditions. In mastery learning, students are assisted by the teacher to master each learning unit before proceeding to the next which is more advanced. This instructional philosophy is based on the belief that all learners can learn if given the appropriate amount of time and the appropriate instructional opportunities. Three basic indicators of learning output could be identified in the work of Bloom (1984). These are cognitive introduction behaviours (i.e preliminary learning which is assumed to be a necessary pre-requisite for learning a concept); emotional introduction features (the extent of learner's motivation to learn); and the quality of teaching activity. The variables (clues, reinforcement, student's participation, feedback and correction) which Bloom described as the quality of teaching activity, explain the activities which are prepared by the teacher to enable mastery learning. According to this theory, if the related introduction features of the student along with the teaching activities are positive, the learning output will reach a high level and the differentiation between the students in terms of performance will be at a minimum level (Sever, 1997).

We posit that if these three variables of mastery learning are approached systematically by the teacher, the learning outcome of the learners should improve significantly.

Literature Review

Many studies have been conducted to determine the effectiveness of mastery learning instructional strategy on learners' learning outcomes. In fact, Guskey and Gates (1986) reviewed 25 studies conducted in this area at the elementary and secondary school levels using a meta-analysis technique. They found that all the 25 studies reported positive effects of mastery learning on students' achievement. Earlier Block (1971) reported that students with minimal prior knowledge of material had higher achievement through mastery learning than with traditional methods of instruction. In a study conducted in Kenya, Wambugu and Changeiywo (2008) sought to find the effects of mastery learning on the achievement of secondary school students in Physics. They found that students taught Physics through mastery learning had higher achievement than those not taught with mastery learning. Similar results were obtained by Arlin and Webster (1983); Clark, Guskey and Benninga (1983), Hon (1990); Kibler *et al.*, (1981); Kulik, Kulik and Bangert-Downs (1990); Ngesa (2002); Oloyede and Demide (2000); Wachanga and Gamba (2004). For instance, Kulik, Kulik and Bangert-Downs (1990) conducted a meta-analysis involving 108 evaluations of mastery learning programmes. They found that mastery learning generally had positive effects on students' achievement. Their study further revealed that the effects of mastery learning were not uniform on all students in a class, as low aptitude students were found to have higher gains than high aptitude students. Ngesa (2002) conducted a study to find out the impact of experiential and mastery learning programs on academic achievement in secondary school Agriculture in Kenya. The result indicated higher student achievement in Agriculture than the regular teaching method.

Lazaowitz, Baird, Bowlden and Lazaowitz (1996) studied the effects of using group mastery learning on the achievement of high school biology students. They found that in group mastery learning students did better in some topics as compared to individualized mastery learning, although their method focused on students' co-operative skills than mastery of the content. A related study by Patriciah and Johnson (2007) focused on mastery of physics content through corrective feedback and remediation rather cooperative skills but the results showed that mastery learning is superior to Regular Teaching Method in terms of achieving higher scores. Research conducted on comparing effects of mastery learning alone, and Regular Teaching Methods on students' achievement in Mathematics by Mevarech (1985) showed that mastery learning was the indicator that significantly increased achievement. Research reports on students' achievement in science on the basis of gender are inconclusive. While many researchers (Arigbabu & Mji, 2004; Bilesanmi-Awoderu, 2006; Din, Ming, & Esther, 2004; Freedman, 2002; Loofa, 2001; Sungur &Tekkaya, 2003) have provided reports that there are no longer distinguishing differences in the cognitive, affective and psychomotor skill

achievements of students in respect of gender, others (Eccles, Lord, Roeser, Barber, & Jozefowicz, 1997; Hyde & McKinley, 1997; Kolawole, 2007; Usman and Ubah, 2007) have found disparities in the achievement of male and female students. However, the literature seems to be dominated with findings indicating no significant gender disparities in students' achievement with many instructional strategies (Aluko, 2004; Chin-Chau, 1997; Drzewiecki & Westberg, 1997; Olatoye, Aderogba & Aanu, 2011; Pandian, 2004; Samuel & John, 2004). Specifically for mastery learning, the study conducted by Wambugu and Changeiywo (2008) showed no significant influence of gender on students' achievement with mastery learning.

Learners generally operate at different levels of intelligence and their ability to perform specific tasks also differs. According to Adesoji (1992), all aspects of science could be said to be problem solving and students have varying ability when they are confronted with problems to solve. Salami (2000) stated that problem solving in science depends on students' cognitive ability level. An intelligent person is someone who can solve a whole variety of difficult questions rapidly. As a matter of fact, there is a strong relationship between the level of individual's intelligence and his mastery of a given task. In the Nigerian educational system, classrooms are generally composed of students of different scoring levels. Hence, any innovation in instructional strategy must consider the influence of students' scoring levels. There is need for good instructional strategies that go a long way in improving learning skills of students no matter their ability level.

Statement of the Problem

In spite of the importance of the mole concept to the field of Chemistry, researchers (Dierks, 1981; Lazonby, Morris, & Waddington, 1982; Nelson, 1991, Oyelekan, 2006; Staver & Lumpe, 1993; Furio, Azcona, Guisasola, & Mujika, 1993; Tullberg, Stromdahl, & Lybeck, 1994) have expressed concerns about the difficulties in the teaching and learning of this concept. These studies have indicated that students find it difficult to understand the mole concept. More worrisome is the revelation from other studies (Azcona, 1997; Furio *et al*. 1993, Furio, Ascona, Guaisasola, & Ratcliffe, 2000; Stromdahl, Tulberg, & Lybeck, 1994) that even teachers did not have a good understanding of the concept.

If teachers who are supposed to teach the topic and make students understand it do not understand it themselves, the outcome of their lessons could easily be predicted. Researchers (Furio *et al.*, 1993; Larson, 1997) have found among others that reasons why students found it difficult to understand the mole concept include the confusion created by the numerous vocabularies used in describing the mole, the inconsistency in the way teachers and textbooks present the idea of the concept and the operative introduction of the mole concept by the teachers which deprives it of its chemical meaning.

Fensham (2008) stated from empirical evidences that students' interest in science had reached a crisis situation in many countries across the globe. Ajaja (2013) identified the 'method adopted for teaching and learning science'(p.1) as one of the factors contributing to this low interest in science and hence expressed the need for a search for alternative instructional strategies that could stimulate students' interest and enhance their achievement.

Empirical data provided by Oyelekan and Olorundare (2009), Oyelekan, Olorundare and Anyimigbo (2013), and Olorundare (2014) indicate that the performance of Nigerian candidates in School Certificate Chemistry Examinations conducted by the West African Examinations Council were not encouraging. The mole concept was identified as one of the problem areas. The difficulties experienced by students in understanding the mole concept could hence contribute to this unsatisfactory situation of students' performance in School Certificate Chemistry. Since mastery learning instructional strategy has been widely acknowledged to enhance students' performance, this study explored mastery learning instructional strategy as an instructional strategy that could probably enhance students' understanding of the mole concept and ultimately contribute to an improvement in the performance of students in School Certificate Chemistry. The study is further premised on the submission of Ajaja (2013) that there is need for detailed assessment of instructional strategies before they are put to use in the science classroom. While it is acknowledged that mastery learning instructional strategy could enhance students' achievement in some topic areas as presented in the literature, the study sought to find whether this position could be extended to the mole concept so as to establish some degree of certainty about the effect mastery learning instructional strategy could have on students' achievement when the strategy is used to teach the concept.

Research Questions

The main purpose of this study was to determine the effects of mastery learning instructional strategy on secondary school students' achievement in chemistry. In achieving this purpose, answers were sought to the following research questions:

1. Is there any significant difference in the achievement of chemistry students taught using the mastery learning instructional strategy and those not taught using the mastery learning instructional strategy?
2. What is the influence of gender on the achievement of students taught using the mastery learning instructional strategy?
3. What is the influence of scoring level on the achievement of students taught using the mastery learning instructional strategy?

Research Hypotheses

The following hypotheses were formulated and put to test:

HO_1: There is no significant difference in the achievement of chemistry students taught using the mastery learning instructional strategy and those not taught using the mastery learning instructional strategy.

HO_2: Gender would not significantly influence the effect of mastery learning instructional strategy on the achievement of secondary school students in chemistry.

HO_3: Students' scoring level would not significantly influence the effect of mastery learning instructional strategy on the achievement of secondary school students in chemistry.

Research Methodology

This study employed the quasi-experimental design. The non-randomized, non-equivalent, pre-test and post-test control group design was adopted to test the hypotheses.

Sample

The sample for the study consisted of senior secondary school one (SS1) students in two intact classes from two government-owned secondary schools in Ilorin metropolis. The parameters used in selecting schools are that the two selected schools were co-educational and chemistry had been taught in the schools for over ten years. Also, the student populations in each of the classes involved were not less than 50 and the allocation of the students into the classes were gender sensitive such that there was a fairly reasonable mix of male and female students. The experimental group consisted of a class of 60 students (29 females and 41 males) while the control group consisted of a class of 50 students (20 females and 30 males). The students in each of the classes were categorized into high, medium and low scorers using their cumulative score in Chemistry in the previous school term. Those who scored above 70% were categorized as high scorers; those who scored between 41 and 69% were categorized as medium scorers while those who scored 40% or less were categorized as low scorers. Hence, the experimental group had 20 high scorers, 27 medium scorers and 21 low scorers, while the control group had 19 high scorers, 19 medium scorers and 12 low scorers. Our preference for intact classes and the ethnographic nature of the study along gender and students' scoring levels limited the sample size of the study. Intact classes are easier to organize and getting an intact class with fair representation of the samples along gender and scoring levels was difficult. In most cases, the distribution of students into classes on the basis of gender was also skewed. In the end we have chosen the best available intact classes.

Instruments

The instruments used for this study were an Achievement Test on Mole Concept (ATMC), and a researcher-designed mastery learning instructional material. The ATMC was a set of 30 multiple choice questions. It was drafted from past West African Senior School Certificate Examination (WASSCE) Chemistry question papers already validated by the West African Examinations Council, the examining body. The ATMC and the researcher-designed mastery learning instructional material were validated by three professional secondary school Chemistry teachers and three science educators in a university.

Context and Data Collection

After due permission was sought from the selected schools by the researchers, the researchers met with the students to seek their consent and explained the aim of the study as well as their level of involvement with the study. The consent of the parents was sought through a parent consent form given to each of the students and which was filled and returned to the researchers. A pretest on mole concept was given to the two groups to determine the students' level of understanding of the selected topic before teaching them. Then, the experimental group was given the treatment over a period of two weeks while the control group was taught in the usual way. The two groups were taught by one of the authors of this paper.

In the Nigerian Senior Secondary School Chemistry Curriculum produced by the Federal Ministry of Education (FME, 2008), the mole concept comes under the theme 'the chemical world'. It is subsumed under the topic 'mass/volume relationships (p.15). It is actually a small portion of the curriculum but its application cuts across virtually all topics involving mathematical calculations. As presented in this curriculum, the mole concept and its applications in solving chemical problems can be taught to students in two lessons, each of 40 minutes duration (Babatunde, 2009). Hence both the experimental and the control groups were taught only two lessons each. Each lesson lasted between 45 and 50 minutes. However, for the experimental group only, revision of each of these two lessons was done for students who could not achieve mastery.

Experimental. In the experimental group, a class was organized for the conduct of the pre-test. The pre-test comprised of 30 multiple choice questions and was administered on the students for 35 minutes. Two experimental lessons were conducted to teach the mole concept and its applications. Each of the two experimental lessons was conducted as follows: The teacher administered a formative test drawn from the content of the day's lesson. The formative test comprised of 10 multiple choice questions to be answered within 10 minutes. Then, the lesson was taught. At the end of each lesson, the formative test was re-administered but with the questions reshuffled. This was to enable the teacher to know whether differences existed in what students knew and could do at

the beginning of the lesson, and at the end of the lesson. The scores of the students also enabled the teacher to know those who had achieved mastery (i.e. those who scored up to 80%). A revision lesson was organized for students who failed to achieve mastery during in this lesson during another lesson. After this extra lesson, a corrective test which was a reshuffled version of the formative test was administered to them. An enrichment test was administered to those who had earlier on achieved mastery to keep them busy as well. The enrichment test items were not the same as the formative test. At the end of the treatment, a post test (which was a reshuffled version of the pre-test) was administered on the group.

Control. In the control group, after the administration of a pre-test, students were taught two lessons conventionally. This conventional teaching involved the teacher delivering his lesson to the students using the chalk and chalkboard and ensuring students' participation in the lesson, but without any special treatment. Assignments were given to them after which the teacher marked the assignments and went through the solutions with them. At the end of the exercise, the post-test was administered to the students.

The pre-test and post-test were marked for the two groups and the scores were used for data analysis. The data collected from pretest and posttests of both groups were analyzed by calculating the mean gain scores and standard deviations for both groups. The hypotheses were tested using t-test and Analysis of Covariance using the pretest scores as covariates.

Data Analysis and Results

Research Question 1

Is there any significant difference in the achievement of chemistry students taught using the mastery learning instructional strategy and those not taught using the mastery learning instructional strategy? The corresponding hypothesis is that there is no significant difference in the achievement of chemistry students taught using the mastery learning instructional strategy and those not taught using the mastery learning instructional strategy.

An independent sample t-test analysis (Table 1) was done in respect of research question 1 and hypothesis 1. The result shows that mastery learning instructional strategy yielded a mean gain score of 15.50 for the experimental group while the control group for which mastery learning was not administered as a treatment had a mean gain score of 7.04. At 0.05 level of significance, a t-value of 21.363, and a p-value of 0.000 was obtained for the independent t-test analysis. (See Table 1).

Table 1:
Paired t-test analysis of the achievement of students when taught using mastery learning instructional strategy compared with those taught with the conventional method.

Group	N	Mean	Std. Dev	Df	T	p-value
Control	70	7.04	2.33			
				118	21.363	.000
Experimental	50	15.50	1.83			

Since the calculate p-value of 0.000 is less than the 0.05 level of significance ($p<0.05$), it means that there was significant difference between the performance of the experimental group and the control group, in favour of the experimental group. Hence, hypothesis 1 was rejected. This implies that students who were taught with the mastery learning instructional strategy had a significantly higher achievement score in chemistry than their counterparts in the control group.

Research Question 2

What is the influence of gender on the effect of mastery learning instructional strategy on the achievement of students in chemistry? The corresponding hypothesis is that gender would not significantly influence the effect of mastery learning instructional strategy on the achievement of secondary school students in chemistry.

In response to research question 2 and hypothesis 2, an Analysis of Covariance (ANCOVA) was conducted to assess whether the effect of mastery learning instructional strategy and the achievement score of students in chemistry co-varied with gender of students. The result showed that the co-variance between Gender and Group (Gender*Group) yielded F= 0.423 and p=0.517 which was not significant since $p>.05$. Therefore, there was no enough statistical evidence to conclude that the effect of mastery learning instructional strategy on achievement in chemistry co-varied with the gender of students. Hence, hypothesis 2 was not rejected.

Table 2:
ANCOVA output for influence of gender on the effect of mastery learning instructional strategy on achievement in chemistry.

Source	Sum of Squares	Df	Mean Square	F	p-value
Gender	7.30	1	7.297	1.593	.209
Group	1923.22	1	1923.225	419.918	.000
Gender * Group	1.94	1	1.939	.423	.517
Error	531.28	116	4.580		
Total	2625.47	119			

Specifically, the findings imply that the observed effect of mastery learning instructional strategy on achievement in chemistry existed and was similar for both male and female students. Table 3 shows that the effect of mastery learning instructional strategy is similar for both male (8.635) and female (8.103) students.

Table 3:
Pairwise comparison test for students' achievement in chemistry based on gender.

Gender	Group	Mean	Difference	Std. Error	p-value
Male	Control	7.146	8.635	0.505	.000
	Experimental	15.781			
Female	Control	6.897	8.103	0.642	.000
	Experimental	15.000			

Research Question 3

What is the influence of scoring level on the effect of mastery learning instructional strategy on the achievement of students in chemistry? The corresponding hypothesis is that students' scoring level would not significantly influence the effect of mastery learning instructional strategy on the achievement of secondary school students in chemistry.

In response to research question 3 and hypothesis 3, an Analysis of Covariance (ANCOVA) was conducted to find out whether the effect of mastery learning instructional strategy and the achievement scores of the students in chemistry co-varied with the scoring level of students. The result showed that the co-variance between

Scoring level and Group (Scoring level*Group) yielded F= 20.836 and p=0.000 which was found to be statistically significant since $p<0.05$. Therefore, there was ample statistical evidence to conclude that the effect of mastery learning instructional strategy on achievement in chemistry co-varied with the scoring level of students.

Table 4:
ANCOVA output for influence of scoring level on the effect of mastery learning instructional strategy on achievement in chemistry.

Source	Sum of Squares	Df	Mean Square	F	p-value
Group	1931.66	1	1931.659	568.882	.000
Scoring level * Group	141.50	2	70.751	20.836	.000
Error	387.09	114	3.396		
Total	2625.467	119			

Specifically, the findings imply that the observed effect of mastery learning instructional strategy on achievement in chemistry is not similar for students of various scoring levels. Table 5 shows that students in the low score (9.562) and medium score (10.494) category experienced a higher effect of the mastery learning instructional strategy than their counterparts in the high score (5.251) category. Thus, low and medium scorers benefited more from the mastery learning instructional strategy than the high scorers. Hence, hypothesis 3 was rejected.

Table 5:
Bonferroni comparison mean response time for control and experimental groups based on scoring level of participants

Scoring Level	Group	Mean	Difference	Std. Error	p-value
Low	Control	6.771	9.562	0.616	.000
	Experimental	16.333			
Medium	Control	5.611	10.494	0.606	.000
	Experimental	16.105			
High	Control	9.118	5.251	0.615	.000
	Experimental	14.368			

Summary of Major Findings

The major findings of this study obtained from the analysis of data based on the hypotheses are summarized as follows:

1. There was statistically significant difference in the achievement of students taught using mastery learning instructional strategy and the conventional teaching method in teaching the mole concept in chemistry. Students taught using the mastery learning instructional strategy had a better achievement than their counterparts for which conventional method of teaching was used.
2. There was no significant difference in the achievement of male and female students taught using mastery learning instructional strategy. This means that gender did not have any significant influence on the achievement of the students when taught using mastery learning instructional strategy.
3. There was a statistically significant difference in the achievement of high, medium and low scoring students taught using the mastery learning instructional strategy. Hence, the effect of this strategy varied across the scoring level of the students. This implies that mastery learning instructional strategy assisted low and medium scorers to improve in their achievement and score closer to high scorers.

Discussion

Findings revealed that students taught using mastery learning instructional strategy as an instructional strategy had a better achievement than those taught using the conventional method. Hence, teacher's use of mastery learning instructional strategy enhanced students' achievement in chemistry.

In the first instruction given to the students, it was observed that students spent more time to achieve mastery but on subsequent instruction, they spent lesser time. This could be attributed to the fact that the first lesson was a prerequisite to the next lesson. Hence, the time that was lost during the first lesson was recovered in the second lesson. Therefore time did not affect the use of the strategy. The strategy facilitated a better understanding of the concept as students were not allowed to learn new lessons until the previous one was properly understood.

This finding agrees with Effandi and Zanaton (2007) who pointed out that teachers should have the knowledge of how students learn science and how best to teach the concepts of science. The presentation of science lessons should be directed away from the traditional methods to a more student-centred approach. Wambugu and Changeiywo (2008) noted that the teaching strategy that a teacher adopts is one factor that may affect

students' achievement and therefore the use of an appropriate teaching method is critical to the successful teaching and learning of science.

Gender had no significant influence on students' achievement with mastery learning. This finding is similar to that of Aluko (2004) who found out that there was no significant difference in the performance of male and female students when exposed to cooperative and individualistic instructional strategies. It is also similar to related studies (Chin-Chau, 1997; Drzewiecki & Westberg, 1997; Olatoye, Aderogba & Aanu, 2012; Pandian, 2004; Samuel & John, 2004) which sought to find out the influence of gender on students' achievement with various instructional strategies.

Findings further revealed that teacher's use of mastery learning instructional strategy had a greater influence on the low and medium scorers than the high scorers. This is because the high scoring students maintained their high scores after they have been exposed to treatment but the low and medium scoring students gained more from this strategy as they scored closer to the high scoring students. This finding further establishes the efficacy of the mastery learning instructional strategy, especially in bridging the achievement gaps among learners of various abilities and scoring levels. Thus, the mastery learning instructional strategy has the potential of leveling up the achievements of learners across various ability groups.

Conclusion and Recommendations

It can be concluded from this study that students achieved better when taught the mole concept using mastery learning instructional strategy than when taught using the conventional method. Mastery learning instructional strategy also bridged the achievement gap between the low, medium and high scorers. So also, gender did not influence students' achievement when mastery learning was used to teach the mole concept.

Based on the findings from this study, the following recommendations are made:

1. Chemistry teachers should take advantage of the mastery learning instructional strategy in teaching the mole concept and other related concepts. School authorities should also create conducive environment for the use of the strategy by teachers.
2. Male and female students should be given equal consideration as far as the use of mastery learning instructional strategy is concerned since gender had no influence on the academic achievement of students with mastery learning instructional strategy.
3. The Federal and State Ministries of Education and other educational bodies like Nigeria Educational Research and Development Council (NERDC) and the Science Teachers Association of Nigeria (STAN) should organize training/ workshops for

teachers so as to update their knowledge on the use of the mastery learning instructional strategy to improve teaching and learning in Nigerian schools.

References

Adesoji, F. A. (1992). *A comparative analysis of problem solving and self-learning techniques in teaching electrolysis.* Unpublished Ph.D. thesis, Obafemi Awolowo University, Ile- Ife, Nigeria.

Ajaja, O. P. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle? *Electronic Journal of Science Education, 17(1),* 1-37.

Aluko, K. O. (2004). *Effects of cooperative and individualistic instructional strategy on the students' problem solving ability in secondary school chemistry in Ilesha, Nigeria*. Unpublished Ph.D. thesis, Department of Science Education, University of Ilorin, Ilorin.

Anderson, J. R. (2000). *Learning and memory: An integrated approach (2nd edition.).* New York: John Wiley and Sons, Inc.

Arigbabu, A. A., & Mji, A. (2004). Is gender a factor in Mathematics performance among Nigerian pre-service teachers? *Sex Role, 51(11 & 12),* 749- 752.

Arlin, M., & Webster, J. (1983). Time costs of mastery learning. *Journal of Educational Psychology,* 75(2), 187-195.

Ayot, M. O., & Patel M. M. (1987).*Instructional methods (General Methods) series on provision of leadership training in Teacher Education supported by ODA through British Council HED School.* Kenyattta University, Faculty of Education and University of London, Institute of Education.

Azcona, R. (1997). *Analisiscrõ tico de la ensenÄanza-aprendizaje de los conceptos de 'cantidad de sustancia' y de mol. Una alternativa didactica basada en el aprendizaje por investigacion*, Doctoral thesis, San Sebastian: Universidad del Pa õ s Vasco.

Babatunde, V. O. (2009). *Effect of competence in Mathematics on Nigerian secondary school students' performance in mole concept problems in Chemistry.* Unpublished Ph.D. thesis, Department of Science Education, University of Ilorin, Ilorin, Nigeria.

Baum, W. M. (2005). *Understanding behaviorism*: *Behavior, culture and evolution.* Malden MA: Blackwell Publishing.

Bilesanmi-Awoderu, J. B. (2006). Effect of Computer-Assisted Instruction and simulation/games on the academic achievement of secondary school students' in Biology. *Sokoto Educational Review, 8(1),* 49-60.

Block, J. (1971). *Mastery learning: Theory and practice*. New York: Holt, Rinehart, & Winston.

Block, J. H. (1976). Mastery learning: Current state of the craft. *Educational Leadership, 37*, 114-117.

Bloom, B. (1968).Learning for Mastery. *Evaluation Comment,1(2),* 1-5. Los Angeles Centre for study of Evaluation Instructional Programmes (UCCLA).

Bloom, B. S. (1974). Time and learning. *American Psychologist, 29(9),* 682-688.

Bloom, B. S. (1984). The 2 Sigma Problem: The search for methods of group instruction as effective as one-on-one tutoring. *Educational Researcher,* 13(6), 4-16.

Chin-Chau, L. (1997). *Effect of goal structure on Chinese elementary school students' goal orientation, achievement, intrinsic motivation, and beliefs about success/failure.* Texas Technology University Libraries.

Clark, C., Guskey, T., & Benninga, J. (1983).The effectiveness of mastery learning strategies in undergraduate education courses. *Journal of Educational Research, 76*(4), 210-214.

Davis, D., & Sorrell, J. (1995).Mastery learning in public schools. *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved January 3, 2013 from http://teach.valdosta.edu/whuitt/files/mastlear.html

Dierks, W. (1981).Teaching the mole. *European Journal of Science Education*, 3, 145-148.

Din Y. Y., Ming M. C., &Esther S. H. (2004). Hong Kong students' achievement in oecd-pisa study: gender differences in science content, literary skills, and test item formats. *International Journal of Science and Mathematics Education,* 2(1), 91-106.

Dori, Y., & Hameiri, M. (1998). The 'mole' Environment' studyware: Applying multidimensional analysis to quantitative chemistry problems. *International Journal of Science Education, 20(3),* 317-333.

Drzewiecki, L. A., & Westberg, K. L. (1997).Gender difference in High School students attitudes towards in mathematics in traditional versus cooperative group. The National Research Centre on the Gifted and Talented. *Spring Newsletter*.

Eccles, J. S., Lord, S. E., Roeser, R. W., Barber, B. L., & Jozefowicz, D. M. (1997). The association of school transitions in early adolescence with developmental trajectories through High School. In J. Schulenberg & J. Maggs & K. Hurrelmann (Eds.), *Health Risks and Developmental Transitions During Adolescence* (pp. 283-320). New York: Cambridge University Press.

Effandi, Z., & Zanaton, I. (2007).Promoting cooperative learning in Science and Mathematics Education: A Malaysian perspective. *Eurasia Journal of Mathematics, Science and Technology Education, 3(1),* 35-39.

Federal Ministry of Education FME (2008).*Senior secondary school education curriculum, Chemistry for SS 1-3.*Abuja: Nigerian Educational Research and Development Council (NERDC).

Fensham, P. J. (2008). *Science education policy-making: Eleven emerging issues.* Paris: UNESCO.

Freedman, M. P. (2002).The influence of laboratory instruction on science achievement and attitude towards science across gender differences. *Journal of Women and Minorities in Science and Engineering*, 8(2), 50-52.

Furio, C., Azcona, R., Guisasola, G., &Mujika, E. (1993). Concepciones de los estudiantes sobre una magnitud ‘‘olvidada’’ en la ensenÄanza de la Quõ mica: la cantidad de sustancia. *EnsenÄanza de las Ciencias*, 11(2), 107-114.

Furio, C., Ascona, R., Guaisasola, J., Ratcliffe, M. (2000). Difficulties in teaching the concepts of ‘amount of substance’ and ‘mole’. *International Journal of Science Education, 22(12),* 1285-1304.

Guggenheim, E. A. (1986). *Thermodynamics: An advanced treatment for chemists and physicists.* Amsterdam: North Holland Physics Publishing.

Guskey, T. R. (2007). Closing achievement gaps: Revisiting Benjamin S. Bloom’s “learning for mastery.” *Journal of Advanced Academics, 19*(1), 8-31.

Guskey, T. R., & Gates, S. L. (1986). Synthesis of research on the effects of mastery learning in elementary and secondary classrooms. *Educational Leadership, 43(8),* 73-80.

Hon, H. (1990). *A study of mastery learning and its effects on science achievement retention, attitudes and self-concept with special focus on educationally disadvantaged students.* Unpublished Doctoral Dissertation, University of Hong Kong.

Hyde, J. S., McKinley, N. M. (1997). Gender difference in cognition. Results from meta-analysis. In Caplan, P. J., Crawford, M., Hyde, J.S. & Richardson, J. T. E. (Eds.). *Gender differences in human cognition* (pp. 30-51). New York: Oxford Press.

Jensen, W. B. (2004). The Origin of the Mole Concept. *Journal of Chemical Education, 81(1409),* 1-2.

Kibler R. J, Cegala D. J, Watson K. W, Barkel L. L. & David, T. M. (1981). *Objectives for Instruction and Evaluation*. Allyn and Bacon Inc. Toronto, U.S.A.

Kolawole, E. B. (2007). Effects of competitive and cooperative learning strategies on academic performance of Nigerian students in Mathematics. *Educational Research Review,* 3(1), 33-37.

Kulik, C., Kulik, J., & Bangert-Drown, R. (1990). Effectiveness of mastery learning programmes: A meta-analysis. *Educational Research Review, 60(2),* 265-306.

Larson, J. O. (1997). *Constructing understandings of the Mole Concept: Interactions of chemistry text, teacher and learners.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (70th, Oak Brook, IL, March 21-24, 1997).

Lazaowitz, R., Baird H. J., Bowlden R., & Lazaowitz R. H. (1996). Teaching Biology in group mastery and effective outcomes. *International Journal of Science Education, 18(4),* 447-461.

Lazonby, J. N., Morris, J. E., & Waddington, D. J. (1982). The muddlesome mole. Education in Chemistry, 19(4), 109-111.

Lee, V. S. (2004). *Teaching and learning through inquiry*. Sterling, V.A: Stylus Publishing.

Loofa, J. K. (2001). Sex, age and performance in chemistry. *Instructional Science, 18,* 119 – 147.

Mevarech, Z. (1985). The effects of cooperative mastery learning strategies on mathematics achievement. *Journal of Educational Research, 78(3),* 372-377.

Nelson, P. G. (1991). The elusive mole. *Education in Chemistry*, 28(4), 103-104.

Ngesa, F. U. (2002). *Impact of experiential and mastery learning programmes on academic achievement in Secondary School Agriculture.* Unpublished Ph.D. thesis, Egerton University, Kenya.

Olatoye, R. A., Aderogba A. A., & Aanu, E. M. (2011).Effect of co-operative and individualized teaching methods on senior secondary school students' achievement in organic chemistry. *The Pacific Journal of Science and Technology, 12(2),* 311-319. Retrieved January 2, 2012 from http://www.akamaiuniversity.us/PJST.htm

Oloruundare, A. S. (2014). Theory into practice: Beyond surface curriculum in science education. *The 147th inaugural lecture, University of Ilorin, Ilorin, Nigeria.*

Oloyede, O. I., & Demide, C. O. (2000). Enhancing transition from concrete to formal cognitive functioning for improved achievement in chemistry. *African Journal of Research in Education, 1(2),* 48-58.

Owolabi, H. O. (2000). Adopting mastery learning instructional strategy for teaching and learning in Nigeria: Time implications. In A. I. Idowu (Ed). *A guide to teaching practice.* Ilorin: Haytee Press & Publishing Co. Ltd.

Oyelekan, O. S. & Olorundare, A. S. (2009).Development and validation of a computer instructional package on electrochemistry for secondary schools in Nigeria. *International Journal of Education and Development Using ICT,* 5(2), 88-104. Retrieved July 5, 2014 from http://ijedict.dec.uwi.edu//viewarticle.php?id=677&layout=html

Oyelekan, O. S. (2006). Secondary school students' level of understanding of selected chemistry concepts in Osun State, Nigeria. *The African Symposium, an online Journal of African Educational Research Network,* 6(3&4), 68-75.

Oyelekan, O. S., Olorundare, A. S., & Anyimigbo, A. O. (2013). Teachers' perception of secondary students' difficulties in understanding gas laws. *Journal of Science, Technology, Mathematics and Education (JOSTMED),* 9(3), 194-206.

Pandian, S. S. (2004).*Cooperative learning in Biology: The effect of computers.* Department of Education, Arunachi University, India.

Patriciah, W. W., & Johnson, M. C. (2007). Effects of mastery learning approach on secondary school students' physics achievement. *Eurasia Journal of Mathematics, Science & Technology Education, 4(3),* 293-302.

Salami, I. O. (2000). *Effect of three instructional modes of student teachers' performance in selected teaching skills.* Unpublished Ph.D. thesis, Ibadan: University of Ibadan, Nigeria.

Samuel O. S. (2007). Effects of personalized system of instruction on students` academic achievement in Chemistry. *Pakistan Journal of Social Sciences, 4*, 132-136. Retrieved October 5, 2012 from http://medwelljournals.com/abstract/?doi=pjssci.2007.132.136

Samuel, W. W., & John, G. M. (2004). Effects of cooperative class experiment teaching method on secondary school students' chemistry achievement in Kenya's Nakuru District. *International Education Journal, 5(1),* 26-35.

Sever, S. (1997). *Turkish teaching and mastery learning.* Ankara: Ani Yayincilik.

Skinner, B. F. (1984). The evolution of behavior. *Journal of Experimental Analysis of Behavior, 41,* 217-221.

Staver, J. R., & Lumpe, A. T. (1993). A content analysis of the presentation of the 'mole' conception in chemistry textbooks. *Journal of Research in Science Teaching*, 30(4), 321-337.

Stromdahl, H., Tullberg, A. &Lybeck, L. (1994).The qualitatively different conceptions of 1 mole. *International Journal of Science Education*, 16(1), 17-26.

Sungur, S., & Tekkaya, C. (2003). Students' achievement in human circulatory system unit: The effect of reasoning ability and gender. *Journal of Science Education and Teaching, 12(1),* 59-64.

Tullberg, A., Stromdahl, H., &Lybeck, L. (1994). Students' conceptions of 1 mole and educators' conceptions of how they teach 'the mole'. *International Journal of Science Education,* 16(2), 145-156.

Usman, K. O., & Uba, A. I. (2007).Improving students' achievement in further chemistry using team teaching approach. *Review of Education*, 18(1), 15-21.

Wachanga, S. W., & Gamba, P. P. (2004). Effects of mastery learning approach on secondary school students' achievement in Chemistry in Nakuru District Kenya: *Egerton Journal. Humanities Social Sciences and Education*, 5(2), 221-235.

Wambugu, P. W. & Changeiywo, J. M. (2008).Effects of mastery learning approach on secondary school students' Physics achievement. *Eurasia Journal of Mathematics, Science & Technology Education,4(3),* 293-302.

Wilson, C. (2004). *Intervention central-prior knowledge: Activating the 'Known'.* Retrieved December 5, 2012 from http://www.interventioncentral.org/htmdocs/interventions/rdngcompr/priorknows.html

Zayum, S. D. (2008). *Performance enhancement skills for teachers of junior secondary school.* Paper presented at Bauchi State SUBEB Workshop, Nigeria, 28th-31st January.