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ENGAGING GIRLS IN 'LEARN SCIENCE BY DOING' AS STRATEGY FOR ENHANCED LEARNING OUTCOME AT THE JUNIOR HIGH SCHOOL LEVEL: A STUDY IN NIGERIA

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A B S T R A C T

In an attempt to impact on girls' interest in science, an instructional package on 'Learn Science by Doing (LSD)' was developed to support science teachers in teaching integrated science at the junior secondary level in Nigeria. LSD provides an instructional framework aimed at actively engaging girls in beginners' science through activities that are discovery-oriented and allow for experiential learning,. The goal of this study was to show the impact of application of LSD on girls' performance and interest in science. The major hypothesis that was tested in the study was that students would exhibit higher learning outcomes (achievement and attitude) in science as effect of exposure to LSD instructional package. A quasi experimental design was adopted, incorporating four all-girls schools. Three of the schools (comprising six classes) were randomly designated as experimental and one as control. The sample comprised 357 girls (275 experimental and 82 control) and nine science teachers drawn from the experimental schools. Questionnaire was designed to gather data on students' background characteristics and their attitude toward science while the cognitive outcomes were measured using tests, Both within a group and between groups, the girls who had exposure to LSD exhibited improved cognitive outcomes and more positive attitude towards science compared with those who had conventional teaching. The data are consistent with previous studies indicating that interactive learning activities increase student performance and interest.

Keywords: Active learning, school science, teaching and learning.

INTRODUCTION

One major criticism of science education in Nigeria has long been lack of stimulation in the teaching of science at school level in general. Students are wont to complain that science lessons are abstract, impersonal, dry and boring. A cursory assessment of science teachers in schools shows that a number of them are not specialist in the subjects being taught and have limited pedagogical knowledge to stimulate their students. The traditional approach to teaching science involving use of knowledge transmission pedagogies with the 'teacher talking and student 'listening and taking notes' is yet to change for the better. This approach has been criticized as constituting a major shortcoming to the enthusiasm of students to learn science as it does not offer opportunities for engagement with science, which is an important learning experience for stimulating interest. Most of the time, students learn science by parroting, that is, memorization and regurgitation without sufficiently comprehending the knowledge and skills underlying the subjects, resulting in superficial learning of basic concepts and principles. Thus the consequence of poor stimulation in the teaching of science is linked to the worrisome quality of science learning.

Educators agree that students learn best what they find understandable and interesting. Efforts at helping students learn science with interest have therefore recommended changes to the traditional pedagogical approaches in such ways that lead to understanding and stimulation of interest. Although a number of instructional strategies have been suggested to make positive impact on motivation to learn science, the consistent emphasis has been on active learning (Weiner, 2002; Tanner, 2005). Simply, active learning seeks to generate knowledge and understanding through

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intellectual engagement of student in the learning process. The emphasis is on creating learning through instructional methods that engage students in meaningful activities during the process of learning. The defining features of active learning are meaningful engagement of learners, seeking information, thinking about what they are doing, interacting and sharing ideas with peers, and applying knowledge in the learning process. Teaching methods for active learning include discussion, problem solving, cooperative learning, debate, role playing, simulation, game, and peer teaching; such methods that engage learners to spend a significant part of instruction time on doing activities and actively processing information in meaningful ways. These are methods that shift the focus from teaching to learning and promote a learning environment that is amenable to the metacognitive development necessary for students to become independent and critical thinkers (Bransford & Brown, 2000). In an active learning classroom, the learner is the centerpiece of the instructional process while the teacher's role is mainly to provide guidance, generate and summarize discussions, questioning and giving explanation. Researchers have confirmed the superiority of active methods over the traditional 'talk-chalk-listen' method, especially at the school level. The evidence indicate that application of active methods in science classroom results in increased conceptual understanding (Bligh, 2000; David et.al., 2007); positive attitude towards science (Preszler, 2007; Armbruster et.al, 2009); better understanding of science processes (Lindberg, 1990); and improved cognitive outcomes (Freeman et.al., 2014; Soltanzandeh et.al., 2013; Janice & Hochevard, 2005; Roman et.al., 2007).

The benefit of active pedagogical approaches for enhanced cognitive understanding in science is anchored on the constructivist paradigm on knowledge construction. Constructivists posits that learning is an active, constructive process created by every learner based on personal experiences and influenced by the social contexts. Basically, constructivism connotes that individual learner generates own knowledge from the interplay between the existing ideas in their knowledge domain (or schema) and their social experiences. The core principles of constructivism are experiencing and reflection on the experiences for individual construction of knowledge. This is also consistent with the goal of inquiry-based science learning (Rakov, 1986) to generate knowledge by doing rather than presenting science as facts. Inquiry learning emphasis investigative attitudes, process skills and creative thinking that lead to discovery and knowledge construction. Like constructivism, inquiry learning is also anchored on experiential knowledge generation through exploration, investigation, reflection, information processing and contextual application. Thus, the implication for school science is to provide meaningful engagement of learners in interactive and mentally stimulating scientific activities as strategy to stimulate meaningful processes for productive knowledge construction and understanding.

The merits of active teaching methods for quality science learning outcomes among girls are many. The interaction with peers and teacher draws benefit from social learning principle of constructivism. The collaborative small group strategy creates self-assuring learning environment for students to be expressive and confident apart from the build-up of motivation that is derived from social interaction and intellectual support. Studies have confirmed that collaborative learning enhances critical thinking and is beneficial for fortifying student motivation [Michael, 2006; Pintrich, 2003; Guthrie, 2000]. Moreover, constructive feedback from peers and teacher reinforce motivation whilst motivation provide stimulus for greater achievement and increased persistence (Boussard and Garison, 2004). However, even though the efficacy of hands-on, minds-on, and collaborative learning as components of active learning strategies is well established in the literature, no serious attempt has been made to integrate a structured framework encompassing the elements into school science curriculum in Nigeria, nor have science teachers developed the skills for applying them. In an attempt to impact on girls' interest in science, an instructional package on 'Learn Science by Doing (LSD)' was developed to support science teachers in teaching integrated science at the junior secondary level in Nigeria. LSD provides an instructional framework aimed at actively engaging girls in beginners' science through activities that are discovery-oriented and allow for experiential learning. The underlying assumptions in the structuring of LSD are that: 1. People learn to do well only what they practice doing; **2.** 'Doing' provides for experiential learning that brings excitement and meaning to learning materials; 3. Meaningful materials enhance understanding and tangible learning outcomes;

and 4. Performance is strong determinant of continuing interest and engagement with science. Therefore, LSD was developed as an instructional package based on these assumptions to guide teachers in science classrooms. LSD manual is structured along a topic-based approach to cover the topics in the approved syllabus in Integrated Science for Nigerian Schools. Five major components run through the content of LSD as follows:

- Group discussion, to allow for collaborative learning, sharing of ideas and peer interaction.
- Investigations and projects, to foster discovery and transfer of learned knowledge.
- Hands-on and minds-on, to create engaging activities and stimulate thinking about science.
- Open-ended problems to encourage creative thinking.
- Continuous assessments, to monitor the level of conceptual understanding and provide feedback to students.
- Teacher demonstration, summary and guide, to focus the teaching process.

The goal of this study was to show the impact of application of LSD on girls' performance and interest in science. The hypothesis tested in the study was that incorporating LSD into the instructional process in beginners'' science would impact on girls attitudes and lead to increased performance. The motivation for this study was derived from the desire to make a difference to the declining interest of girls in post-compulsory school science. Even though the evidence shows that ability to do science is not a problem for girls - girls are found to achieve as well as boys in high school science (Sanders, 2010) - the recurring concern is about encouraging participation. The need to impact on girls interest is particularly apt at Junior Secondary level where "leak in the pipeline" toward science careers builds up prior to making subject choices.

METHODOLOGY

The study was prospective, beginning with students in the second year of junior secondary school (JSS2) and following them through to JSS3. A quasi experimental design was adopted, incorporating four all-girls schools. Three of the schools (comprising six classes) were randomly designated as experimental and one as control. The schools are all government owned with comparable teaching facilities and student population drawn from diverse socio-economic background. The sample comprised 357 girls (275 experimental and 82 control) and nine science teachers drawn from the schools. The LSD manual provided the working instrument for teaching in the experimental schools while the control received regular instruction.

The trial of the manual was done in a school to obtain feedback on the approach, structure and the layout of the materials as well as its effectiveness to create an engaging learning environment. Teachers also made observations, comments and suggestions on each of the topics for the revision of the manual. A 4-day workshop was organised for nine science teachers drawn from the three experimental schools to introduce them to the manual, and to provide opportunity for demonstration of skills and simulated practices. The application of the revised manual covered four terms in the three experimental schools. The teachers were guided through the application of the manual in their schools. Regular monitoring ensured that the teachers followed the manual correctly. To positively enjoy the benefit of collaborative learning, students in each class were organised into heterogeneous ability grouping of four, and each group worked together through the period, and in almost every class, groups were given a problem to solve or a project assignment. In some instances, think-pair-share technique was adopted to make the students reflect first on particular issue before getting other ideas from peers. Group representatives were made to report to the class after each group problem-solving session, and every effort was made to move the presentation round every member. During in-class group work, the teacher would move around to monitor student activities and offer suggestions if a group encountered difficulty. In addition, a variety of in-class exercises in form of cross word puzzles, word search, matching grid, quizzes, word problems were incorporated into the package as formative assessments to provide regular feedback and monitor learning.

Questionnaire was designed to gather data on students' background characteristics and their attitude toward science. The attitude scale comprised 21 items measuring four constructs: attitude towards the teacher, the subject, science learning materials, and scientific activities. Students responded to the statements by indicating yes or no. The scale has a test-retest reliability of .79. A 20-item multiple-choice test covering the basic knowledge of science covered in the first year was administered to both experimental and control groups prior to the study. Then, students took end-of-term tests over three terms. The test items were gathered from the teachers in all the schools; each teacher was made to submit 10 multiple choice questions on the topics covered and thirty items were randomly selected for each test. The interactive effects of continuous testing and feedback were eliminated by exposing the two groups to all the tests and providing the scores to students. A 25-item multiple choice achievement test (test-retest reliability =.83) covering the topics taught during the period was administered at the end of the treatments. Finally, a short questionnaire was administered among students in the experimental group after the treatments to ascertain their level of enjoyment and preference to continue the different activities in the package on a 4-point scale. Students were to indicate whether or not the activity was enjoyed and would like it to continue in their science classroom. The response ratings were scored as: well enjoyed, continue often =4, just enjoyed, continue sometime =3, not enjoyed much, may not continue = 2 and not enjoyed at all, not to continue =

RESULTS

The data in Table 1 illustrate student performance on the tests in all 3 terms and show consistent increases in performance for the experimental group. The mean pretest scores (T1) show that the groups are comparable in terms of cognitive achievement prior to the treatment (t = .71, p>.05). Periodic assessments of the students at the end of each term (T2-T4) show that on average, the experimental group recorded a steady and higher increase in means on performance from 51.9 (SD=15.7) on test 1 to 60.6 (SD=11.6) on test 3 as against the control group (M = 44.3 to 52.5). The t values (4.28, 4.31, 6.35) are significant (p<.05). The overall mean on the achievement test (T5) for the experimental group (M = 63.8, SD = 10.1) is significantly higher than the control (M= 51.9, SD = 12.1) as indicated by t-test (t = 5.19, p<0.5) and r value (.28) representing a medium sized effect. Students' mean scores on the attitude scales (Table 2) indicate that before the experiment the overall mean score on the attitude scale was not significantly different for the experimental and control group (t = 1.76, p<.05), even though on the specific scales the control appeared to show slightly more positive attitude. After the treatment, however, the experimental group recorded significantly higher positive change in attitude on all the scales. (t = 8.13, 9.63, 5.18, 31.6, p<.05). The means on attitude scales for the experimental group produced highest effect size (r = .86) for scientific activities, suggesting that the treatment significantly altered interest in doing scientific activities. The within-group change in attitude (Table 3) is consistently higher for the experimental group on all the scales with r values indicating high effect sizes in comparison with the change in control group.

The means in figure 1 show the level of student satisfaction with the different activities in LSD. Five activities in-class group exercises, experiments, teacher's explanations, facts for students and class discussion have mean scores greater than 3, suggesting that the students enjoyed them very well and would like the teacher to continue the activities often in their science classes.

Table 1. Between-group comparison of means on tests. *P <0.05

	School 1		School 2		School 3		Combined		Control		t	R
	M	SD	M	SD	M	SD	M	SD	M	SD		
	N =89		N =94		N =92		N =275		N =52			
Test 1	48.8	14.2	50.9	12.9	47.9	17.2	49.1	6.8	48.2	10.8	0.71	.04
Test 2	51.5	17.8	53.2	10.7	52.9	18.6	51.9	15.7	44.3	13.6	4.28*	.22
Test 3	58.8	16.6	59.7	12.3	60.4	15.9	58.7	14.7	48.9	11.4	4.31*	.22
Test 4	59.8	13.8	60.1	15.3	61.4	12.1	60.6	11.9	52.5	7.9	6.35*	.32
Test 5	61.9	11.9	63.5	10.6	66.3	9.9	63.8	10.1	51.9	12.9	5.19	.28

Table2. Between-group comparison of means on attitude scales. *P <0.05

	Before					After					
Scales	Experimental		Control			Experimental		Control		t	r
	M	SD	M	SD	t	M	SD	M	SD		
Teacher	1.31	0.07	1.39	0.19	3.71	1.53	0.24	1.42	0.18	8.13*	.41
Subject	1.46	0.32	1.49	0.29	-1.81	1.69	0.15	1.41	0.09	9.63*	.45
Materials	1.16	0.41	1.24	0.16	-2.6	1.41	0.32	1.28	0.14	5.18*	.28
Activities	1.39	0.18	1.42	0.35	-1.37	1.79	0.16	1.35	0.09	31.65*	.86
Overall	1.33	0.25	1.38	0.18	1.76	1.61	0.23	1.37	0.13	12.1*	.54

Table3. Within-group comparison of means on attitude scales. *p<.05

	Experimental						Control					
Scales	N= 275						N= 82					
	Before		After				Before		After		t	r
	M	SD	M	SD	t	r	M	SD	M	SD		
Teacher	1.31	0.07	1.53	0.24	14.6*	.66	1.39	0.19	1.42	0.18	-1.04	.11
Subject	1.46	0.32	1.69	0.15	9.38	.49	1.49	0.19	1.41	0.09	3.45*	.36
Materials	1.16	0.41	1.41	0.32	11.7	.58	1.24	0.17	1.28	0.14	1.65	.18
Activities	1.39	0.18	1.79	0.16	-24.2	.83	1.40	0.25	1.35	0.09	-1.71*	.19

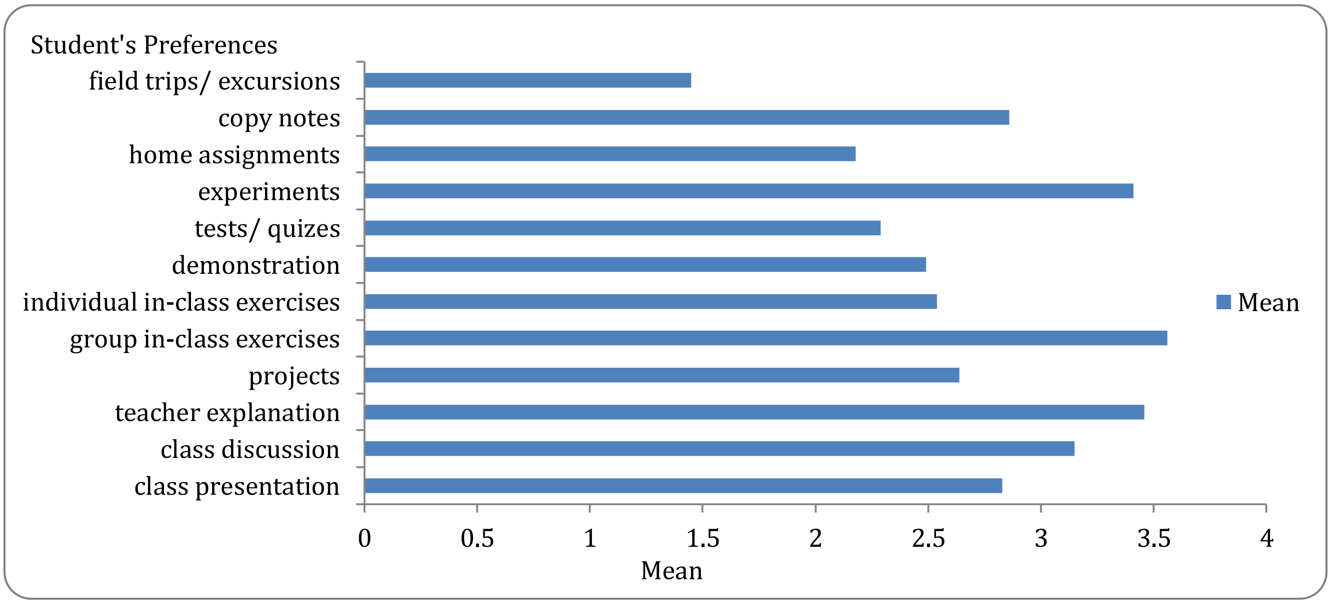

Figure 1. Student mean preference for activities.

DISCUSSION AND CONCLUSION

The primary goal of this study was to make positive impact on girls' interest in school science, guided by the hypothesis that enhanced interest would stimulate positive attitudes and lead to improved learning outcomes. The LSD package was introduced into science teaching to actively engage students in the learning process and create a more interactive classroom environment. The data clearly indicate that the instructional package improved student attitudes toward science and increased student performance. Both within a group and between groups, the girls who had exposure to LSD were found to exhibit improved cognitive outcomes and more positive attitude towards science compared with those who had conventional teaching. The outcomes have therefore added to the existing evidence on the benefit of active involvement of student in the learning process. The data are consistent with previous studies indicating that interactive learning activities increase student performance and interest (Boussard and Garison, 2004; Roman et.al.,, 2007). For example, Romann compared active learning using labs with traditional instruction in biology. The test data showed that students gained significantly more content knowledge and knowledge of process skills using the labs compared to covering the same content through traditional methods. Students also perceived greater learning gains after completing the labs and were reported by teachers to have their behaviour changed. The underlying principle that students learn best if they are actively engaged with activities that are closely linked to understanding learning materials has been confirmed in the study. A significant high effect size was obtained for the experimental group on all the attitude scales after exposure to treatments, with the highest effect on scientific activities scales. The interactive scientific activities offered a medium for students to contextualize, construct and own their knowledge. The experiences gained from the scientific activities had impact on competence and bolstered their confidence. Confidence building has been identified as a critical factor in helping girls to develop interest in learning science; confidence feeds interest and interest feeds success. When students record success on a learning task, it positively affects their motivation, reinforce their confidence and motivation to learn new materials and the probability of continuing involvement in the task increases. The implication is that interest and persistence in science among girls is anchored on success and confidence. These findings support previous study that indicated a strong relationship between scientific interest, performance and choice of science among high school girls [Erinosho,1997; Grazia, Nadja and Christian 2011).

Students most likely also benefitted from regular testing, feedback and in-class remedial activities. Moreover, the collaborative group learning experiences, sharing of ideas through discussion and class presentations must have significantly impact on learning outcomes. Studies have shown that collaborative learning promoting active exchanges of ideas within the group, enhances critical thinking and higher achievement and retention of information than solo learning (Han-Yu and Gwo-Jen, 2011). The outcomes of this study also show that experiments and investigations came top among the activities enjoyed. This is not unexpected because apart from making them see real science, their curiosity is also kindled. For example, it was exciting for students to view the components of blood under a microscope, or cut open a rabbit and view the organs or generate electricity and see its effects, or engage in water treatment project etc. Also, as students are guided through the activities to find out on their own the content becomes real, understandable and easy to retain. Research evidence shows that when students find personal relevance supported by concrete experience in the material they are learning, they learn better and are more apt to retain information.

Thus, a critical issue in promoting the interest of girls in science is to help teachers to gain experience in creating varied settings that provides student-oriented activities with challenging tasks, open discussion, presentation of ideas and sharing of experiences which should lead to increase student enjoyment, excitement about science, and learning about science. Teachers should support girls beyond 'learning to do science' to 'doing to learn science' as this can bring powerful change to school science learning and enthusiasm of girls in the subject. Of importance however is that the activities must be focused on important learning outcomes and promote thoughtful engagement of the students.

An unanticipated effect of the instructional package is the enthusiasm that was generated among the teachers too. They all exhibited visibly remarkable interest in teaching with the package, and expressed strong merit in adopting the instructional approach. However, some of the challenges that have implications for successful adoption of the approach requiring consideration include:

- Having to manage large classes. The noise level accompanying student discussions during class presentations and group work could be intolerable.
- Lack of materials in some cases to support the in-class activities. This require that teachers develop skills in improvisations and construction of low-cost alternative instructional resource materials.
- Extra work load on the teacher who in some cases had to purchase, create or improvise learning materials.
- Examination-bound syllabus and the pressure to run through the prescribed curriculum.

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