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Effect of Problem-Based Learning on Acquisition of Creative Thinking Skills among Chemistry Students in Ogoja Education Zone, Cross River State, Nigeria

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Abstract
The study investigated the effect of problem-based learning strategy in fostering creative thinking skills among senior secondary chemistry students in Ogoja Education Zone of Cross River State, Nigeria. Three research questions and three null hypotheses guided the study. A pre-test, post-test non-randomized control group quasi experimental design was adopted while a sample of one hundred and twenty-five (125) senior secondary two (SS 2) Chemistry students drawn from a population of 2533 chemistry students participation in the study. One co-educational school each was selected from two out of five Local Government Areas in the zone through purposive and simple random sampling techniques. An intact class from each of the two schools was randomly assigned to experimental and controls groups. An instrument titled Creative Thinking Skills Acquisition Scale (CTSAC) with a reliability index of 0.09 was used for data collection. The data obtained was analyzed using mean scores to answer the research questions and the analysis of covariance (ANCOVA) used to test the hypotheses at 0.05 level of significant. The results showed that students exposed to problem-based learning strategy exhibited a higher propensity in the acquisition of creative thinking skills than those taught using the conventional lecture method of instruction. The result further indicated that there is no significant influence of gender on students' acquisition of creative thinking skills. Based on the result obtained, it was therefore recommended that problem-based learning strategy be used to teach chemistry and other STEM subjects in secondary school to help students develop creative thinking skills.

Introduction

Chemistry is a branch of science, which deals with the studies of the structure, composition and properties and reactions of matter in different forms. Chemistry is very important in the scientific and technological development of any nation. Infact, chemistry is the heart of science and science is the foundation on which technology is built in developing a nation (Chemistry Society of Nigeria, 2010).

Chemistry plays important roles in critical areas such as efficient production and preservation of foods that are healthy and nutritious, development of new processes for energy generation, industrial production and in the creation of better, cheaper and more robust field methods for environmental monitoring and impact assessment (Owoyemi, 2018).

In Medicine, chemistry is useful in the development and testing of new medical treatment and medicines (Helmenstine, 2020). This is because the drugs used for treating or preventing diseases are made of chemicals and the development of such drugs involves chemical analysis and synthesis of new compounds.

Chemistry also has a wide application in Agriculture ranging from the manufacturing of materials for the production of improved variety of crops and animals for consumption or commercial purposes. Through the knowledge and application of chemistry, a variety of fertilizer have been produced to increase yield, a number of pesticides and insecticides to control pest and insects, plastic pipes for improved irrigation among others.

Important as chemistry and other STEM subjects are as bedrock for national advancement, many students are found to dislike sciences and thus often switch to Art subjects in secondary schools. The main reason for this is due to the consistent use of the conventional lecture method that tend to render the learners passive in the learning process (Eriba, 2000). Many researchers agree that the lecture method does not help students to construct their own understanding and opined that the uninspiring teaching methods adopted by science teachers lead not only to low achievement in the science but also incapacitates students from developing required skills necessary for creative and innovative thinking (Johnson and Johnson, 2002, Kolawole, 2007, Samba & Iortim, 2014). As Pink (2005) puts it, creative and innovating thinking is increasingly necessary to accomplish goals in our complex and interconnected world and its importance to success in the 21st century is undeniable. Yet, despite this increased awareness of the relevance of creativity and innovation, teachers still fall short of the tact and knowledge of how to nurture and support creativity and innovation in science classroom situation as they often resort to pure conventional lecture procedures (Henrikson and Mishra, 2013) which makes it impossible for them to infuse creativity and innovation into teaching (Giroux & Schimdt, 2004, Samba & Iortim, 2014).

Creativity is a mental and social process involving the generation of new ideas or concept or new associations of the creative mind between existing ideas and concepts. The process of creativity entails both mental and social (Giroux & Schimdt, 2004). This shows that individuals level of intelligence is important in creativity. Every learner is endowed with certain level of intelligence. There is no learner with absolute zero Intelligent Quotient (IQ). It is inferred therefore that every learner has tendency of being creative but the creativity level might differ from one learner to the other.

The social aspect of the process emphasizes interaction of learners with people in their surrounding. In this case, their interaction with teachers who are custodians of instruction goes a long way in enhancing their creativity level. The method of instruction employed by a teacher in most cases will determine the involvement of learners in teaching and learning process (that is, to be active or passive). Thus a teacher-dominated instructional method disallows exhibition of new ideas from learners.

A shift is therefore advocated by researchers to methods that will enable learners construct their own understanding (Samba, Achor & Ogbeba, 2010, Mohammad, 2012, Oludipe, 2015). Such methods have their root in constructivism. This model focuses primarily on the learners' ability to construct his own understanding from experiences and in so doing make meaning of what they learn (Oludipe, 2015). This strategy is learner-centred and often provide opportunity to develop other skills needful for survival.

Among these strategies is the problem-based learning strategy which is a student-centred pedagogy where students acquire learning experiences through solving open-ended problems. The goal of problem-based learning as put forward by Schmidt (2005) is to help learners develop flexible knowledge, effective problem-solving skills, self-directed learning, effective collaboration skills and intrinsic motivation. This method allows students to work in groups and by so doing, they identify what they already known, what they need to know, and how and where to access new information that may lead to the solution of the problems. The role of the teacher is to guide, and facilitate learning by supporting and monitoring the learning process and at the same time building the students' confidence in their work.

Torp and Sage (2012) described problem-based learning as being focused, experiential learning organized around the investigation and resolution of real life problems. Learners are engaged problem-solvers seeking to identify the underlying problems and the condition needed for a good solution and in the process becoming self-directed learners. The method fosters collaboration among learners, stresses the development of creative and innovation problem-solving skills within the context of professional practice, promote effective reasoning skills and is aimed at increasing motivation for life-long learning (Torp & Sage, 2012).

According to Johnson and Johnson (2002) in problem-based learning group members work to maximize and to also gain from each other, students and teachers become co-learners, co-planners, co-producers and co-evaluators as they design, implement and continually refine their plan of activities.

Studies by Johnson, Johnson and Holubec (2006) and Panitz (2009), Afomafa (2012), Abonyin, (2013, showed positive effect in the use of problem-based learning strategy in enhancing students' learning and interpersonal skills. Their findings further indicates that students learn more material when they work together co-operatively, are motivated to learn the materials as their interest in the subject is kindled exudes more positive attitude towards learning and develop analytical problem-solving skills.

According to Kerka (2015) one essential attribute of problem-based learning is that it challenges learners to use problem-solving skills, self-directed learning strategies team participation skills and disciplinary knowledge all of which facilitate creativity and students' intrinsic motivation to learn. In the same vein, Johnson and Stanne (2013) in their study on problem-based learning noted that any method of instruction which enables learners to be active participants in constructing their learning seems to improve understanding, application and creativity. This becomes even more evident when one considers that in the process of problem-based learning, students state goals, brainstorm, formulate problems, work co-operatively, discuss constructively and come out with consensus decisions. Therefore, decisions teachers make in structuring class lessons can influence students' interactions with others, creating an atmosphere that enables the development of vital interpersonal skills which Kerka (2015) asserts are essential for thriving creativity and innovation. These skills include goal setting skills, leadership skills, manipulative skills, brainstorming, communication skills and decision making skills.

Marble (2017) investigated the effect of problem-based learning on students' acquisition of creativity skills and found no significant differences in the mean creativity scores of male and female students. Also Abdulahi and Duyilemi (2013) investigated the relative effectiveness of problem-based learning and competitive teaching strategies on Biology students' acquisition of innovative and creative skills in Kaduna State, Nigeria. The result revealed that there was no significant difference in innovative and creative skills of students taught biology with problem-based learning and competitive instructional strategies. However, females in the problem-based learning group showed higher acquisition of creative skills than their male counterparts. Contrary to this finding, Okigbo and Etoniru (2012) has earlier reported that there was a significant difference in the mean creativity scores of males and females exposed to mathematics with problem-based learning and competitive teaching strategies in favor of males. Thus, the findings on the influence of gender on students' creativity skills is not consistent and therefore inconclusive. It thus becomes necessary to empirically established the effect of problem-based learning strategy on male and female secondary school chemistry students' creativity skills in Ogoja Education Zone of Cross River State, Nigeria.

Problem of the study

Creative and innovative thinking has been persistently very poor among science students and this cannot be unconnected with teacher's poor method and strategies or the strict adherence to the use of the conventional lecture method. Creative and innovative thinking is necessary to accomplish goals in our complex and interconnected world and its importance to success in the 21st century is undeniable. Yet, despite this increased awareness of the relevance of creativity, teachers skills fall short of the tact and knowledge of how to nurture and support creativity and innovation in current classroom practices as they often over depend on the pure conventional lecture method which makes it impossible for them to infuse creativity into teaching. This study therefore investigates the effect of problem-based learning strategy in fostering creative thinking skills in senior secondary school chemistry students in Ogoja Education Zone of Cross River State, Nigeria.

Purpose of the study

The main purpose of the study is to determine the effect of problem-based learning strategy on acquisition of creative thinking skills among senior secondary school chemistry students as compared to the conventional lecture method of instruction. Specifically, the study seeks to determine:

i) The creativity mean score of senior secondary school students taught chemistry using problem-based learning strategies and those taught with conventional lecture method.
ii) The difference in the creativity mean scores of male and female students taught chemistry using problem-based learning strategy and those taught with conventional lecture method
iii) The interaction effect of methods and gender on the students' creativity mean scores in chemistry.

Research questions

1. What is the difference in the creativity mean scores of SS 2 students taught chemistry using problem-based learning strategy and those taught with conventional lecture method?
2. What is the creativity mean scores of male and female students taught chemistry using problem-based learning strategy and those taught with the conventional lecture method?

3. What are the interaction effects of method and gender on the students' creativity mean scores in chemistry?

Hypotheses

Three null hypotheses guided the study and were tested at 0.05 levels of significance.

1. There is no significant difference between the creativity mean scores of SS 2 students taught chemistry using problem-based learning strategy and those taught with the conventional lecture method.
2. There is no significant difference between the creativity mean scores of male and female students taught chemistry using problem-based learning and those taught with the conventional lecture method.
3. The interaction effect of methods and gender on students' creativity mean scores in chemistry is not statistically significant.
4.

Method

The study adopted a quasi-experimental design. Specifically, the pre-test, post-test, non-randomized control group design was used. The use of intact classes did not allow for randomization of the research participants because the schools used for the study had all their students organized into different arms already which the authorities did not allow to be disorganized for the purpose of the study.

The population of the study comprised two thousand five hundred and thirty-three (2533) senior secondary two (SS 2) Chemistry students in public secondary schools within Ogoja Education Zone of Cross River State Nigeria. A breakdown shows that 1,259 are males and 1,274 females. A sample of one hundred and twenty-five (125) SS 2 chemistry students was drawn through multistage procedure for the study. The first stage involved the selection of two out of five Local Government Areas in the Education Zone through the simple random sampling method. The second stage involved the selection of one school each from among the co-educational secondary schools in the two Local Government Areas. Thus two schools were purposively chosen from the two Local Government Areas by the researcher so as to provide classes where the males and females could work under the same classroom environment. Finally, from the two schools, one intact class was randomly assigned through balloting to experimental group (Group taught chemistry with problem-based learning strategy) and one to the control group (group taught chemistry with the conventional lecture method).

The instrument for data collection was Creative Thinking Skills Acquisition Scale (CTSAC) developed by the researcher for the purpose of the study. The instrument comprised 30-items constructed based on five creative thinking skills namely; Brainstorming, problem-solving skills divergent thinking, open-mindedness and communication skills. The instrument was validated by experts and the reliability was established using Kuder Richardson Formula 21 (K-21) and this yielded 0.79 which was considered appropriate for the study.

Experimental procedure

The regular chemistry teacher for the experimental group (i.e. group taught chemistry with problem-based learning strategy) was trained on the instructional package by the researcher for one week before the commencement of treatment. The chemistry teacher that taught the control group (group taught with the conventional lecture method) was not trained but was however briefed on the purpose of the research. The students in the two groups were initially pre-tested using the Creative Thinking Skills Acquisition Scale (CTSAC) before the commencement of the treatment.

Thus, the problem-based learning strategy was used in teaching the participants in the treatment group while the conventional lecture method was used in the control group. The chemistry teachers in the selected schools were used as research assistants in conducting the study. The study was carried out during normal school hours using the schools timetable. At the end of the experiment which lasted for six weeks, a post-test was administered to the students in both the treatment and control groups. The pre-test and post-test were the same for both groups. The scores that were collated from the pre-test and post-test were used in answering the research questions and for testing the hypotheses at 0.05 level of significance

Results

Research question one:

What is the difference in the Creatively mean scores of students taught chemistry with problem-based learning strategy and those taught using the conventional lecture method?

Data collected with the Creative Thinking Skills Acquisition Scale (STSAC) for both the pre-test and post-test were used to answer this research question. Descriptive statistics involving adjusted means and standard deviation were utilized and the results are as shown in table 1.

Table 1: Creativity mean scores of students taught chemistry using problem-based learning strategy and those taught with the conventional lecture method.

Groups	**Adjusted mean (x)**	**SD**	**N**
Problem-based learning (PBL) (Treatment group)	48.11	11.13	59
Conventional lecture method (control group)	36.76	13.36	66

Summary data analysis presented in table 1 shows that the adjusted mean for the problem-based learning group (48.11) is higher than those taught chemistry with the conventional lecture method (36.76). The problem-based learning strategy thus appears much better than the conventional lecture method in facilitating students' creative thinking skills in chemistry.

Research question 2

What is the creativity mean scores of male and female students taught chemistry using problem-based learning strategy and those taught with the conventional lecture method? The results are presented in table 2.

Table 2: Creativity mean scores of male and female students taught chemistry with problem-based learning strategy and those taught with the conventional lecture method.

Groups	**Gender**	**Adjusted mean (x)**	**SD**	**N**
Problem-based learning	Male	47.64	10.15	29
	Female	45.13	13.10	30
Conventional lecture method	Male	38.97	9.08	35
	Female	40.32	7.11	31

Summary of data presented in table 2 shows that in the PBL group the adjusted creativity mean scores for males (47.64) is higher than that of the females (45.13) whereas in the conventional lecture method group the adjusted creativity mean scores for the males (38.97) is less than that of the females (40.32).

Research question 3

What is the interaction effect of methods and gender on students' creativity mean scores in chemistry?

Summary of results in table 2 indicate that the problem-based learning strategy is superior to the conventional lecture method at the two levels of gender implying that there is no interaction between method and gender on students' creativity mean scores in chemistry.

Testing of hypotheses

The data collected with the creative thinking skills acquisition scale for both the treatment and control groups were subjected to analysis of co-variance so as to test the hypothesis. summary of the result is presented in table 3.

Table 3: Summary ANCOVA test of significance on the effect of methods and gender on creative thinking skills in chemistry

Sources of variation	**Sum of square**	**Df**	**Mean square**	**F**	**Significance of F**
Covariates	19215.814	1	19215.814	270.486	0.000
Main	11398.352	2	5697.188	80.214	0.000
Methods	10739.479	1	10739.479	161.180	0.000
Gender	37.155	1	37.155	0.508	0.478
2-way interactions	164.031	1	164.031	2.308	0.068
Explained	30941.851	4	7735.363	107.882	0.000
Residual	20743.058	121	71.038		
Total	**51684.909**	**125**	**175.611**		

Hypothesis one: There is no significant difference in the creativity mean scores of students taught chemistry with problem-based learning strategy and those taught with the conventional lecture method.

Table 3 presents the results of the analysis of covariance (ANCOVA) on the main effect of strategy on students creative thinking skills in chemistry. The results reveals a significant outcome ($F(1,121) = 161.180$, $P = .000 < 0.05$). This implies that the difference between the creativity mean scores of the students taught chemistry using problem-based learning and those taught with the conventional lecture method is statistically significant. Hence the null hypothesis one is rejected in favour of the alternate hypothesis. Therefore, it is concluded that there is significant difference in the creativity mean scores of students taught chemistry using problem-based teaching method and those taught using the conventional lecture method.

Hypothesis two: There is no significant difference in the creativity mean scores of male and female students taught chemistry using problem-based learning strategy and those taught using the conventional lecture method. The results in table 3 indicates the ANCOVA test on the main effect of gender on students' creative thinking skills in chemistry. The result shows a non-significant outcome $F(1,121) = 0.508$, $P = 0.478 > .05$). This implies that the difference in the creative thinking skills between the male and female chemistry students is not statistically significant. Therefore, the null hypothesis two is upheld. Based on this result, it is concluded that there is no significant difference in the creativity mean scores of male and female students taught chemistry both with the problem-based learning strategy and those taught with conventional lecture method.

Hypothesis three: The interaction effects of methods and gender on the creativity mean scores in chemistry is not statistically significant. Table 3also shows the result of the ANCOVA test on the interaction effect of method and gender on students creative thinking skills scores in chemistry. The result shows a non-significant outcome ($F(1,121) = 2.308$, $P = .068 > 0.05$). This implies that the difference between the creativity mean scores of the male and female students taught with the problem-based learning strategy and the conventional lecture method is not statistically significant. Hence, the null hypothesis three is upheld. Therefore, it is concluded that there is no significant interaction effect of method and gender on the creativity mean scores of students in chemistry.

Discussion

The results showed that students taught chemistry using problem-based learning strategy demonstrated high acquisition of creative thinking skills than those taught with the conventional lecture method. The finding is in line with the study of Johnson and Holubec (2006), and Panitz (2009) who reported that the problem-based learning strategy is more effective in fostering creative thinking in students than the conventional lecture method. They concluded that if secondary school chemistry teachers could incorporate problem-based learning strategy into their teaching, there would be an enhancement in the acquisition of creative thinking skills among chemistry students.

The result also indicated that the creativity mean scores of male students are higher than that of the female students for the group taught chemistry with problem-based learning strategy but the different is not significant. Johnson and Stanne (2013) have all added that any method of instruction which enable all learners to be active participants in constructing their learning seems to improve understanding, application and helps to reduce gender differences. The result also lay credence to the works of Abdulahi and Duyilemi (2013), Marble (2017) which showed a non-significant difference in creativity means scores between male and female students when exposed to problem-based learning and competitive teaching methods. Furthermore, the result indicates that problem-based learning strategy is more efficacious than the conventional lecture method at the two levels of gender which implies that there is no interaction between method and gender on students' creative thinking skills in chemistry.

Conclusion

From the result of the study, the following conclusion were drawn.

i) The problem-based learning strategy is superior to the conventional lecture method in facilitating students' acquisition of creative thinking skills in chemistry.
ii) The problem-based learning strategy does not discriminate across gender in enhancing students' acquisition of creative thinking skills in chemistry.
iii) There is no interaction between strategy and gender on students' acquisition of creative thinking skills in chemistry.
iv)

Recommendations

Based on the result of the study, the following recommendations are made.

1) Chemistry teacher as well as other STEM teachers should make use of problem-based learning strategy because it does not only facilitate teaching and learning but also acquisition of creative thinking skills.
2) The problem-based learning strategy should be used for both male and female students because the approach does not discriminate across gender.

3) To improve students' acquisition of creative thinking skills, problem-based learning should be introduced into chemistry teaching at secondary school level.
4) Government, through Ministry of Education and professional associations should organize public lectures, seminars and workshops to acquaint teachers with emerging instructional strategies as a way of improving the teaching and learning of all STEM subjects in secondary schools.

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