

Effect of Three Steps Metacognitive Instructional Model on Students' Achievement in Basic Science

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ABSTRACT

This study investigated the effect of three steps metacognitive instructional model (3-step MIM) on students' achievement in Basic Science. Two research questions and three null hypotheses guided the study. A non-equivalent control group quasi experimental design was employed. A sample of 140 JS1 students from four public co-educational secondary schools in Ankpa Local Government Area of Kogi State, Nigeria was used. Two schools were assigned to the experimental and control groups respectively. The experimental groups were exposed to 3-step MIM while the control groups were exposed to the expository instructional method (EIM). The research instruments used for data collection were Basic Science Achievement Test (BSAT). Mean and standard deviation scores were used to answer the research questions while the Analysis of Covariance was used to test the null hypotheses. The result revealed that the students taught using 3-step MIM achieved higher than those taught with the EIM ($P < 0.05$). It was recommended that teachers should employ participatory activity-based and learner centered instructional methods like the 3-step MIM in the teaching and learning as this will enhance cognitive domain of the students in Basic Science.

Introduction

The Universal Basic Education (UBE) Programme which is a 9-Year continuous schooling from the primary to junior secondary school (J.S.S.) was introduced in 1999 by the Federal Government of Nigeria. The purpose of this programme was for a functional and qualitative education of the Nigerian child, in order to enhance national development. The UBE programme was planned so as to help Nigeria achieve the Millennium Development Goals (MDGs). The MDGs was translated into the critical targets of the National Economic Empowerment and Development Strategies (NEEDS), (Nigerian Educational Research and Development Council NERDC, 2013). It is against this background that the Federal Government of Nigeria restructured and re-aligned the then existing curriculum of education for primary the school and the Junior Secondary School (JSS) to fit into the 9-year Basic Education Programme (Igbokwe, 2015).

The philosophy of the revised 9-year basic education programme in Basic Science is that every learner who has gone through the new curriculum should have acquired: appropriate levels of literacy, numeracy, communicative and manipulative life skills among others needed for laying a solid foundation for a life-long learning, as a basis for scientific and reflective thinking (NERDC, 2013). Elaborating on the objectives of the revised 9-year basic education curriculum in Basic Science the NERDC, (2013) enunciated that the objectives are to enable the learners to: develop interest in science and technology; acquire basic knowledge and skills in science and technology; apply their scientific and technological knowledge and skills to meet societal needs; Take advantage of the numerous career opportunities offered by science and technology and become prepared for further studies in science and technology.

Over the years, the performance of students in Integrated Science now Basic Science has been on the decline in the Junior Secondary Certificate Examination (JSCE) in Ankpa Local Government Area (LGA) of Kogi State, Nigeria (Statistics unit: Kogi State Post Primary School Education Board Lokoja. 2012-2016 session). The result is such that most of the candidates who sat for the JSCE in Basic Science failed to obtain credit pass in the subject that would enable them take to core science subjects at the Senior Secondary School (SSS.) level and consequently do not take up scientific studies and future careers in science.

Studies however, have shown that the objectives of the UBE programme has not been achieved. Also there has been poor performance of both male and female students in Basic Science (Okunuga, Ojo, & Yewande, 2013; Oludipe, 2012). This poor performance of students in Basic Science was attributed to the predominant use of the lecture instructional method of teaching the subject. This method emphasizes learning through the teacher's guidance at all times (Ekon, 2012). Thus, there was a need to use a student centered method of teaching the revised curriculum for Basic Science and compare its efficacy with the expository instructional method (EIM) on the learners.

In order to achieve a holistic presentation of the objectives of the revised UBE programme for Basic Science for both male and female students, and also be in line with global best practices in science, the use of innovative teaching methods to teach the subject is paramount (Adesikeola, 2015). Studies on innovative methods which includes those of Nwosu, (2015); Jayapraba, (2013); Ekon, (2012); and (Ayogu, 2011) have shown that with student centered method, and when students interact with their environment, their learning outcome is enhanced. Research work on metacognitive instructional model (MIM) using its relevant strategies has been recommended as an effective method that could enhance learning (Oludipe, 2012; Ayogu, 2011; Flavell, 1976).

Metacognition is a learning process that focuses on higher order thinking. It involves active control over the cognitive processes (attention, recognition, memory storage, memory retrieval, inferring, comparing, and analyzing) which are involved in learning situations (Flavell, 1979). It is an appreciation of what one already knows, which is connected with a correct comprehension of a learning task, and what knowledge and metacognitive skills it requires to accomplish the learning task (Peirce, 2003). The 3-step MIM adopted in this study is concerned with: the modification of concepts and beliefs (prior conceptions) which learners bring into the classroom; selecting thinking strategies; and planning, monitoring and evaluating thinking processes (Blakey and Spence, 1990). However, there is paucity of literature on the use of 3-step MIM in teaching Basic Science in the revised 9-year Basic Education Programme to ascertain its effect on enhancing both male and female students' achievement in Basic Science.

Academic achievement has been described as the scholastic standing of a student at a given moment. It refers to how an individual is able to demonstrate or apply his/her intellectual abilities. The scholastic standing could be explained as the grades a student obtained in a course or group of courses taken within a stipulated period (Egbo, 2014). Thus, stake-holders in education have a great role to ensure that students receive and achieve the best quality learning that would broaden their outlook and knowledge in the society. Studies that compared lecture method with strategies on Metacognitive Instructional Model indicated that the lecture method used in teaching Basic Science did not improve the academic achievement of the students (Okpara and Eze-Odurukwe, 2011; Ekon, 2012; Ayogu, 2011).

Also research works aimed at gender and different teaching methods on students' academic achievement were inconclusive and conflicting in their findings: Oludipe, (2012); Bassy, Joshua, and Asim, (2008); Ezedinma, (2007); Erinsho, (2005); Onyeizugbo, (2003); Ukwungwu, (2002). This has necessitated the need to determine the effectiveness of 3- step MIM to find out its efficacy on students' academic achievement and compare it with the expository instructional method (EIM) in Basic Science. Another factor is that Basic Science differs remarkably from Biology, Chemistry, Physics and Mathematics in which metacognitive strategies have been studied, both in scope, content and method of instruction (Egbo, 2014; Ekon, 2012; Ayogu, 2011).

Purpose of the Study

The main purpose of this study was to determine the effect of 3-step MIM on students' academic achievement in learning Basic Science. Specifically, the study determined the:

1. Mean achievement scores of students taught Basic Science content with the 3-step MIM and those taught same content with the EIM.
2. Mean achievement scores of male and female students taught Basic Science content with the 3-step MIM
3. The interaction effects of methods and gender on students' academic achievement in Basic Science.

Research Questions

The following research questions guided the study:

1. What is the mean achievement test scores of students taught Basic Science content with the 3-step MIM and those taught the same content with the EIM?
2. What is the mean achievement test scores of male and female students taught Basic Science content with the 3-step MIM?

Hypotheses

The following formulated null hypotheses (Ho) guided this study;

Ho1. There is no significant difference between the mean achievement test scores of students taught Basic Science with the 3-step MIM and those taught with the expository instructional method in Basic Science.

Ho2. There is no significant difference in the mean achievement test scores of male and female students taught Basic Science with the 3-step MIM.

Ho3. There is no significant interaction effect of methods and gender on students' mean achievement test scores.

Research Method

The design of this study was quasi-experimental design. Specifically, the quasi experimental design that was used was the non-equivalent, control group design. This design was used because of non-randomization of the subjects.

The population for the study consists of all the 1,773 students from the twenty-two (22) public co-educational secondary schools in Ankpa Local Government Area of Kogi State (Statistics Unit: Kogi State Post Primary School Management Board Lokoja, 2016/2017 session). Co-educational schools were used since gender effect was investigated in this study.

The sample size was made up of 140 JS 1 students comprising 72 males and 68 females. Simple random sampling was used to draw four secondary schools out of the 22 government-owned co-educational secondary schools in the area of the study. Two out of the four (4) sampled schools were randomly assigned to experimental and control groups respectively. In each of the sampled school one intact arm of JS 1 class was randomly assigned for participation as experimental or control group.

Procedure

Two instructional methods were used for this study. The instructional packages that were used for the two teaching methods were the same in terms of instructional objectives and instructional content. The researcher provided lesson plans, notes of lesson involving the methods 3-step MIM and expository instructional methods also teaching aids/materials for both groups respectively. The main difference was on the instructional methods where the research assistants (RAs) for the experimental groups used the 3-step MIM to teach. The 1st step of the method is: Connecting new information to previous knowledge. The teacher (research assistance- RA) will interact with the students by asking them questions so as to identify any alternative conception or misconception before introducing the new lesson. Step II: Selecting thinking strategies. The teacher asks the students questions based on the

displayed teaching materials or topic to be taught. Step III: Planning, monitoring, and evaluating the thinking processes. Planning (P):

The teacher groups the students heterogeneously based on mixed ability, knowledge, gender, ethnicity etc. and presents different food items (as shown in the chart below) to each group to observe and note down comments on their observations and discussions. *Monitoring*: The teacher guides the students as they make efforts to answer the questions asked. She/he encourages the students to use self-questioning strategies. *Evaluation*: The teacher supports (bridges the gap between what the students find difficult to give the right answers) the students to reflect and evaluate what they have learnt as they answer questions asked.

Activity: The students are asked to come together and make their presentations to the class. A member from each group is given an opportunity to present what the group discussed. The second and subsequent groups are to add to what the first group did not mention. They are expected to write the correct answers to the questions below in their note book for future reference.

The RAs for the control groups used the expository instructional method. Both groups were given a pre-tests on BSAT to establish the students' entry status by their regular Basic Science teachers (RAs). The researcher equally developed marking scheme for the pretests BSAT. After the pre-test, the RAs commenced teaching using instructions on the lesson notes prepared by the researcher. The instructional intervention which was conducted during the Basic Science period on the school time table lasted for four (4) weeks. The instrument was then reshuffled and administered on the two groups as post- tests to determine the effect of the treatment on the students. The test items were scored one mark each for any correctly answered item. Data of the pretest and posttest from each of the two groups were recorded separately.

Training of Research Assistants (RAs) of both groups

The researcher organized a training session for the research assistants (RAs) of both groups (experimental and control groups). The content of the training was based on the use of the 3-step MIM for the experimental group and the expository instructional method (EIM) for the control group. Specifically, two topics: Family and Health; Energy and Materials for the Communities which are in the JS 1 section of the Basic Education Curriculum (BEC) in the area of Basic Science was selected for this study. The topics were chosen because they cut across every aspect of man and his environment at this level of education.

The training was carried out twice weekly for two weeks. The RAs for the experimental groups were trained on the use of 3-step MIM while the RAs for the control groups were trained on the use of EIM. The purpose of the training was to enable the RAs become conversant with the required instructional methods upon which this study was based. The researcher discussed the significance of the instructional model in this study during the training session. The RAs had a micro teaching exercise to ascertain the mastery of the expected methods they are using respectively.

The research questions were answered using mean scores and standard deviation. The research hypotheses were tested using analysis of covariance (ANCOVA). ANCOVA was used because the study subjects were not randomly selected. The pre-test scores were used as covariates to partial out the initial differences.

RESULTS

Research Question 1

What is the mean achievement scores of students taught Basic Science contents with the 3-step Metacognitive Instructional Model (3-step MIM) and those taught the same content with the expository instructional method?

Table 1: Mean and Standard Deviation of pretest and posttest achievement scores of Students taught Basic Science with the 3-step MIM and those taught with EIM

Teaching Methods	N	Pretest		Posttest		\bar{X} Gain
		\bar{X}	SD	\bar{X}	SD	
3-step MIM	72	14.94	4.19	22.52	4.17	7.58
CTM	68	14.97	3.85	19.81	4.54	4.84

Data in Table 1 reveal that students in the 3-step MIM group had a pretest mean score of 14.94 with a standard deviation (SD) of 4.19 and a posttest mean of 22.52 with SD of 4.17. The difference between the pretest and posttest mean was 7.58. The EIM group had a pretest mean of 14.97 with SD of 3.85 and a posttest mean of 19.81 with SD of 4.54. The difference between the pretest and the posttest mean for the EIM group was 4.84. For 3-step MIM and EIM, the posttest mean were greater than the pretest mean with the 3-step MIM having higher mean gain. This shows that the 3-step MIM was more efficacious in improving students' achievement in Basic Science.

Research Question 2

What is the mean achievement scores of male and female students taught Basic Science content with the 3-step MIM?

Table 2: Mean and Standard Deviation achievement scores of male and female students taught Basic Science with the 3-step MIM.

Method of Teaching	Gender	N	Pretest		Posttest		\bar{X} Gain
			\bar{X}	SD	\bar{X}	SD	
3 - step MIM	Male	72	14.80	3.62	23.03	4.12	8.23
	Female	68	14.94	4.42	22.05	4.23	7.11

Data in Table 2 indicates that the male Basic Science students' had a pretest mean score of 14.80 with a standard deviation (SD) of 3.62 and a posttest mean of 23.03 with SD of 4.12. The difference between the pretest and posttest mean was 8.23. The female Basic Science students taught with the 3-step MIM had a pretest mean score of 14.94 with SD of 4.42, and a posttest mean of 22.05 with SD of 4.23. The difference between the pretest and the posttest mean for the female group is 7.11. This revealed that the males taught with the 3-step MIM achieved higher (23.03 > 22.05) than their female counterparts. The difference in achievement was in favor of the male students.

Hypothesis 1

H₀₁: There is no significant difference between the mean achievement scores of students taught with the 3-step MIM and those taught with the expository instructional method (EIM) in Basic Science.

Table 3: Analysis of Covariance (ANCOVA) of the difference in the mean achievement scores of students taught Basic Science with the 3-step MIM and those taught with the EIM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1139.615 ^a	4	284.904	21.955	.000
Intercept	1343.719	1	1343.719	103.54	.000
BSATTOTAL	861.008	1	861.008	66.351	.000
Gender	6.520	1	6.520	.502	.480
Treatment	244.994	1	244.994	18.880	.000
Gender *Treatment	.606	1	.606	.047	.829
Error	1764.825	136	12.977		
Total	66267.000	141			
Corrected Total	2904.440	140			

Table 3 shows that an F ratio of 18.88 at significant level of 0.00 was obtained with regards to the difference in the mean achievement scores of Basic Science students taught with the 3-step MIM and those taught with the EIM. Since the associated probability (0.00) was less than 0.05, the null hypothesis (Ho₁) was rejected. Hence there is a significant difference in the mean achievement scores of students taught Basic Science with the 3-step MIM and those taught the same concept with EIM.

HO₂: There is no significant difference in the mean achievement scores of male and female students taught Basic Science with the 3-step MIM. Table 3 shows that the computed F ratio of the gender 0.50 at significant level of 0.48 was obtained with regards to the difference in the mean achievement scores of students taught Basic Science with the 3-step MIM. Since the associated probability (0.48) was higher than 0.05, the null hypothesis (Ho₂) was not rejected. Hence, there was no significant difference in the mean achievement scores of male and female students taught Basic Science with the 3-step MIM.

HO₃: There is no significant interaction effect of treatment and gender on the mean achievement scores of students in Basic Science.

Table 3 shows that the F-ratio of 0.05 with associated probability value of 0.83 was obtained with regards to the interaction effect of treatment and gender in students' mean BSAT scores in Basic Science. This indicates that the effect of treatment (3-step MIM) remains constant regardless of gender in Basic Science students. Since the associated probability value of 0.83 is greater than 0.05 (0.83 > 0.05), the null hypothesis (Ho₃) was therefore not rejected. Thus, there is no significant interaction effect of treatment and gender on students' mean achievement in Basic Science.

Major Findings

1. The students taught Basic Science with the 3-step MIM achieved significantly higher mean achievement scores than those taught with the EIM.
2. The male students had higher mean achievement scores than their female counterpart when taught Basic Science with the 3-step MIM.
3. There was no significant interaction effect of gender and treatment on students' achievement score in Basic Science.

Discussion

Table 1 revealed that the students taught Basic Science with the 3-step MIM scored higher than those taught with the EIM. This difference was tested further with the null hypothesis which revealed that there was a significant difference in the mean scores of the students' academic achievement when exposed to the 3-step MIM and compared with those taught with the EIM. This result was an indication that the treatment, (3-step MIM) helped the students in the experimental group to achieve higher scores than those taught with the EIM (control group). The result is in agreement with Oludipe, (2012); Ayogu, (2011); Rahman ur Fazal, (2010) who stated that MIM holds a great deal of promise in enhancing students' academic achievement. Many other studies have shown that the significant achievement of the students taught with 3-step MIM was as a result of the method of teaching which includes activity-oriented, student-centered and interactive in nature (Jayaraba, 2013; Ozsoya and Atama 2009). Researches done outside Nigeria by Rahman, (2010); Churchill et.al. (2011); Costa and Kalick, (2008) confirmed these findings of higher achievement using metacognitive strategies in learning. The studies using metacognitive strategies were done on different subject contents, class level and location. Thus there was a need to for this study to authenticate their findings using 3-step MIM on JS1 students in Basic Science in Ankpa LGA.

Table 2, showed that the male students in the experimental groups who were taught with the 3-step MIM had higher achievement scores than their female counterpart. A null hypothesis further explained this difference. It revealed that there is no significant difference in the mean scores of the male and female students academic achievement when taught Basic Science using the 3-step MIM. This result is in agreement with some findings of researchers like; Igboegwu and Okonkwo (2012); Nwagbo, and Okoro (2012); and Ukwungu, (2002) which found that there is no significant difference in the mean scores of the male and female student's academic achievement. Similarly, Aguele and Agwagah (2008) observed that male students performed better than female in academic achievement because, males have more positive attitude to everyday application of science than the females and this can be attributed to their better performance.

However, other studies indicated that when females are exposed to female-gender friendly curriculum materials, they usually obtain higher mean achievement scores than their male counterparts (Bilesemi-Awoderu, 2006; Arigbabu and Mji 2004 and Akalonu 2001). The reviewed studies and the present study in metacognitive-based learning revealed that there was no distinguishing differences in the academic achievement between male and female students.

Table 3, showed that there was no significant interaction effect on gender and treatment on Basic Science achievement scores. The computed F- ratio of group and gender is 0.05 at significant level of 0.83. Since the F-ratio was significant at 0.05 level of significance, the hypothesis was therefore accepted. Hence, there was no significant difference in the interaction effect of gender and group in 3- step MIM and EIM in Basic Science. It means that the students' achievement depends on gender.

Recommendations

1. Schools should make provisions for space, instructional materials, also allocate sufficient time on the time table for effective implementation of the 3-step MIM in teaching Basic Science.
2. Teacher training institutions should incorporate 3-step MIM in the Integrated Science curriculum so that the pre-service science teachers will acquire the use of 3-step MIM in teaching and learning of Basic Science.
3. Federal and state ministries of education should organize seminars, conferences and workshops periodically for Basic Science teachers to become acquainted on the use of the 3-step MIM for effective teaching and learning.

Conclusion

1. Use of Metacognitive Instructional Models like 3-step MIM enhances students' achievement in Basic Science.
2. Government and other professional bodies like: the Science Teachers' Association of Nigeria (STAN) should organize seminars, conferences and workshops to popularize the use of 3-step MIM in schools.

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