

MASTERY LEARNING INSTRUCTIONAL STRATEGY: EFFECT ON STUDENTS' ACADEMIC PERFORMANCE AND ACQUISITION OF SCIENCE PROCESS SKILLS IN SENIOR SECONDARY SCHOOL SCIENCE

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Abstract

Achievement in Senior Secondary Science has over the years been appalling. Literature linked this decline with inappropriate instructional strategies. On the basis of this, the effect of Mastery Learning was investigated. Prettest, Posttest, Control group quasi-experimental design was adopted. Three null hypotheses were tested. Mastery Learning Instructional Strategy and the Conventional teaching strategies were the treatment. 155 SSII Science students from two schools in Ilorin metropolis participated. Instruments used were Science Achievement Test (.71) and Science Process Skill Inventory (.73). Analysis of Covariance and Estimated Marginal Means were used for data analyses. Result showed that Mastery Learning Instructional Strategy was more effective in enhancing achievement and acquisition of Science Process Skills than the Conventional Teaching Strategy indicating that Instruction had significant effect on achievement ($F_{(1,155)} = 107.465, p < .05$) and acquisition of SPSs ($F_{(1,155)} = 93.593, p < .05$). Gender did not have any effect on achievement ($F_{(1,155)} = 1.364 P > .05$) and acquisition of SPSs ($F_{(1,155)} = 1.129 P > .05$). Interaction of treatment and gender could not produce any significant effect on achievement and acquisition of Science Process Skills ($F_{(1,155)} = 1.925 P > .05$ and $F_{(1,155)} = .726 P > .05$ respectively). Recommendation was that MLIS be adopted in teaching and learning of Science at the Secondary School level as it is not gender sensitive.

Key Words: Mastery learning, instructional strategy, science process skills, academic achievement

Introduction

A modern and vibrant education system entails wide-ranging activities that would ensure functional, qualitative education of

the highest possible standards at basic, post-basic and tertiary levels. Ibidapo-Obe (2010), expressing his views on Vision 2020 and its attainment, opined that achieving the Vision is very possible if we focus on quality education, especially in Science and Technology and pursue it consistently. This view aligns well with Owolabi (2013), where he expressed that Science is an integral part of human life, impacting on every sphere of it so much so, that it is intricately linked with a nation's development. Furthermore, the National Policy on Education stipulates that Secondary School education should equip students with viable means to live effectively in modern age of Science and Technology (FME, 2004). Science therefore, is receiving much emphasis in education because it is a great enterprise which nations depend on in order to advance technologically.

Onasanya and Omosewo (2011) have also described Science as the foundation upon which the bulk of present day technological breakthrough is built. Through Science, man has been able to understand his environment better. This has enabled him to manipulate the environmental conditions to his benefits and acquire his needs faster and better.

The awareness of the vital role of Science and Technology in National development has prompted both the developed and developing countries of the world to include Science and Technology subjects in their school curricula right from the first stage of learning; the Primary school (Oriahe, Uhumuavbi & Aguele, 2010).

According to them, the proper teaching and handling of Science and Technology subjects in schools will result in the training of the minds of students in the understanding of the world around them, in the acquisition of appropriate skills, capacities, competencies necessary for them to live and contribute to the development of their society.

Literature, (Ango, 2002, Nwagbo & Chukelu, 2011) has widely shown that in today's information age, for educational system to be relevant and fitting into the pace of things, they should provide students with information acquisition skills instead of directly providing them the information they need. As opined by Padilla (1990), one of the most important and pervasive goals of schooling today, is to teach students to think, and that all schools' subjects should share in accomplishing this overall goal. He further emphasized that Science, more than any other discipline contributes its unique skills, with its emphases on hypothesizing, manipulating the physical world and reasoning from data, towards attaining this goal. The main goal of Science teaching therefore should be to help students understand the nature of Science and how to use scientific enquiry methods, and thus improve students' achievement in Science subjects by so doing.

Because of the importance and relevance of science to the individual and the society, the National Policy on Education (2013) on Senior Secondary School stipulates that, at least one science subject must be offered at the Senior Secondary School as part of

the core subject requirement for graduation from this level of education, irrespective of the students' subject combination. For the students of Science, three main Science subjects; Physics, Chemistry and Biology are compulsory while a majority of other students in the commercial and arts classes often offer Biology as their compulsory Science subject.

Science as an area is a precursor for many fields of learning, contributing immensely to the technological growth of the nation (Nwagbo & Chukelu, 2011). These they highlighted to include Medicine, Forestry, Agriculture, Biotechnology and Nursing. The study of Science in Senior Secondary Schools can equip students with useful concepts, principles and theories that will enable them to face the challenges before and after graduation, particularly in today's information communication technology driven age. The National Policy on Education (2013) and the Science curriculum see Science as a practical and inquiry-oriented area that should be taught practically, that is, involving the students in the art of doing (Okoye & Okechukwu, 2006). They submit that when the students are involved in 'doing science' in the study of Science contents and concepts, science process skills such as careful observations, classification, measurement, inference, communication, interpreting, predicting events, designing experiments, organizing information, reporting and generalization will be acquired (Ango, 2002, Sunyono, 2018).

The acquisition of these Science Process skills (SPSs) and enhancement of achievement in science cannot be realized except through the effective effort of the classroom teacher working through effective learning strategies (Nwagbo & Chukelu, 2011). Ajaja and Kpangban (2000) asserted that what the student knows or does not know depends mainly on the teacher. A number of factors have been identified as contributing to the non-acquisition of skills by students which invariably lead to poor academic performance and one of the factors according to them is the teacher's method of teaching or strategy adopted (Ezike (2012), Othman, Amiruddin & Mansori (2015) in Amiruddin and Zainudin, 2015). Okoli (2006) indicated that many science teachers prefer the traditional expository method shying away from the activity oriented strategies that are more learner-centred. Nwagbo (2008) observed that such teacher-centred approaches do not enhance academic performance or promote the acquisition of Science Process Skills. In the same vein Williams and Ochiama (2018) are of the view that productive and rewarding outcomes of instructional process depend upon effective teaching methods and this is why researchers are trying to find out constructive, productive and worthwhile methods at every level.

Science educators over the years have been focusing attention on how to improve Science instruction in schools by going beyond the stereotypic methods of obtaining knowledge in science (Okoye & Okechukwu, 2006). Ariyo (2011) noted that

this is more so as the academic achievement of students in the sciences has been a subject of concern to major stakeholders in Science Education. Yoloye (2004) and Adeyemo (2005) adduced to several pedagogical factors, socio psychological variables as well as other attribute variables as correlates of the prevailing poor performance in Nigerian Secondary School sciences. To this effect, Okoye (1999), Okebukola (2002) and Okechukwu (2003) have shown that Biology teachers and indeed all science teachers should therefore be equipped with the right teaching strategies for effective learning to take place. They share the opinion that if learning experiences are based on sound pedagogical principles of learning, taking into account learner characteristics, it may be possible for a majority of learners to attain all the competencies necessary for good performance.

It is against this background that this study investigated the effects of Mastery Learning on the acquisition of Science Process Skills (SPS) and the achievement of students in Senior Secondary School Science. Mastery learning Instructional Strategy (MLIS) is an instructional approach where students are allowed unlimited opportunities to demonstrate mastery of content they are taught.

Mastery learning as an instructional strategy was introduced into the pedagogical literature by Bloom (1968) while working to develop what he considered a better approach to instruction. While appreciating the value of

traditional practice, pointed out that it was vital for teachers to assess students' learning at the end of the unit, and also use classroom assessment as learning tools both to provide students with feedback on their learning progress and to guide the correction of learning errors. Assessment should be used as part of the instructional process diagnose individual learning difficulties and prescribe remediation procedure. He outlined a specific instructional strategy to make use of this feedback and corrective procedure describing it as learning for Mastery.

Commenting on mastery learning, Guskey (2007) wrote, a classroom with a Mastery Learning focus as opposed to traditional form of instruction would reduce the achievement gaps between groups of students. The basic theoretical assumption of MLIS is that students must have predetermined sets of necessary skills and knowledge in order to achieve their learning objectives (Amiruddin and Zainudin, 2015). The concept of Mastery learning is attributable to behaviourism principles of operant conditioning. The theory states that learning occurs when an association is formed between a stimulus and response (Skinner, 1984). The learner is therefore expected to exhibit behaviour that is both observable and measurable which is an indicator that learning has occurred. This agrees with Anderson's (2000) and Filgona's (2016) comments that to demonstrate mastery over each lesson, students must be able to overtly show evidence of understanding before moving to the next lesson. Also Guskey (2007) in Amirudin (2015) wrote that the theoretical

basic assumption of MLIA is that students must have predetermined set of necessary skills and knowledge in order to achieve their learning objectives

Apart from the influences of instructional strategies on learning outcomes, gender is also often implicate in students' achievement in science, though often as intervening variable (Yoloye, 2004). Literature (Alele, 1999, Okeke, 2007, Amelink, 2009, Nwagbo & Chukelu, 2011, Ariyo, 2011) has shown that the issue of gender and gender stereotyping permeate every aspect of human endeavour, with the consequences cutting across social, economic, political and educational development, especially in the areas of Science and Technology.

However, there have been conflicting reports with respect to gender and achievement in Science (Igwe, 2002). International trends reveal mixed results with regard to the gender difference in Science achievement. In some instances, such as course work completed, females perform equal to their male peers, however, assessment geared towards measuring mastery of content, reveal that differences between male and female education surface in Elementary School and continue at the High School level (Ingels & Dallon, 2008). Differences in Science achievement at the higher level are attributed in part to fewer females attaining degrees in Science, Technology, Engineering and Mathematics (STEM) fields (Madigan, 1997, Hazari, Tai & Saddler, 2007). This study is theretofore

expected to contribute to the ongoing debate.

Empirical studies (Wambugu & Changieywo, 2007, Oloyede, 2010, Abakpa & Iji, 2011, Jacobson & Obomamu, 2011, Dorgu, 2012, Amiruddin & Zainudin 2015, Williams & Ochiama 2018) on the use of MLS in Africa and Nigeria in particular, have also consistently reported significant higher performance in students for which it was employed, in a given task. Other research findings also suggest that MLS yields greater interest and more positive attitudes in various subjects than non-Mastery learning strategies (Ngesa, 2002, Wachanga & Mwangi, 2004). These studies have been done mostly in areas of Mathematics, Physics, Chemistry, Social studies and English Language. Be that as it may, performance indicators in Nigerian education, continue to show dismal deterioration, rather than improvement, in standard of education generally, and in Secondary Science and Mathematics in particular. All stakeholders in education keep calling for ways to curb this debilitating trend in performance, which is a bane for the nation's development. It has become imperative therefore, that very urgent intervention strategies be put in place to stimulate the desired changes. An experimental study of the effect of Mastery Learning Instructional Strategy on Students' academic performance and acquisition of Science Process Skills and in Senior Secondary Science could be a pointer to an effective pedagogical strategy for positive change.

Purpose of study

The main purpose of this study was to investigate the Effect of Mastery Learning Instructional Approach on students' academic performance and acquisition of Science Process Skills in Senior Secondary School Science

Research hypotheses

For the purpose of this study, three null hypotheses were postulated and tested at .05 level of significance.

H₀₁. There is no significant effect of treatment on students':

- (a) Performance in Senior Secondary School Science and
- (b) Acquisition of Science Process Skills

There is no significant main effect of gender on Students'

- (a) Academic performance in Senior Secondary school Science and
- (b) Acquisition of Science Process skills.

H₀₃. There is no significant interaction effect of treatment and gender on students':

- (a) Academic performance and (b) Acquisition of Science Process Skills in Senior Secondary School Science

Methodology

Research design: The study adopted a pre-test, post-test, control group quasi-experimental design

Population: The target population for this study was Senior Secondary two (SSII) Science students in all the Senior Secondary Schools in Ilorin Central of Kwara state.

Sample and Sampling Procedure One hundred and fifty-five (155) Senior Secondary two (SSII) Science students drawn from two mixed, public schools in Ilorin metropolis were used for the study. SSII students were used because they are the most stable and relevant class of Senior Secondary students, not fresh in Senior Secondary School Science like the SSI class, and not preparing for terminal national examinations like the SSIII class. Purposive sampling technique was used to select both the schools and students. This was well suited for the study because given the nature of the study, existing student' classes had to be used intact.

Instruments

Two instruments were used. They are the Science Achievement Test (SAT) and Science Process Skills Inventory (SPSI).

(i) Science Achievement Test (SAT)

The SAT was a 30-item multiple choice objective test with four options lettered A, B, C and D. The test covered topics selected from Biology, Chemistry and Physics. The SAT measured the students' level of mastery of the instructional content before and after the treatment.

The construction of the test covered the six major levels of the cognitive domain (Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation). These six levels were condensed into three following the scheme used by the Educational Testing Service in order to overcome the difficulty of generating items which adequately measures these levels (Okpara and Onocha, 1995). The condensed form is given as follows: Remembering (Knowledge)-Recall, Understanding (Comprehension and Application) and Thinking (Analysis, Synthesis and Evaluation). Content validity of the SAT was established by two Science experts in University of Ilorin Secondary School. It was administered to a parallel sample 30 students that were not part of the experiment It was scored and used for reliability estimation. A coefficient of 0.71 was obtained using KR-20.

(ii) Science Process Skills Inventory (SPSI)

The Bourdeau and Arnold (2009), SPSI was adopted to measure the students' level of acquisition of Science Process Skills for this study. The inventory is an 11-item Likert scale type questionnaire designed to measure the six basic science skills. Each item consists of a statement describing a skill expressed by; Never (N), Sometimes (S), Usually (U), and Always (A). This was also completed by each student before and after the treatment. The inventory was administered to the same thirty randomly selected SSII students used for the BAT to establish the reliability. Cronbach's alpha calculated yielded a coefficient of 0.73.

Research procedure

Since intact classes were used for the study in both the experimental and control groups, the regular Science teachers in the two schools were used to do the teaching. The research covered a total period of six weeks. Week one was used to train the teachers for the treatment, and administration of the SAT and SPSI pre-tests to the two groups. Week two to week five (4 weeks) were used to implement the teaching (treatment).

Week six was used for the administration of SAT and SPSI post tests following treatment. Two broad topics: The chosen topics taken from the school scheme of work as at time of study, were taught to the two groups for twelve 35 minutes lesson periods in the four weeks of treatment by the Biology, Chemistry and Physics teachers. The researchers designed lesson plans for the experimental and control groups with the same, instructional objectives, instructional materials, teachers' and students' activities (which included lots of hands on and practical activities, to enhance students acquisition of skills); and notes of lesson.

The experimental group's teacher taught the class, using the lesson plans prepared for the group, using the MLIS. The lesson plan used here differed slightly from that of the control group's with the inclusion of two short responses, (2-3 items) formative test in each of the lessons. The teacher administered one of the tests at the end of each lesson and got the students to exchange and mark them to get the intermediate picture of their performance.

The teacher began each next lesson by discussing the corrections to the previous test and goes on over the last lesson when less than 80% of the class could not answer all the questions correctly. The teacher then administered the second equivalent test for the lesson in such a case but moved on to the new lesson only when satisfied that at least 80% of the class answered all the formative questions correctly. This means that students who have not mastered the learning unit will be required to undergo remedial instruction (Hussain and Suleiman 2016; Filgona, Filgona and Linus 2017; Barr & Wessel 2018). The teacher for the experimental group had to give extra lessons, for an hour during evening prep period of the class for two days in each of the first two weeks of the four weeks of treatment to keep up with the scheme of work.

Data Analysis

The data collected were analysed using Analysis of Covariance (ANCOVA) and Expected Marginal Means

Results

The result of this study was based on the three stated null hypotheses tested at 0.05 level of significance.

H_{01a}. There is no significant main effect of treatment on Students' performance in Senior Secondary school Science. To test this hypothesis, Analysis of Covariance (ANCOVA) was carried out and the result is presented in Table 1.

Table 1: Summary of ANCOVA of Post-test Achievement scored by Treatment

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1604.702	4	401.175	37.656	.000	.374
Intercept	16921.482	1	16921.482	1588.303	.000	.379
Pre-test	40.676	1	40.676	3.818	.053	.064
Treatment	1144.915	1	1144.915	107.465	.000	.237
Gender	14.533	1	14.533	1.364	.205	.014
Treatment * Gender	20.504	1	20.504	1.925	.050	.031
Error	1598.072	150	10.654			
Total	80886.000	155				
Corrected Total	3202.774	154				

a. R Squared = .501 (Adjusted R Squared = .488)

The data above show a significant main effect of treatment in Science ($F_{(1,155)} = 107.465, p < .05$). Based on this finding, the hypothesis was rejected showing that the

strategy of instruction had effect on achievement. In order to show how the two groups performed, Estimated Marginal Means (EMM) was used and the result is presented in Table 2 below.

Table 2: Estimated Marginal Means of Post test Achievement Scores according to Treatment

Grand Mean				
Dependent Variable: Post-test				
Mean	Std. Error	95% Confidence Interval		
		Lower Bound	Upper Bound	
22.523 ^a	.286	21.957	23.089	

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 8.55.

Treatment: Instructional Strategies

Dependent Variable: Post-test Instructional Strategies	Estimates			
	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Experimental Group Mastery Learning	25.492 ^a	.392	24.717	26.267
Control Group Conventional Teaching Strategy	19.553 ^a	.418	18.728	20.379

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 8.55.

From the data in the EMM Table, the grand mean is 22.523 for achievement. The data revealed that Mastery Learning Instructional Strategy had higher adjusted mean score of 25.492 while the Conventional Teaching Strategy (Control) had an adjusted mean of 19.553.

H_{01b}. There is no significant main effect of treatment on acquisition of Science Process Skills. ANCOVA was carried out to test the hypothesis and the result is presented in Table 3.

Table 3: Summary of ANCOVA of Post-test Achievement scored by Gender

Tests of Between-Subjects Effects

Dependent Variable: Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3134.012 ^a	4	783.503	30.777	.000	.451
Intercept	8439.719	1	8439.719	331.523	.000	.688
Pretest	38.201	1	38.201	1.501	.222	.010
Treatment	2382.636	1	2382.636	93.593	.000	.384
Gender	28.729	1	28.729	1.129	.290	.007
Treatment * Gender	18.491	1	18.491	.726	.395	.005
Error	3818.607	150	25.457			
Total	161035.000	155				
Corrected Total	6952.619	154				

a. R Squared = .451 (Adjusted R Squared = .436)

The data show a significant main effect of treatment on students' acquisition of Science Process Skills ($F_{(1,155)} = 93.593, p < .05$). Based on this finding, the hypothesis was rejected showing that the instructional

approach had effect on the acquisition of Science Process Skills. In order to show how the two groups performed, Estimated Marginal Means (EMM) was used and the result is presented in Table 4.

Table 4: Estimated Marginal Means of Post test Achievement Scores according to Treatment

Grand Mean				
Dependent Variable: Post-test				
Mean	Std. Error	95% Confidence Interval		
		Lower Bound	Upper Bound	
31.707 ^a	.441	30.836	32.578	

Treatment: Instructional Strategies

Estimates				
Dependent Variable: Post-test				
Instructional Strategies	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound

Experimental Group Mastery Learning	36.023 ^a	.606	34.826	37.220
Control Group Conventional Teaching Strategy	27.391 ^a	.648	26.111	28.672

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 17.64.

From the data in EMM Table, the grand mean is 31.707 for acquisition of Science Process skill. The data revealed that Mastery Learning Strategy had higher adjusted mean score of 36.023 while the Conventional Teaching Strategy (control) had an adjusted mean of 27.391 which is lower than the grand mean.

H₀₂. There is no significant main effect of gender on Students' (a) achievement in Senior Secondary school Science and (b) acquisition of Science Process skills. From the ANCOVA summary, Table 2, it could be seen that there was no significant effect on gender on students' achievement in Science ($F_{(1,155)} = 1.364$ $P > .05$). Based on this result, hypothesis 2 was not rejected. This means that gender did not produce any remarkable change in the achievement of students in Science. In like manner, gender did not have any effect on the Acquisition of Science Process Skills ($F_{(1,155)} = 1.129$ $P > .05$) as shown on the ANCOVA summary of Table 3. Therefore hypothesis 2 (b) was also rejected.

H₀₃. There is no significant interaction effect of treatment and gender on

(a) students' achievement in Senior Secondary School Biology and

(b) acquisition of Science Process Skills

From the ANCOVA summaries, Table 1 and 3, it could be seen that there were no significant interaction effect of Treatment and Gender on students' achievement in Science ($F_{(1,155)} = 1.925$ $P > .05$) and Acquisition of Science Process Skills ($F_{(1,155)} = .726$ $P > .05$) respectively. Based on this result, both hypotheses were not rejected. This means that the interaction effect of Treatment and Gender did not produce any remarkable changes in the achievement of studies in Biology and Acquisition of Science Process Skills.

Discussion

The results of this study show significantly higher performance in Science and Acquisition of Science Process Skills among the experimental group exposed to MLS during treatment as opposed to those taught using the Conventional Teaching Strategy. This is so because of the nature of the experimental strategy which requires that lessons are repeated until about eighty percent success is achieved. In the process, elaborations are made which enhances understanding and hence improves achievement and acquisition of Science Process Skills. Even in Nigeria and around Africa with their peculiar needs and context, studies have shown MLS to be most suitable for improving students' performance in Science subjects and acquisition of Science Process Skills. Filgona, Filgona & Linus

(2017) worked on the effects of Mastery Learning Strategy and Learning Retention on Senior Secondary School Students' achievement in Physical Geography. The results of the study revealed that Mastery Learning Strategy improved the students' learning retention and achievement compared to traditional method. Hussain & Suleman (2016) reported that Bloom's mastery learning approach had a positive effect on students' academic achievement and retention compared to traditional learning approach. Salami (2001), found that MLS was quite effective in bringing about a difference in the academic achievement in Chemistry of students in the experimental class than close in the control group. Ango (2002) carried out a study with the MLS on the acquisition of Science Process Skills, Wambugu & Changeiywo (2008) used the strategy in teaching Physics among Secondary School students, Oloyede, (2010) used the strategy in an experimental study in teaching Chemistry and Abakpa & Iji (2012) used it to teach Geometry, a branch of Mathematics. Also Dorgu (2012) found that the strategy was effective in enhancing achievement in Christian Religious Studies than the conventional teaching strategy.

Gender on the other hand was found to have no statistically significant effect on Students' achievement in Biology and acquisition of Science process skills. The result of this study is an indication that MLS improve the achievement scores of both male and female students in post BAT and SPSI equally. The non significant difference in the mean achievement scores

is an indication that the MLS minimizes gender difference in understanding learning instruction. This is line with Olele (2002) who also found that Mastery Learning does not produce any difference in the achievement of male and female students in English Language. The studies showed that there is no gender difference when good teaching method is used. However, it disagrees with the views of Abiam and Odok (2006), Akinsola (2007), Eng, Li and Julaihi (2010), and Vale (2009) who reported that female students are weaker in some area of Mathematics and Science than the male students. Dorgu (2012) also reported that male students performed better in CRS when taught with the MLS.

Conclusion and Recommendations

The findings of the study confirms that Mastery Learning Strategy with its guaranteed positive impact on students' learning, essentials skill acquisition and achievement, is workable even with all the factors militating against Secondary School Science teaching an learning in Nigeria. It may as well be the panacea of pedagogical change we need to curb the falling trend of Secondary Science Education.

On the basis of this conclusion, this paper recommends as follows:

- Building formative assessment into lessons for learners' feedback and correction should be introduced at policy level.
- Rigorous teacher training and retraining of teachers are

expedient to change the typical science teacher's attitude towards seeing science teaching as more of doing than talking; being contented with the normal curve trend of students' achievement as okay, as well as train the teacher in the MLS' more effective use of classroom assessment and time to suit learner characteristics.

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