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Effect of Mastery Learning on Senior Secondary School Students' Cognitive Learning Outcome in Quantitative Chemistry

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Abstract
The cognitive learning outcome of Senior Secondary School chemistry students has been poor over the years in Nigeria. Poor mathematical skills and inefficient teaching methods have been identified as some of the major reasons for this. Bloom's theory of school learning and philosophy of mastery learning assert that virtually all students are capable of attaining a high degree of learning if given the appropriate, prior and concurrent conditions. This study investigated the effect of mastery learning on senior secondary school students' cognitive learning outcome in quantitative chemistry. Quasi-experimental control group design was used for the study. Four Secondary Schools were randomly selected and randomly assigned to experimental and control groups. A total of four hundred and one (401) chemistry students were used for the study. Data was collected using a 25-item chemistry achievement test (CAT) drawn from stoichiometry and mole concept. The instrument was pilot tested and Kuder Richardson formula 21 (KR21) was used to establish the reliability coefficient (r = 0.7). Pre-test was administered to both the experimental and control groups to ascertain if the two groups were comparable and have the same entry characteristics before the treatment. A post-test was administered to both groups after two weeks of exposing the experimental group to mastery learning and the control group to conventional teaching method. Data were analyzed using independent sample t-test. The mastery learning group had a higher mean score ($\bar{x}$ = 78.2; s = 9.90) than the control group ($\bar{x}$ = 58.4; s = 16.07). The difference was highly significant (t_{399} = 14.92; p = 0.00). About sixty nine percent (69%) of the students in the mastery learning group scored 80% and above, a score attainable by only 17.5% of the students in the control group. Similarly, about half (50%) of the students receiving conventional instruction scored between 40% and 49% whereas less than 1% of the students in the mastery learning group were in this group. The effect size was substantial (0.6). The researcher concluded that mastery learning is a very effective method of teaching and better than the conventional teaching method and recommended that chemistry teachers should be encouraged to adopt it in order to enhance the cognitive learning outcome of students in quantitative chemistry.
Keywords: Mastery Learning, Quantitative Chemistry, Feedback, Corrective instruction, Cognitive Learning Outcome

1. Introduction

Feedback on students learning outcome in Senior Secondary School chemistry in Nigeria is not encouraging. Students' Performance in Senior Secondary School Certificate Examination in Chemistry from 2002 to 2011 (Appendix A) shows that about 53% of the students who sat for the examination within this period could not attain a credit level pass. Studies have shown that a number of factors are responsible for this. However, most of the emphasis is on the teacher, his teaching methods and materials. Studies on underachievement of students in secondary school subjects found inefficient teaching methods by school teachers as a major factor for the underachievement of students (Pepple, 2010, Usman and Memeh, 2007, Nwagbo, 2001, Osokoya, 1999).

The West African Examination Council Chief Examiner's Report (2009, 2010 and 2011) indicated poor mathematical skills as one of the major reasons for the poor performance of students in chemistry. This agrees with Krammer (2005) and Badru (2004) who found that students with poor mathematics knowledge could not solve calculation problems in chemistry. *Udousoro* (2011) also found that students with high mathematics ability performed significantly better than those with low mathematics ability in chemistry. Yewande (2012) suggested that chemistry is a subject that involves some quantitative aspects that seems to influence the overall achievement in chemistry. Ahiakwo (1991) stated that through the years, the suggestion has been made that the reason students have difficulties in general chemistry is that they cannot handle their mathematics.

If the method a teacher adopts in teaching and poor mathematical skills of the students are some of the major reasons for the poor performance of students in chemistry, then the question is 'how can we break this circle of failure'? Is there a teaching method that could help students to overcome learning problems with quantitative chemistry? Bloom's theory of school learning asserts that virtually all students can learn what they are taught (that is 'A' standard) if given the appropriate and prior conditions. Bloom (1968) argued that if students were normally distributed with respect to aptitude and are given uniform opportunity to learn and

quality of instruction, only few students would achieve mastery in their learning since the aptitude of each student will determine the degree of learning, which means students with high aptitude will perform well and those with low aptitude will perform poorly. On the other hand, if the students are given different opportunity to learn/time allowed for learning and quality of instruction that will match their need and situation, at least 80% or higher, even as much as 95% could achieve mastery in learning. Based on this, Bloom developed a mastery learning model called Learning for mastery (LFM).

Bloom's learning for mastery was derived from Carroll's group-based mastery learning model which was only conceptual and theoretical. Bloom expanded and transformed Carroll's model into an instructional and practical system for classroom learning in 1968. Mastery learning is a theory that suggests that virtually all students can attain a high degree of learning if given the needed time and appropriate learning conditions and that if teachers could provide these appropriate conditions, virtually all students could reach a high level of achievement and the differences in their levels of achievement would vanish. Bloom (1968) stated that the precondition to the development of mastery learning is to define what mastery is, specify the objectives and content of instruction and to set the criteria accepted as mastery so that the teacher will be able to know if a student has attained mastery or not.

The material the students are to learn over a period of time should be divided into smaller units and criteria for performance should be established, then formative tests should be administered during the teaching of each unit of learning. The results of the formative tests should provide feedback to the teacher and the students. This will enable the teacher to find out the students that have gained mastery and the ones that have not, and to enable the students to know the aspects they are not doing well and will need to improve upon. This is done by checking the performance from the formative tests against the set criterion accepted as mastery level. The students that have attained mastery are commended and could be used as peer tutors. The students that did not gain mastery are given corrective instruction based on the identified areas of difficulties from the results of the formative test and the test is administered to them again. The corrective instruction could be done through re-teaching, peer tutoring, homework, small group discussion, etc. This process continues until virtually all the students master the taught material before the teacher moves to the next unit of learning. Bloom argued that if students are taught with this form of teaching virtually all of them will attain a high degree of learning.

Bloom and his students conducted many empirical studies that showed that mastery learning programmes are very effective in a wide variety of situations (Levine, 1985). Other researches on mastery learning in schools have also shown positive cognitive learning outcomes in students (Akinsola, 2007, Aderemi, 2006, Kazu, Kazu and Ozedemi, 2005, Guskey & Gates, 1986). Abadom (2002) reported that results of studies using Bloom's learning for mastery (LMF) approach showed that the mean score for the mastery learning group is usually at least one standard deviation higher than the mean score of the conventional teaching method group. This agrees with Adeyemi (2007) who studied the effectiveness of learning social studies through mastery learning approach on students' performance in social studies using two groups of 200 level students from a University in Nigeria and a study centre of the same University. He found that students taught with mastery learning in the two groups performed better than students taught with the conventional approach to teaching. Another study was conducted by Ogan (2012) on the effect of mastery learning on senior secondary school achievement in Geography and he found that the mastery learning group performed better than the control group (conventional teaching method). Majidat (2002) also did a study on mastery learning titled, 'effects of three instructional strategies on cognitive learning outcome of students in mathematics' and found that mastery learning was very effective in enhancing students' performance irrespective of their sex.

Patricia and Johnson (2008) studied the effects of mastery learning approach and gender on students' achievement in physics using two groups of students in co-educational schools. One group (experimental) was taught with mastery learning approach and the other group (control) was taught with conventional teaching method. They found that the group taught with mastery learning achieved better than the group taught with the conventional teaching method. They also found that there was no significant effect of gender on the achievement of the students and concluded that mastery learning is an effective teaching method, which physics teachers should be encouraged to use. Ogba (2000) studied the effect of mastery learning on cognitive learning outcomes of junior secondary school mathematics and found mastery learning better than conventional teaching method. This study is therefore to answer the question: can mastery learning lead to a better cognitive learning outcome in quantitative chemistry?

2. Methodology

Quasi-experimental control group design was used. Four Secondary Schools were randomly selected and randomly assigned to experimental and control groups. A total of four hundred and one (401) Senior Secondary 2 chemistry students were used for the study. Data was collected using a 25-item chemistry achievement test (CAT) drawn from stoichiometry and mole concept. The instrument was pilot tested and Kuder Richardson formula 21 (KR21) was used to establish the reliability coefficient (r = 0.7). Pre-test was administered to both

the experimental and control groups to ascertain if the two groups are comparable and have the same entry characteristics before the treatment. A post-test was administered to both groups after two weeks of exposing the experimental group to mastery learning and the control group to conventional teaching method.
Data were analysed using descriptive statistics and independent sample t-test.

3. Results and discussion

3.1 Pretest Scores in Chemistry

Table 1. t-test of Pre-test Scores in Chemistry of Mastery Learning and Control Groups

Group	n	$\bar{x}$	s	df	t	P
Mastery Group	207	31.88	8.024	399	0.616	0.538
Control Group	194	31.44	6.148			

P>0.05

Table 1 presents the pre-test scores of the mastery learning and control groups in quantitative chemistry. This is to find out how comparable the groups are before treatment. The mean scores of the mastery and control groups are 31.88% and 31.44% respectively. There is no significant difference in their scores (P>0.05). This implies that the two groups were comparable before the treatment.

Table 2. Frequency Distribution of Post-test Scores in Chemistry of the Mastery learning and Control Groups

Score (%)	Relative Frequency (%)	
	Mastery Group	Control Group
Below 40	0	0
40-49	0.48	49.48
50-59	3.38	7.73
60-69	14.02	7.23
70-79	13.04	18.03
80 and Above	69.08	17.53
Total	100	100

Table 2 shows that 69.08% of the students in the mastery learning group scored 80% and above in the post-test while only 17.53% of the students in the control group attained this level. About half of the students (49.48%) in the control group scored between 40 and 49 whereas less than one percent (1%) of the students in the mastery learning group scored in this range.

3.2 Post-Test Scores in Chemistry

Table 3. t-test of Post-test Scores in Chemistry of Mastery Learning and Control Groups

Group	n	$\bar{x}$	s	df	t	P
Mastery Group	207	78.2	9.90	399	14.92	0.000
Control Group	194	58.4	16.07			

P<0.05

Table 3 shows that there is significant difference between the cognitive learning outcome in quantitative chemistry of the mastery learning group and the control group (P = 0.00). The effect size is 0.60. This is substantial.

The mean score in the post-test for mastery learning group was 78.2% and the standard deviation was 9.90 and the mean score in the post-test for control group was 58.44% and the standard deviation was 16.07 (Table 3). The mean difference is (78.2 - 58.4 = 19.8) which is highly significant t(399) = 14.92, P<0.05. The effect size is 0.60. The effect size of treatment on the cognitive learning outcome of the students is substantial. Treatment accounted for variation in learning outcome (mean difference = 78.2% - 58.4% = 19.8%). The mean score (78.20%) of the students in the mastery learning group is a distinction score and is more than one standard deviation higher than that of the control group which is 58.44% (Table 3). Similarly, about half (50%) of the students receiving conventional instruction scored between 40%-49% whereas less than 1% of the students in the

mastery learning group were in this group.

The result implies that mastery learning teaching method is more effective and better in enhancing students' cognitive learning outcome. This finding is consistent with that of Bloom (1981) who found in his study that students performed at least 80% or higher on a test with the application of mastery learning principles. The result of this study showed that the mean score for the mastery learning group was 78.2% which is consistent with Bloom's findings. The result is also consistent with Ajogbeje (2012), Majid and Zahra (2010), Olufunmilayo (2010), Patricia and Johnson (2008), Ozedemi (2008), Kazu, Kazu and Ozedemi (2005), Adeyemi (2007), Wachanga and Gamba (2004), Abadom (2002), Olopade (2002) who found that mastery learning teaching method improves students' achievement better than the conventional teaching method. Mastery learning accounted for the high cognitive learning outcome of the students in mastery learning group.

4. Recommendations

The curriculum should be planned based on mastery learning principles and chemistry teachers should be encouraged to adopt mastery learning approach of teaching in order to enhance the cognitive learning outcome of students in quantitative chemistry.

5. Conclusion

The cognitive learning outcome of Senior Secondary School chemistry students has been poor over the years in Nigeria. Several factors have been shown to be responsible for this, including inefficient teaching methods. The results of this study showed that mastery learning teaching method significantly improved students' learning in quantitative chemistry better than the conventional teaching method which is consistent with previous studies. Perhaps the adoption of this strategy as a regular means of teaching quantitative chemistry could lead to a massive reduction of the failure rate in chemistry.

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APPENDIX A

Students' Performance in Senior Secondary School Certificate Examination in Chemistry from 2002 to 2011

Year	Total Entry	% that sat for the Examination	% Credit & above Grade	% Pass Grade (D7 & D8)	% Fail Grade (F9)	% Pass & Fail Grade (D7, D8 & F9)
2002	271372	96.85	34.42	29.47	36.09	65.56
2003	288324	97.84	50.98	24.26	21.84	46.10
2004	275978	98.07	38.97	26.38	34.19	60.57
2005	357658	97.84	50.94	18.71	27.28	45.99
2006	389462	97.59	44.90	22.73	30.11	52.84
2007	432230	97.79	45.96	24.76	26.33	51.09
2008	428513	97.65	44.44	27.41	26.39	53.80
2009	138004	93.35	43.40	20.15	23.04	43.19
2010	138321	92.53	39.12	23.13	27.14	50.27
2011	172137	92.73	35.53	21.98	35.68	57.66
Average %			42.87%	23.90%	28.81%	52.71%

Source: West African Examinations Council (WAEC)

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