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EFFECTS OF TWO INNOVATIVE INSTRUCTIONAL DELIVERY STRATEGIES ON JUNIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN BASIC SCIENCE AND TECHNOLOGY

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Abstract

The study investigated effects of two innovative instructional delivery strategies on junior secondary school students' achievement in Basic Science and Technology. The population comprised 3050 JSII students in 41 public co-educational junior secondary schools in Karu LGA of Nasarawa state made up of 1701 male students and 1349 female students. A quasi-experimental pre-test, posttest non-equivalent group research design was employed as design and without a control group. Through multi-stage random sampling, 2 intact JSII classes were selected with sample size of 121. Using balloting, one of the classes was assigned as experimental group taught using sensory stimulation strategy and the other with inquiry strategy. The instrument used for data collection was Basic Science and Technology Achievement Test (BSTAT) with a reliability coefficient of BSTAT is 0.82 analyzed using Spearman Brown rank order correlation. Two research questions were formulated with corresponding hypotheses and were tested at 0.05 level of significance for the study. Data collected were analyzed using mean, standard deviation and ANCOVA statistics. The study revealed significantly higher achievement for students taught Basic Science and Technology concepts using sensory stimulation as against those taught using inquiry strategies. Though male students achieved higher than their female counterparts when taught using sensory stimulation strategy, the difference is not significant. It is recommended that teachers of Basic Science and Technology should adopt sensory stimulation strategy in their instructional delivery approach. The multiple appeals to students' senses by sensory stimulation strategy tends to make learning pleasurable and supports meta-cognitive processes which aids easy remembering, reduces agitation and increases alertness during learning.

Key words: sensory stimulation, inquiry, achievement, gender, basic science and technology, innovative instructional strategy

Introduction

Teaching is one of the oldest noble professions that play a pivotal role in actualizing the internationally recognized 4th Sustainable Development Goal of ensuring quality education for all by 2030. Instructional delivery approaches used by teachers around the world must be geared every day to ensure that an inclusive and equitable quality education and lifelong learning opportunities become a reality for all categories of learners (UNESCO, 2019). Need to achieve the Millennium Development Goals (MDGs) and the goals of Education for All (EFA) initiative had led the Federal Government of Nigeria to initiate a 9-year Basic Education programme in 2007. To this end, according to Ibrahim and Muhammad (2015), it became necessary to implement the framework of the National Economic and Empowerment Development Strategies (NEEDS) with the hope of achieving vision 20:20:20. The framework of NEEDS is majorly aimed at empowering the citizenry towards acquiring skills and knowledge that would prepare them for the world of work. It became expedient that curricular used for primary and junior secondary schools be reviewed, re-aligned and re-structured to fit in to a 9-year Basic Education programme. Nigerian Educational Research and Development Council (NERDC) were then directed by the National Council on Education (NCE) in her meeting held at Ibadan in December, 2005 to carry out the assignment on the new curriculum (NERDC, 2012). The NCE approved the new curriculum structure which includes: Lower Basic Education (Primaries 1 to 3), Middle Basic level (Primaries 4 to 6) and upper Basic Education (Junior Secondary 1 to 3) with subject listings that include Basic Science and Technology among others. Also addressed in the development of the curricular is the issue of gender mainstreaming. To facilitate the implementation of the broad-based national curricular, according to NERDC (2012), resource materials were developed such as Teachers' Handbooks, Teachers' Guides, Syllabuses, individual subject curriculum incorporating themes, topics, objectives, teachers and students' activities respectively among others.

The overall objectives of the recent Basic Science and Technology curriculum as outlined by NERDC (2012) are meant to help students and pupils to:

(a) Have interest in science and technology at an early stage;
(b) Get crucial fundamental knowledge and skills in science and technology;
(c) Apply scientific and technological knowledge and skills to solve societal problems;
(d) Utilize the several career opportunities offered by science and technology; and
(e) Be prepared for further academic pursuit in science and technology.

The National Policy on Education, in its objective has identified the acquisition of correct skills, abilities and competencies both psychological and physical as tools for the individual citizen to contribute his/ her quota to the advancement of the society (Federal Republic of Nigeria, 2014). In order to ensure implementation of these noble objectives, teaching and learning of Basic Science and Technology should be activity –based and learner-centered. The teaching and learning of concepts in Basic Science and Technology have been found to be challenging in the past with a view to achieving desirable outcome. Effectiveness in instructional delivery approaches demands teachers with varied innovative ideas and readiness to vary teaching-learning strategies, styles and methods so as to carry all categories of learner along.

Learning impact depends on how materials are presented to learners and how active learners interact with the learning experiences being presented. The new trend in teaching-learning of science, technology, engineering and mathematics (STEM) demands a radical departure from the traditional lecture method to an innovative strategy. These innovative strategies often involve problem-solving activities and active participation of learners and co-operation among learners, even in open-ended

field science practical laboratory exercises and technology workshops acti vities. Conventional lecture method has been discouraged because it is found to be teacher dominated and tend to make students passive listeners and redundant recipients of knowledge. Another argument against conventional methods of teaching according to Anyaegbunam, Nwodo and Enibe (2015) and Sambo (2018) is that it encourages memorization and rote learning of concepts without allowing students to be really exposed to the challenges that will make them be actively engaged. The over reliance on these conventional methods of teaching-learning have tended to influence students' performance in the subjects related to science and technology.

Sensory stimulation refers to a variety of techniques applied to stimulate the senses with a view to increase alertness and reduce agitation (Gammeltoft, 2005). To Vozzella (2007) sensory stimulation includes visual, auditory, tactile, olfactory, kinesthetic and taste stimulation. The sensory integrative processes help people to interact effectively with the environment (Ayres, 1972). Indeed, the sensory stimulation theory claims that effective learning takes place when the senses are stimulated. Research findings have proven that of the majority of knowledge held by adults, 75% is learned by process of seeing; hearing is next most effective accounting for about 13%, while the other senses (smell, taste and touch) account for 12% of what is known (Laird, 1985 in Dunn, 2002). When multiple senses are stimulated at the same time, learning can be enhanced. The senses can be stimulated through greater variety of colours, volume levels, strong statements, facts presented in visual form and the use of a variety of techniques and device. It's a type of hands-on teaching-learning that gives learners more ways to connect new information with previous knowledge; understand and work through problems and inculcates non-verbal problem-solving skills in the learner (McGraw, Webb & Moore, 2008).

Inquiry involves students finding out basic concepts via active investigation and use of guiding questions (Jin & Bierma, 2011). Inquiry has to do with 'active learning' technique that emphasizes the understanding of a concept through a process oriented approach and based on previous knowledge. Students use their prior knowledge to build their own enquiries around the previous knowledge built by the teacher. Students work in teams and are guided through questions to consider various procedural steps instead of following instructions in their practical assignment until they realize or uncover trends and patterns in the mechanisms at work. Students have the freedom to be the thinkers. Teachers introduce the lesson bearing in mind where they want to end, but giving the learners opportunity to drive it to that point. Teachers guide with questions to get students thinking and learning how to question themselves. Students keep working through their procedure until they all agree. The teacher returns to check what the group have arrived at (Edutopia, 2016).

Achievement is the past-oriented way of trying to measure the degree of attainment of success of an individual in an area or activity after adequate training has been carried out (Mangal, 2014) and (Sambo, 2014 a & b, 2017, 2019a, 2011a & 2011b). In the study already done, the achievement of students in Basic Science and Technology was determined after adequate teaching has been done for four weeks' duration. Achievement tests are used to measure achievement in a learner. Achievement looks at the past and indicates what an individual has learned or acquired in a particular field. In Measurement and evaluation, aptitude and achievement are both measures affability (Anikweze, 2013). Aptitude denotes what a person has learned to do without requiring any training while achievement refers to what one has learned to do as a consequence of training.

The influence of students' gender in their achievement in Basic Science and Technology has been of concern to education researchers for long. Yet according to Ugwu and Nzewi (2015) and Sambo

(2010, 2014a, b and c) no trend had emerged on the issue. In Nigeria, gender bias is still prevalent in science and technology education spheres; it has persisted even within the Basic Technology classroom. Sambo and Mankilik (2010) and Agu and Edward (2015) pointed out that Nasarawa state as one of the States in the North Central geopolitical zone of Nigeria (and which forms part of the geographical scope of this study) is often considered one of the educationally disadvantaged states especially in terms of female access to and aspiration in science and technology subjects at Secondary school level. There is no evidence yet on whether comparing effect of use of sensory stimulation and inquiry is gender related. It is, therefore, worthwhile to find out if sensory stimulation and inquiry would bridge the gap in achievement between male and female students taught energy concepts.

Innovative instructional delivery strategies are active creations which teachers can embrace as a help to improve students' engagement during classes and meant to make teaching-learning interesting (Isaiah, Sambo, Abimiku, & Emmanuel, 2014) (Heather, 2018), and Sambo (2019a) and Samuel and Sambo (2019b). Examples of these innovative strategies include inquiry-based learning, project-based learning, wisely managed classroom technology, jigsaws, self-reflection strategy, audio and video tools audio-video-tools classroom strategies, visualization, differentiation, cooperative learning, behavior management and sensory stimulation among several others. It is against this backdrop that the researchers wish to investigate the effects of two innovative instructional delivery strategies on Junior Secondary School Students' achievement in Basic Science and technology.

Statement of the Problem

In a normal situation where appropriate choice and correct teaching method and strategy are applied, impact of teaching-learning effectiveness is better felt in the society. If the teaching-learning process is effective, the result is higher achievement and retention among learners and subsequently translating to a scientifically literate society. However, the prevailing situation is far from being palatable as research reports and results from public examinations have consistently shown that students' performance in Basic Science and Technology subject is generally poor. The continual decline in achievement and poor retention capacity of students in Basic Science and Technology is becoming a source of concern. The larger society suffers set-back in the long run as the required skilled manpower needed to bring about the much needed industrial revolution in economy through science and technology is insufficient. The larger society continues to be scientifically and technologically illiterate. Ironically, this has been the bane of economic and developmental transformation in Nigeria and other developing countries of the world. There are some positive attitudes and skills which scientific and technological literacy inculcates into learners and subsequently translates into a safer society.

Several promising policies and efforts have been made by present and past administration to correct the ugly trend, yet the problem tends to persist. A number of researches have been carried out which identified some factors as responsible for influencing performance of students. Useful suggestions have been made and several measures taken and attempted to address and mitigate the problem of instructional delivery approaches and teacher quality. Instead of improving, the poor performance/ under-achievement seems to persist. The effect is a visible set-back to the actualization of vision 2020 of the National Economic and Empowerment Development Strategies (NEEDS) which has become a mirage. The adverse effect is a consequence of combination of several factors including ineffectiveness in instructional delivery approaches. If nothing is positively done to address the problem of effectiveness in instructional delivery approaches, actualizing the internationally recognized 4th sustainable development goal to ensure quality education for all by 2030 may become remote, unachievable and go the way of the failed vision 2020.

Research Questions

1. What are the mean achievement scores of students taught Basic Science and Technology concepts with sensory stimulation and inquiry instructional strategies?
2. What is the difference in the mean achievement scores of male and female students taught BST concepts with sensory stimulation and inquiry instructional strategies?

Hypotheses

1. There is no significant difference in the mean achievement scores of students taught BST concepts with sensory stimulation and inquiry instructional strategies.
2. There is no significant difference in the mean achievement scores of male and female students taught Basic Science and Technology using Sensory stimulation strategy and inquiry instructional strategies.

Methodology

The design of this study is a quasi-experimental design; specifically, the pretest, posttest non-equivalent group design. No control group was used because treatment was administered to the two groups. The two treatment groups were randomly assigned to two intact classes. The study was conducted in Karu Local Government Area (LGA) of Nasarawa State, Nigeria. The population of the study consists of 3050 JS2 students of 41 public co-educational junior secondary schools in Karu LGA of Nasarawa State made up of 1701 male students and 1349 female students. A random sample of 10 schools was selected from the 41 schools from which one stream of intact JS2 class was randomly selected from each of the 10 schools. Achievement test was administered to the 10 different intact classes of the 10 selected schools. Means and standard deviations were estimated for the 10 schools from which two intact classes were chosen for the study based on the closeness of their mean and standard deviation. Sample size comprises 121 students in the two intact classes. One class was assigned to Sensory Stimulation Strategy (SSS) and the other to Inquiry Strategy (IS). The instrument used for data collection was Basic Science and Technology Achievement Test (BSTAT). The reliability coefficient of the instrument was estimated and found to be 0.82 using the Spearman Brown rank order correlation. Three lesson plans were prepared and used for each instructional delivery approaches. The analysis of pretest scores and emergence of similar groups took one week. Real experimental teaching was carried out for 4 weeks' duration after pretest. Posttest was administered as soon as the last class session was over. Data collected were analyzed using mean, standard deviation and ANCOVA statistics.

Results

The results of the analysis based on the two research questions and two null hypotheses (tested at 0.05 level of significance) that guided the study are as follows:

Research Question 1

What are the mean achievement scores of students taught Basic Science and Technology concepts with sensory stimulation and inquiry instructional strategies?

Table 1: Mean and Standard scores deviation scores of Students taught BST using Sensory stimulation and Inquiry Instructional Strategies

Groups	Pretest Mean ($\bar{x}$)	Pretest SD.	Posttest Mean ($\bar{x}$)	Posttest SD	N	Mean Gain
Sensory stimulation	14.09	3.466	27.44	3.417	57	13.35
Inquiry teaching	15.45	2.817	25.28	2.786	64	9.83
Total	14.29	3.715	24.96	3.872	121	

Table 1 shows the mean posttest scores of the two groups, the mean gain scores and the standard deviations for the groups. The result revealed that the higher mean gain of 13.35was for group taught using sensory stimulation strategy, followed closely by inquiry strategy with a mean gain of 9.83. The extent of dispersion is closer for the posttest than the pre-test for all experimental groups. Students gained more knowledge with the use of sensory stimulation strategy in their achievement of BST concepts.

Research Question 2

What is the difference in the mean achievement scores of male and female students taught BST concepts with sensory stimulation and inquiry instructional strategies?

Table 2: Mean and standard deviation scores of male and female students taught BST using sensory stimulation and Inquiry instructional strategies

	Groups	Pretest Mean ($\bar{x}$)	Pretest SD	Posttest Mean ($\bar{x}$)	Posttest S D	N	Mean Gain
Male	Sensory stimulation	13.87	3.721	27.63	3.528	30	13.76
	Inquiry teaching	15.31	2.878	25.83	2.802	35	10.52
Female	Sensory stimulation	14.33	3.211	27.22	3.344	27	12.89
	Inquiry teaching	15.62	2.783	24.62	2.665	29	9
Total	Sensory stimulation	14.09	3.466	27.44	3.417	57	13.35
	Inquiry teaching	15.45	2.817	25.28	2.786	64	9.83
	Total	14.29	3.715	24.96	3.872	121	

Table 2 shows the mean scores, the standard deviations and the mean gain scores of male and female students taught BST concepts with the sensory stimulation and inquiry instructional strategies on achievement for the groups. For the various teaching strategies, the male had higher mean gain score.

Males taught using the sensory stimulation strategy had the higher mean gain of 13.76 as against their female counterparts taught using sensory stimulation who had 12.89. Male students taught using inquiry teaching strategy followed male students of sensory stimulations with a mean gain of 10.52 as against their female counterparts who had mean gain of 9. Male and female students had higher mean gain when taught using sensory stimulation than inquiry.

Hypotheses

HO_1 There is no significant difference in the mean achievement scores of students taught BST concepts with sensory stimulation and inquiry instructional strategies.

Table 3: Analysis of Students' mean achievement scores in Basic Science and Technology

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1244.400[a]	3	414.800	45.371	.000	.399
Intercept	4310.515	1	4310.515	471.481	.000	.697
Treatment	580.464	2	290.232	31.745	.000	.236
Pretest Scores	587.624	1	587.624	64.274	.000	.239
Error	1874.213	205	9.143			
Total	133294.000	209				
Corrected Total	3118.612	208				

a. R Squared = .399 (Adjusted R Squared = .390)

Table 3 reveals that after adjusting for pre-test scores, there was a significant difference of posttest on students' achievement. [$F(2, 205) = 31.74$, $P<0.05$, Partial $\eta^2 = .236$; $R^2=.055$]. The implication of this is that since p-value (.000) of the F-ratio was significant, it follows that the null hypothesis on the mean posttest scores and difference of treatment was rejected. Therefore, the R Squared shows that the independent variables accounted for only 5.5% of the variation in the treatment and posttest scores of students' achievement in energy concepts. The estimated partial Eta squared indicates that the treatments accounted for 23.6% of the variance observed in the posttest score.

Table 4: Comparisons of Experimental Groups on Students' Posttest in Basic Science Concepts

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Conf. Interval for Difference[b]	
					Lower Limit	Upper Limit
Control	Sensory stimulation	-4.084*	.515	.000	-5.099	-3.069
	Inquiry teaching	-1.294*	.509	.012	-2.297	-.291

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for Multiple Comparisons: Least Significant Difference (equivalent to no adjustments).

The post-hoc test result presented in Table 4 shows the differences between the experimental groups after the posttest. The study shows there is also a significant mean difference between sensory stimulation and inquiry teaching strategies (p = .000; p<.05).

HO_2 There is no significant difference in the mean achievement scores of male and female students taught Basic Science and Technology using Sensory stimulation strategy and inquiry instructional strategies.

Table 5: ANCOVA Test on Effect of Sensory Stimulation and Inquiry Instructional Strategies on Achievement of male and female students in Basic Science and Technology Concepts

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	811.793[a]	3	270.598	24.047	.000	.260
Intercept	4112.579	1	4112.579	365.472	.000	.641
Pretest Scores	681.144	1	681.144	60.531	.000	.228
Gender	104.251	1	104.251	9.264	.003	.043
Gender * Pretest Scores	68.002	1	68.002	6.043	.015	.029
Error	2306.819	205	11.253			
Total	133294.000	209				
Corrected Total	3118.612	208				

a. R Squared = .260 (Adjusted R Squared = .249)

Table 5 reveals that there was a significant difference in the posttest scores of male and female students taught with the two strategies [F(1, 205) = 6.04, P<0.05, Partial η^2 = .029 R^2=.00084]. The implication of this is that since p-value (.000) of the F-ratio was significant, it follows that the null hypothesis was rejected. Therefore, the R Squared shows that the independent variables accounted for only .08% of the variation of gender on posttest of students taught BST concepts using the innovative strategies. The estimated partial Eta squared indicates that the treatments accounted for 2.9% of the variance observed in the posttest score.

Table 6: Comparisons of Gender Groups on Students Achievement in BST concepts

Gender	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
				Lower Bound	Upper Bound
Female	1.223*	.466	.009	.305	2.141
Male	-1.223*	.466	.009	-2.141	-.305

Centred on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Table 6 shows the post-hoc test between gender and groups, where the difference between the treatments groups lie after the posttest in Basic Science and Technology. The result reveals that there is a significant difference in the mean achievement scores of male and female students (p = .009; p<.05) taught BST concepts.

Discussion

The result from this study showed that students taught using sensory stimulation strategy achieved significantly better than the students taught using inquiry strategy. The significant difference could be due to the multi-sensory appeal of sensory stimulation strategy which helped to reduce agitation, increase alertness and its tendency to make learning pleasurable. All categories of learners in the class might have benefitted from the multisensory instruction which translated into improved achievement of students taught using sensory stimulation strategy. This is unlike the inquiry strategy which involves students asking leading questions and problem-solving through challenging task with minimal assistance and information guide by teachers. Perhaps, the guided inquiry could have produced effect than the inquiry when compared with the sensory stimulation strategy.

The result of this study supports the views of previous researchers like Strom, Ytrehus and Grov (2016) and Morin and Wilson (2015) who indicated that learners especially persons with dementia improved significantly when taught with sensory stimulation strategy than when taught with the conventional method. The study carried out in Norway by Lykkeslet, Gjengedal, Skrondal and Storjord (2014) found out that the innovative use of sensory stimulation strategy improved the interaction between health care workers and patients with behavioural and psychological symptoms of dementia and helped both low and high ability learners achieve higher mean achievement. The result of this study further supports the work of Rincover and Newson (2013) which compared the effects of sensory stimulation and edible reinforcers in teaching autistic children. Results of the work indicated that multiple sensory stimulation reinforcers responded better to more trials than the edible reinforcers in teaching autistic children.

The findings of this study also indicated that male students taught using sensory stimulation strategy achieved higher mean achievement scores than female students at all levels, though not with a significant difference. There could be an acknowledged problem of female under-achievement when compared with their male counterparts apparently under equivalent conditions and this problem appear to be more pronounced in science, technology and mathematics. However, some research works have shown contradictory evidences in students' academic achievement in sciences and technologies due to gender. Usman in Uzoechi and Gimba (2015) observed that it is the female students that perform better than male students in learning activities that require manipulations.

Conclusion

The result obtained in the study of effects of two instructional innovative delivery strategies on junior secondary schools' achievement in Basic Science and Technology, it was found that students taught Basic Science and Technology Concepts with sensory stimulation strategy had higher mean achievement scores than those students taught with inquiry strategy. The male students achieved higher scores than the female students when taught with sensory stimulation strategy, though not with a significant difference.

Recommendations

Based on the findings of this study and their implications, the following recommendations are made:

1. Since the use of sensory stimulation strategy in teaching has been found to enhance achievement in Basic Science and Technology, teachers of the subject should employ such innovative instructional strategy as sensory stimulation in the teaching of Basic Science and Technology topics and concepts.

2. Efforts should be made by government agencies in charge of education, school heads (both private and public) and school administrators to provide facilities and materials that are capable of multiple appeals to learners' senses of perception. Also ensure steady supply of electricity to enable teaching-learning that involves computer based devices that have multiple appeals to students' stimuli.
3. Seminars and workshops should be organized for book authors, publishers and teachers of Basic Science and Technology on the use and benefit of tested innovative strategies particularly sensory stimulation strategies.

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