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INFLUENCE OF PROBLEM-BASED CLASSROOM INTERACTION PATTERN AND STUDENTS' GENDER ON SENIOR SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND ATTITUDE TOWARDS LEARNING OF CHEMISTRY

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ABSTRACT

The study investigated the effects of the use of problem solving instructional strategy on students' performance at cognitive and affective levels of educational attainment. In actual sense, the study determined the impact of the use of modified Selvaratram-Frazer model for solving quantitative chemistry problems on senior secondary school students' achievement in quantitative analysis and their attitudes towards practical chemistry. 206 senior secondary students drawn from four local government areas of Oyo state, Nigeria participated in the study. Data analysis was by means of Analysis of Covariance (ANCOVA). Findings from the study showed that exposing students to problem-based classroom interaction enhanced better learning of chemistry than using the conventional or expository method of teaching and learning of chemistry. The study also revealed that the use of problem-based classroom learning strategy is gender sensitive in favour of the girls, especially at the cognitive level; but not at the affective level. Finally, the study showed insignificant interaction effect of treatment and gender on attitudes towards learning of Chemistry. The findings from this study have significant implications for chemistry teachers, Education policy makers, and other stakeholders on secondary education.

INTRODUCTION

Background to the Problem

Learning involves the process of acquiring knowledge or skills based on experience, practice or study or by being taught by a teacher (Webster, 2012). It is a process wherein knowledge is generated or created through transformation of experience (Kolb, 1984). It is also the acquisition of new or modification of existing knowledge, behaviours, skills, values or preferences, and may involve creating different forms of information. This inherent ability to learn is possessed by animals including human beings and perhaps some machines. Learning, when it occurs, brings about a lasting change in the behaviour of that which results from the acquired experience.

In any classroom setting, learning occurs majorly through teaching or instruction as teaching and learning are just like the two sides of a coin. In the process of learning, knowledge, skills, or attitudes are imparted to the learners by the teachers. The process of classroom interaction can be expository, and unproductive especially if facts and knowledge are acquire through memorization without meaningful understanding of the underlying principles. (Ajeyalemi and Busari, 1986, Adeoye and Raimi, 2006). Learning can also be an active process, rather than a collection of factual or procedural knowledge. This kind of learning process involves the learners' active participation and interactions (such as doing, discovering, discussion and problem solving) with peers and materials to be learnt (Cole 1986, Eggen and Kauchak, 2007).

In Nigeria classroom interactions most often than not tend to focus on the former than the latter approach to teaching and learning. Okebukola (1997), Raimi, (2002). This often tend to poor acquisition of knowledge, skill, and attitude on the part of learners, the result of which is low achievement in science, especially chemistry. This practice is at the expense of improved learning strategies that encourage active participation of learners in what they are being taught such as it obtains in problem-based classroom interaction. Past studies that confirmed the dominance of expository and unproductive method of teaching by Science Teachers especially at the secondary school levels in Nigeria include those of Ajewole, 1985, Orji, Adesoji,1991 1998, Aratona 2001, Adegoke,2000, and Raimi,2002. Evidence abound, that this unproductive mode of classroom interaction still persists in almost all our science classrooms. For instance, annual chief examiners WAEC reports on senior school certificate examinations have always lent credence to this fact. The situation has always led to poor performance and low enrolment in science and, chemistry in particular, (WAEC, 2005, WAEC, 2009). Hence, there is need for teachers to shift emphasis from this unproductive classroom interactional pattern in the form of expository method to better learning strategies that would make learners active participants in their learning. The present study intends to fill the gap. Chemistry is an important school subject, which is central to the growth and development of any nation. Its importance in the technological advancement of any nation cannot be underestimated. This importance is strengthened by the National Policy on Education which gave it prominence amongst other school subjects (NPE, 2013). Chemistry as a subject also promotes the acquisition of organized body of knowledge and skills and the ability to use these skills for solving problem in a specific domain. Despite the importance attached the subject, it is evidently clear the from results of past studies and WAEC's chief examination reports that senior secondary school students have difficulties in learning science in general and chemistry in particular (WAEC, 2007, Acar & Tahan, 2007, Opara, 2009).One of the major sources of the identified learning difficulties experienced by chemistry students is the use of the predominantly teacher-centered teaching methods of classroom interaction. This mode of classroom interaction presents a kind of classroom situation in which the teacher acts as the custodian and dispenser of knowledge and students as receptors of knowledge. (Adeoye, 2014). This mode of classroom interaction has also been found to be grossly inadequate and inappropriate for the attainment of conceptual learning and critical thinking (Gabell, 1996) Adesoji and Raimi, 2004). This and other underlying reasons informed the need to adopt an enhanced classroom interaction which will engender conceptual learning and critical thinking in secondary school students such as the present study is intended. A number of problem-solving techniques for solving chemistry problem literature. These include Mettes, Pilot, Rossnik and Krammers (1981), Selvarathnam-Frazer (1982), Systematic Approach to Problem solving (SAP) for the purpose of the present study, Selvarathnam and Farzer model of solving problems in chemistry is adopted for use.

Reports on past studies revealed the efficacy of these models in enhancing the problem-solving abilities of students in chemistry. Few of these have been carried out in relation to students' attitude towards learning of chemistry. The present study intends to fill this gap. The efficacy of the use of this mode of classroom interaction on students' achievement especially in relation to titrimetric inorganic analysis shall be investigated.

The performance of students in chemistry can also be influenced by other learners' characteristics such as gender. Though, effect of gender on learning outcomes in science and mathematics is still a major point of debate among educators. This is as a result of conflicting nature of results from researchers that focus on gender issues in science and mathematics. This study intends to further investigate the effects of gender on students' achievement and attitude toward learning of chemistry especially in a problem- based learning situation.

With this background in focus, it becomes expedient to study the effect of problem-based learning strategy (using the Selvarathnam-Frazer model) on students learning outcomes (achievement in and attitude towards learning of) chemistry

Statement of the Problem

The study sought to investigate the effect of modified Selvarathnam –Frazer model of teaching on student's achievement and attitude towards learning of chemistry. It also determined the moderating effect of students' gender on learning outcome at both the cognitive and affective domains of learning, especially at the secondary school level in Nigeria.

Statement of Hypotheses

The following hypotheses were tested in the study at 0.05 level of significance

(1) There is no significant main effect of treatment on students' (a) cognitive achievement and (b) attitude towards learning of chemistry

(2) There is no significant main effect of gender on students' (a) cognitive achievement and (b) attitude towards learning of chemistry

(3) There is no significant interaction effect of treatment and gender on students' achievement and attitude towards learning of chemistry.

Delimitation of the study

The study was carried out in twelve secondary schools in Oyo town and its environ. Age of students ranged from 15 to 18 years. Only senior secondary school class II students of the participating schools were involved in the study. All the twelve secondary schools that took part in the study were chosen by judgmental sampling method. The schools were selected considering the following criteria.

1. Availability of standard chemistry laboratory
2. Availability of appropriate and adequate number of chemistry teacher
3. Accessibility of the school.
4. Evidence of having graduated senior secondary students for at least five (05) years.

5. Readiness of the required members of teaching staff of the participating schools and students to collaborate in the study.

Methodology

Design of the Study

The present study adopted a pretest-posttest Experimental and control group design in a non-randomized condition, using a 2x2 factorial representation. These include, the instructional strategy at two levels (i.e. problem based classroom interaction strategy and the conventional teaching method (the control) Gender at two levels (male and female)

Variables in the study

The variables are:

(i) Independent variable

(a) Instructional method – Selvarathnam – Frazer (1982) problem solving strategy.

(b) Conventional method of teaching chemistry

(ii) Moderator variables

Gender (male and female)

(iii) Dependent variables:

(a) achievement scores

(b) Attitude towards learning of chemistry

Population and Sample

The population for this study consisted of all secondary school students within Oyo Township and its environ. Only senior secondary school class II chemistry students in the twelve participating schools were involved in the study. Intact classes were used and in all a total of 260 students constituted the sample for the study. However, the number of students offering chemistry varied from one school to another. Of the total sample, 138 males and 122 females were involved their ages ranged from 15 – 18 year with the average age of 16.5 years and standard deviation of 1.6.

Instrumentation

Two valid and reliable instruments were used to collect relevant data for this study. These include:

(i) Chemistry Attitude Test (CAT)

(ii) Chemistry Attitude Inventory (CAI)

The researcher also used one instructional guide i.e. Selvarathnam – Frazer (1982) problem solving instructional guide.

The Chemistry Achievement Test (CAT), is a 30 – item multiple choice test which were based on problems relating to quantitative inorganic analysis. The CAT multiple choice items had five options (A – E). The items were drawn based on students' knowledge of topics which were relevant to quantitative inorganic analysis (otherwise called volumetric / titrimetric analysis).

These include topics such as, formulae, equation mass-volume relationship mole concept and volumetric analysis. All these topics were considered relevant to the objectives of the present study. All the test items are constructed in line with the classification of Education Testing Services (ETS) of the United States to reflect the three categories of cognitive tests namely: remembering, understanding and thinking.

The Chemistry Attitude Inventory (CAI) was a modified form of and Wilkinson"s (1979) attitude inventory. It is a 30 – item attitude inventory made up of statements which are relevant to chemistry. The items were rated on 4 – point Liker type interval scale ranging from Strongly Agree (SA) to strongly disagree (SD). Items which indicate positive attitude were graded on points ranging from 4, 3, 2, 1 (i.e.4 for strongly agree and 1 for strongly Disagree) which the scoring patterns for each item which indicated negative attitude were oppositely graded (i.e. 4 for strongly Disagree (SD, to 1 for strongly Agree (SA). The CAI was used to assess students' attitude towards learning of chemistry.

The Selvarathram-Frazer (1982) problem solving model was used to promote learning of the calculation / quantitative aspect of volumetric inorganic analysis. The model has been found very useful in the teaching and learning of concepts in science in particular chemistry (Raimi, 2002, Raimi & Adeoye 2004, Raimi & Adesoji, 2004). This model was used to teach the treatment group. The model consists of 5 – stages found to be very useful in solving chemistry problems.

Validity and Reliability of the Instrument

The CAI items were pretested after face validity two university graduate secondary schools' teachers and two science education with bias in chemistry in a secondary school which did not take part in the real study. The trial last result was compared with that obtained from a similar chemistry achievement test scores. This gave criterion related validity value of 0.87. The test re-fast reliability value using the Kudar Richadson formula K.A – 21 was also determined. This gave a reliability value of 0.75. For the CAI, the criterion related validity value 0.75 was obtained. To determine the reliability, the CAI item was administered to a group of 30 senior secondary class II students. Two weeks later, the CAI was re-administered on the same set of students and the reliability coefficient was determined. The test – retest reliability value of the CAI was determined using the Cronbach Alpha. This game a reliability value of 0.85. These values were considered adequate for the study.

Procedure

The SS II chemistry teachers in the twelve selected secondary schools involved in the study handled the instructional sessions of the study on request and they consented. They were given 2-week tutorials on the use of the Selvarathnam - Frazer (1982) problem solving model for the teaching of topics under

investigation. At the end of the 2-week long training, two trained observers for each of the training sessions confirmed the teachers'
mastery of the use of the instructional guide (inter –rater reliability ranged from 0.65 – 0.35). These observers also served as research assistants on the field. The teachers in the control group were only with use of the conventional (expository method) for solving problems relating to titrimetric analysis. The whole treatment lasted for 12 weeks. Two weeks for training of teachers and observers, one week for pre-test administration, 08 weeks of instruction and one week of post-test administration.

Experimental Group

Students in the experimental group were exposed to the use of Selvarathnam-frazer model of learning how to solve quantitative problems in volumetric analysis. In this lie their peculiarity. Teachers in this group served as a guide to learners which emphasis were laid on mastery of skills for solving quantitative problems. Teachers in this group guided students on how to solve quantitative problems using the following steps

i. Clarify and define the problem
ii. Select the key equation or formula
iii. Collect the data, check the units and calculate
iv. Derive equation for the calculation
v. Derive and learn from the solution

Control Group

Students in the control group were made to solve quantitative problem in chemistry using the conventional or the formula method i.e. the use of $^{CAVA}/_{CBVB}$ = mole ratio

Data analysis procedure

Analysis of relevant data collected in connection with the study was carried out by means of Analysis of Covariance(ANCOVA). Multiple classification

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analysis of the scores were also carried out to identify the magnitude and direction of the significance.

Results

Table 1 – summary of 2x2 ANCOVA of post test achievement scored by treatment and Gender.

*sig at 0.05

Table 1 shows the results 2x2 ANCOVA of students' achievement scores in titrimetric inorganic analysis. It indicates significant main effect of treatment and gender on students' achievement in titrimetric inorganic chemistry practical. $F_{1,}$ 258 = 97.97 p < 0.05 and 258 = 23.88, p < 0.05) respectively. It also shows that there exist no significant interaction effects of treatment and gender ($F_1$238 = 4.180, p <0.05) on students' achievement in practical chemistry, especially in titrimetric inorganic analysis.

Sources of variation	**Sum of squares**	**Df**	**Mean square**	**F**	**Sig. of F**
Covariates	185.305	1	185.305	32.529	.000*
Pretest	185.305	1	185.305	32.529	.000*
MAIN EFFECTS	1674.347	1	558.116	97.973	.000*
Treatment	1674.347	1	558.116	97.973	.000*
Gender	248.964	1	248.964	.737	.513
Treatment x gender	12.539	1	4.180	.737	.513
Explained	2293.950	16	143.372	33.063	.000
Residual	1166.456	269	4.336		
Total					

*Significant at p < 0.05

2: **Multiple classification analysis of the performance chemistry / achievement Test according to Treatment and Gender**

Grand mean = 13.86

Variable + category	**'N'**	**Adjustment Deviation**	**'Etr'**	**Adjusted independent deviation**	**Beta**
Treatment					
Experimental control	140 120	2.24 - 3.46	.73	2.24 -3.72	.73 .27
Gender					
1. Male	138	.84	.27	.82	.27
2. Female	122	1.08		1.06	
Multiple R^2					.537
Multiple R					.733

Multiple classification analysis (table 2) reveals that there exist significant interaction effects of treatment and gender on students' achievement in practical chemistry. This is reflected in the mean score (x =14.10) of the experimental group which is higher than that of the control group (x = 10.44). It also revealed that students' gender significantly influence performance in practical chemistry in favour of female students. This is because, the means score of female students (x = 14.92) was found to be higher than that of the male students (x = 14.06)

Table 3: Summary of 2x2 ANCOVA of Post-test Attitude Scores of Students According to Treatment and Gender

Sources of covariates	Sum of squares	DF	Mean square	F	Sig. of F
Covariates	.558	1	.550	2.690	.102
Pretest	.558	1	.550	2.690	.102
MAIN EFFECTS	3.901	1	1.300	6.263	.000*
Treatment	3.901	1	1.300	6.263	.000*
Gender	.273	1	.273	1.246	.265
2 way interactions	1.807	1	.602	2.953	.265
Treatment x gender	1.807	1	.602	2.953	.033*
Explained	22.967	13	1.435	22.544	.000
Residual	39.831	246	.148		
Total	62.798	259			

Table 3 shows that there is a significant main effect of treatment (PBLI) and non-significant main effect of gender on students' attitude towards learning chemistry (F, 258 = 6.263, $p < 0.05$) and F, 258 =1.246, $p > 0.05$) respectively. It is revealed that there existed significant interaction effects of treatment and gender on students' attitude towards learning of chemistry.

Table 4. Multiple classification Analysis of thePost Test Attitude Scores of Students According to Treatment and Gender

Grand mean = 83.87

Variable + Category	'N'	Unadjusted Deviation	'Eta'	Adjusted for Independent Deviation	'Beta'
Treatment					
1. Experimental	140	3.80	.26	3.60	.26
2. Control	120	-4.10		- 4.50	
1. Male	138	.90	08	0.9	.07
2. Female	122	- .12		- 0.9	.07
Multiple R^2					.071
Multiple R					.226

Multiple classification analysis table 4 shows that treatment (i.e. problem based learning classroom interaction) could be a veritable means of enhancing students' attitude towards learning of chemistry. This is because students in the treatment group obtained higher mean score[1] (x= 87.47) than those in the control group with a mean score of (x = 79.37). Male students also exhibited better or more positive attitude towards learning of chemistry than female students with mean attitude score of (x = 84.77) and (x = 82.99) for male and females students respectively.

Discussion of findings and Implication for Chemistry Teaching

Result of findings as shown in tables 1, 2, 3 and 4 reveal that there exist significant main effects of treatment on students' achievement in practical chemistry especially when quantitative inorganic analysis is involved. This lends credence to the fact that the adoption of a problem –based classroom interaction learning interaction is a strategy which a teacher can employ to promote good performance of students at the cognitive level of educational attainment. It also revealed that students' attitude towards learning of chemistry can be enhanced if this mode of classroom interaction is employed by chemistry teachers. These findings confirm earlier results obtained by other researchers such as Raimi, 2002, Adeoye, 2013, Raimi and Adeoye 2004, Raimi, & Sodamade 2014. Adesoji, 2005. It also corroborates the findings of Oloyede 2012, Yagar 2010, and Lay 2010, when they found in their various studies that exposing learners to thought provoking classroom interaction has the potential of promoting good learning of science concept. They also found that, there exist strong relationship between teaching / learning strategies that promote logical reasoning such as that which is problem based and students' performance in science. Similarly, researchers such as, Kamarudeen, Abubakar, Serif and Slew (2008), Adesoji (1991), Grant and Alexander (1993) also found out that the use of problem solving technique either as a teaching strategy or self-learning technique was more effective was more effective in learning of chemistry especially when quantitative problems are to be solved such as in titrimetric inorganic analysis.

In addition, the superiority of the problem based learning strategy over the conventional classroom interaction can be attributed to the logical and sequential manner with which instructions are presented in problem- based technique. Thus, a student who is exposed to this type of teaching or learning strategy is more likely to possess a meaningful and in-depth knowledge of the content area Danjuma (2005), and Adeoye (2013). Such students' are likely to have the ability to organize their thoughts in a logical manner which is a basic ingredient for solving quantitative problems in chemistry. When this happens, it is most likely that students will develop enhanced interest in chemistry and consequently have positive attitude towards the subject.

Table 2 and 4 revealed significant main effects of gender on students' achievement in quantitative inorganic chemistry; in favour of female students. This is in line with Adekoya 2009, 2010 Yusuf 2005, Raimi, (2002),when they found that gender is a factor that can influence students' achievement in chemistry. This reported significant main affect of gender on students' cognitive achievement negates the findings of Akale and Usman (1993) Chang & Mao (2010) who found insignificant effect of gender on performance in science. The findings of these study, though similar in terms of showing significant effect of gender on achievement in chemistry is at variance with the findings of Okpala and Onocha (1997) Hacker (1992), Okum (1995), Alexopoulou (1997) and Adeoye (2000) who in their various studies established that there exist gender difference in favour of boys.

That females performed significantly better than males in chemistry achievement especially when they were exposed to problem- based classroom interaction as obtained in this study corroborates the findings of Chang and Mao 2010, Raimi, 2002 when they obtained the same results in related studies. However, this negates the popular belief being held by people that science is a masculine subject, as females are fast catching up with males in their performance in science. This insignificant interaction effects treatment and gender, further shows that to regard science as masculine subject is fast disappearing as females of recent have come up in their achievement in the areas of science than ever before. This findings throws a challenge to practicing chemistry teachers, that the use of problem-based classroom interaction strategy, where both males and females interact and are given equal opportunity to learn chemistry is desirable, especially when topics relating to quantitative inorganic analysis is involved.

Tables 3 and 4 revealed insignificant interaction effects of students' treatment and gender on attitude towards chemistry suggests that the effect of the use of problem-based classroom interaction is not gender sensitive. Thus when viewed against the background of significant main effect of treatment further suggest that where students are to be taught and assessed at the cognitive and affective domains should use or adopt a suitable problem- based classroom interaction while teaching boys and girls (male and female). This is because gender of students does not appear to inhibit the extent to which students become interested in chemistry and consequently have no effect on their attitude towards learning the subject as suggested by this study. The independent variables (treatment and gender) when taken together, could also be used to explain 53.7% and 7.1% of variation as contained in table 2 and for the two levels of learning outcome (cognitive and affective), that is chemistry achievement and attitude towards learning of chemistry. These findings confirm earlier results of studies by Raimi, (2002), Adeoye (2013) when they obtained a similar results in related studies.

Conclusion and Recommendation

It is crystal from the results of this study that the use of problem-based classroom interaction is a veritable tool for promoting good learning of chemistry at the senior secondary school level. This is so, especially when learning of such concepts as quantitative inorganic chemistry are involved. If this is so, then practicing secondary school chemistry teachers should endeavor to adopt appropriate problem-based classroom interaction pattern / strategy that will assist secondary school. Students acquire the required learning of chemistry. Students irrespective of their sexes, should be given equal opportunities to learn chemistry as it is now becoming more evident than ever before that the age long belief that science is masculine, has almost disappeared. The use of the conventional teaching or leaning strategy is no longer fashionable, hence chemistry teachers especially at the senior secondary school level should engage in paradgm shift in terms of their classroom teaching to a more problem-based learning situation that will enhance 'students' achievement in chemistry. Concerned authorities in secondary education should organize refresher courses and training workshops for teachers on the use of enhanced teaching skill. When such workshops are put in place, teachers should also endeavor to attend and be attentive such that the desired benefit of the organized workshop can be acquired. It is believed that if this recommendation is adopted, it has the potential of improving teachers' teaching skills, which will enhance students" performance in chemistry and engender the right type of attitude towards learning of the subject.

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