Asian Journal of Education and Social Studies

5(1): 1-7, 2019; Article no.AJESS.50307
ISSN: 2581-6268

Gender Influence on Students' Perception in Learning Chemistry Using Multiple Representations in Learning Chemistry in Nigerian Secondary Schools

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Authors' contributions

This work was carried out in collaboration between both authors. Author TCO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author EOB managed the analyses of the study. Both authors managed the literature searches, read and approved the final manuscript.

Article Information

DOI: 10.9734/AJESS/2019/v5i130135
Editor(s):
(1) Dr. Ana Sofia Pedrosa Gomes dos Santos, Assistant Professor, Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal.
Reviewers:
(1) Etta Mercy Aki, University of Buea, Cameroon.
(2) Joseph O. Mukolwe, Jaramogi Oginga Odinga University of Science and Technology, Kenya.
(3) Wasantha Rajapakshe, Sri Lanka Institute of Information Technology, Sri Lanka.
Complete Peer review History: http://www.sdiarticle3.com/review-history/50307

Original Research Article

Received 16 May 2019
Accepted 26 July 2019
Published 06 August 2019

ABSTRACT

This study was aimed for investigating the influence of gender difference in learning chemistry using multiple representations which were spurred towards obtaining an improved academic achievement. The study employed a descriptive research design using a survey across the senatorial districts in Ondo state. Data collected were subjected to descriptive statistics while inferential analysis was carried out using Paired *t*-test Statistical Analysis. Findings from the study showed that there was no significant gender difference in the preferred effectiveness of multiple representation. However, female students showed more interest in the use of multiple representation in learning chemistry than male students. Based on the findings of this research, teachers should permit better student interactions and engagements in their classroom for a better understanding of chemistry context.

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Keywords: Multiple representations; Chemistry; learning; gender difference; Ondo State.

1. INTRODUCTION

Chemistry is a branch of science and a prerequisite subject for many science fields contributes immensely to the technological growth of the nation. The study of chemistry entails the learning of concepts, established principles, laws and theories and also substantial activity-oriented laboratory work. Chemical representations refer to various types of formulas, structures, and symbols used to represent chemical processes and conceptual entities (e.g. molecules and atoms). Chemical representations can be viewed as metaphors, models, and theoretical constructs of chemists' interpretation of nature and reality [1].

The context of chemistry is different from other science subjects, which exists in three levels and are difficult to understand at the same time. The three levels being the macroscopic, microscopic and the symbolic representation levels [2]. The macroscopic level chemical processes are observable while the microscopic level of chemical phenomena is explained via the arrangement and motion of molecules, atoms, or subatomic particles. Chemistry at the symbolic level is represented by symbols, numbers, formulas, equations, and structures. The three levels are intertwined and there is a need to understand how they are related. Except for experts in the subject, it is difficult to quickly move from one level to the other and therefore it should be done in stages for easy comprehension of the three levels. To help students understand chemistry at the three levels, earlier research have suggested a variety of teaching approaches such as adapting strategies based on the conceptual change model [3], integrating laboratory activities into class teaching [2], using concrete models [4] and using technologies as learning tools [5]. Among these approaches, the use of concrete models and technologies as learning tools seems to have the highest potential. Multiple linked representations provided by multimedia tools allow students to visualize the interactions among molecules and understand the related chemical concepts [5]. Multiple representation of scientific concepts is provided for achieving good educational goals. Summarily, the advantage of multiple representation illustrated by a functional taxonomy falls into three broad classes proposed by Ainsworth [6] in Fig. 1.

The constructivists recommend learning through active engagement and with understanding which is more permanent than memorisation of content or learning by equation or formula. It is argued that for deep learning to occur, students' need to be placed at the centre of the learning and supported to construct meaningful understanding out of the experience and prior knowledge [7]; Driver et al. [8]. Active engagement in activities provides opportunities for the students to receive, share and record information for processing.

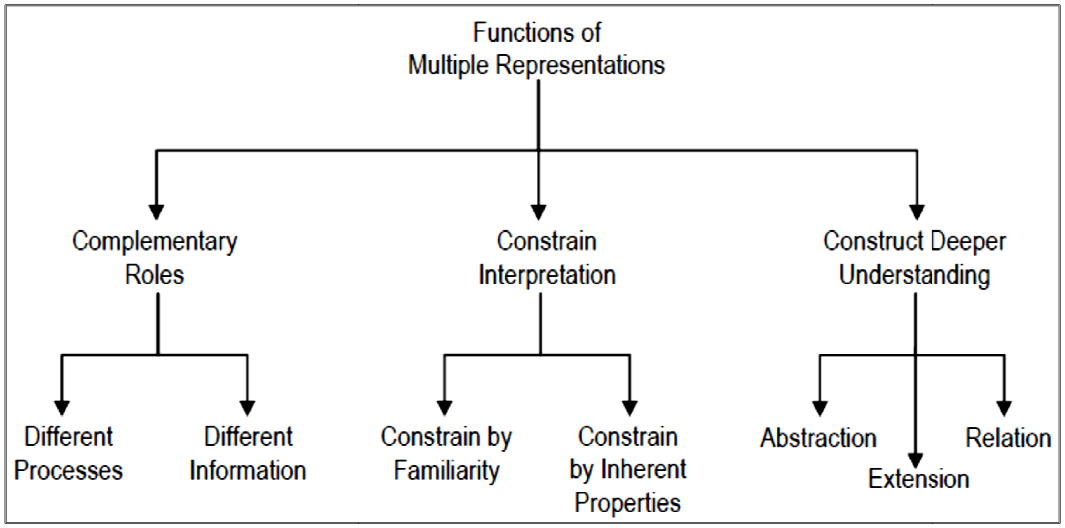

Fig. 1. Functions of multiple representations [6]

Gender is a psychological term used in describing behaviours and attributes expected of individuals based on being born as either male or female [9]. It is a cultural construct that differentiates roles, mental and emotional characteristics between females and males developed by society. The studies of gender are not just mere identification of male and female sexes but have gone further to identify responsibilities assigned to opposite sexes and to analyze the conditions under which those responsibilities are assigned [10]. Gender is a major factor that influences career choice and subject interest of students.

In science education, differences in achievements and attitudes have been observed between boys and girls. Many researchers and educators proposed that gender difference is one of the factors that affect the teaching and learning of science. Gender differences in engagement and interest in many areas of science have been studied in middle school in many countries [11]. It was found that gender differences may shape the student's perception of self-competence in various school subjects which may turn affect their achievements in science. A variety of reasons have been presented to account for such gender differences in science education. It was found by Murphy [12] that boys and girls are different in their interest and attitude from an early age. Additionally, Goman et al. (1988) revealed that at age 15, more boys favour reading the accurate facts books while more girls like to read for understanding. Moreover, Kimbell et al. (1991) showed that girls prefer to work and discuss in groups while boys prefer to work independently. Furthermore, Morphy (1997) found that girls keep considering contextual features as a whole part of the science tasks while boys keep considering issues in isolation. Thus girls usually formulate more complex multivariable investigations that are difficult to work on. Din et al. [13] found that boys had high scores in tests with more earth and physical sciences items. Understanding of scientific knowledge but girls had a higher score on recognizing the question and identifying evidence items. It implied that boys perform better in understanding than girls, particularly in the physical sciences. Bruce and Gabel (2002) observed that a more visual representation of chemical interaction has a significant effect on both girls' immediate and delayed achievement for several representations of the matter including traditional symbolic chemistry problems. Chang et al. [14] observed that boys showed higher learning interest in sustainability issues and scientific topics than girls. Evans and Rennie [15] found that girls' low interest in many areas of science was problematic because they have low interest which subsequently affect their achievement scores. Furthermore, Catsambis [16] found that boys were more likely to look forward to science class and think of how science would be useful to their future and was less afraid to ask questions in science classes than their girl peers.

1.1 Statement of Problem

The important function of a school system is to improve the academic performance of students and produce a pool of skilled manpower irrespective of their gender. The Nigerian science education system over the years is faced with a lot of challenges and one of the most serious challenge is the continuous low performance of students in chemistry. This could be attributed to the way it is taught, such that students remain passive most of the time making chemistry learning dull, non-exciting and senseless information [17]. Furthermore, could be attributed to the local peculiarity of Nigerian culture in which gender-role differentiation is very much pronounced in society. This places a very serious constraint on the academic performance of male and female students in chemistry thereby limiting their full participation, development and utilization of individual potentials either directly or indirectly. Thus, the study is aimed improving of chemistry teaching and learning at the senior secondary level.

1.2 Purpose of the Study

The purpose of the study was to determine whether multiple representation has any significant effect on the learning of chemistry and the influence of gender on learning using multiple representation in Ondo State secondary schools.

1.3 Research Questions

The study was guided by the following research questions:

- Does multiple representation have any significant effect on the learning of chemistry in Ondo State's secondary schools?

1.4 Research Hypothesis

The null hypotheses were formulated to guide the study and tested at 0.05 level of significance:

- It was hypothesized that there will be no significant gender difference in the effectiveness of multiple representation.

2. METHODOLOGY

The study employed a survey research design. The population of the study consists of all chemistry students in both public and private secondary schools in Ondo State. A purposive sampling technique was used to constitute a sample of 600 (300 males and 300 females) senior secondary two (SS2) Chemistry students who participated in this study from the three senatorial districts of Ondo state. The choice of SS2 Chemistry students for the study was based on the fact that the students have had background knowledge and experience about the Chemistry classroom to enable them to describe their situation.

2.1 Instrumentation

The instrument used to collect relevant data for the study was a structured questionnaire, the Chemistry Learning Inventory (CLI). The Chemistry Learning Inventory (CLI) was a closed type questionnaire which allows for either strongly agrees (SA), Agree (A), Strongly disagree (SD), or Disagree (D) responses from respondents. The instruments were validated by the researchers and other educational experts.

2.2 Procedure for Administration of Questionnaire

The researcher visited the participating schools for this study and administered the instruments to the students during the first term of the 2017/2018 session. The study was conducted during normal morning periods. Participants were requested to respond independently. Filled copies were retrieved on the spot to avoid instrument mortality. The instruments administered to the students were evaluated and data generated were collected for statistical analysis based on the research hypothesis.

2.3 Data Analysis

The collected data in this study were analyzed using descriptive statistics of percentages, means and standard deviations to answer the research questions. The hypotheses formulated were analysed inferentially using Analysis of variance (ANOVA) and Paired t-test statistical analysis to test the hypothesis at 0.05 level of significance.

3. RESULTS

The results on whether there is any significant gender effect of multiple representation on the teaching and learning of chemistry in Ondo State's secondary schools are shown in Table 1.

The data on Table 1 revealed that items had their mean above the cut-off of 2.50. This implies that most of the students used for the study agreed that there is a gender effect of multiple representations on the teaching and learning of chemistry in Ondo State's secondary schools. The standard deviations range from 0.543-0.737. This revealed that the respondents were close to one another in their responses and that their responses are not too far from the mean. However, student's opinion based on gender across the three senatorial districts about the significance of multiple representations on the teaching and learning of chemistry along the senatorial district is presented in Table 2.

Table 2 shows the percentages of gender effect analysis of multiple representations on the teaching and learning of chemistry in secondary schools in the three senatorial district of Ondo State. Analysis revealed that students have positive opinion that multiple representations have significant effect on teaching and learning of chemistry in secondary schools. On examination, 92.67% and 94.67% of male and female respondents respectively showed significant multiple representation on the teaching and learning of chemistry in Ondo State's secondary schools. This suggests that female student tends to benefit more when utilizing multiple representation in teaching and learning of chemistry in Ondo State secondary schools. Students' perception was considered based on their opinion about multiple representations and their interest. Hence, this shows that gender influenced the students' choice of multiple representation in teaching and learning chemistry in Ondo State secondary schools.

The hypothesis was tested by computing the responses of the respondents on the effectiveness of multiple representation in teaching and learning of chemistry. The respondents were classified based on their gender as either "Male" or "Female". Thus, their

Table 1. The table showing the mean and standard deviation of respondent's decision on the gender effect of multiple representation on teaching and learning chemistry in Ondo State's secondary schools

S/N	Item	Mean		Standard deviation	Decision
		M	F		
1	The use of different representation approach in Chemistry lessons such as graph, picture, model, concept map can aid proper understanding of Chemistry context and ideas	3.29	3.24	0.737	Agree
2	An adequate understanding of Chemistry ideas results in improved Students' performance during assessments and external examination	3.64	3.63	0.548	Agree
3	The type of representation strategy utilized by Chemistry teacher influences the Students' learning process	3.31	3.16	0.543	Agree
4	The context of Chemistry topic to be taught by the teacher should determine the representation approach to be used during teaching	3.31	3.27	0.572	Agree

Table 2. Results of percentage analysis of respondent's opinion regarding the gender effect of multiple representation on teaching and learning chemistry in Ondo State's secondary schools

Option	Ondo North		Ondo Central		Ondo South		Average	
	Male	Female	Male	Female	Male	Female	Male	Female
Strongly Agree (%)	44.0	36.0	40.0	35.0	42.0	36.0	42.00	35.67
Agree (%)	51.0	61.0	52.0	58.0	49.0	58.0	50.67	59.00
Disagree (%)	5.0	3.0	8.0	5.0	9.0	6.0	7.33	4.67
Strongly Disagree (%)	-	-	-	2.0	-	-	-	0.66
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Results of paired T-test analysis on the significant gender effect of multiple representation on the learning of Chemistry in Ondo State secondary schools

Sex	Paired samples test					
	Mean	Std. deviation	df	t_{cal}	t_{crit}	Sig. (2-tailed)
Male	3.39	0.596				
Female	3.32	0.653	599	1.887	1.960	0.060

responses were compared for statistical significance using Paired t-test Analysis at 0.05 confidence level of significance. The computed results are indicated in Table 3.

Table 3 presents the Paired T-test analysis on the significant gender effect of multiple representation on the teaching and learning of Chemistry in Ondo state's secondary schools. From the result of the paired sample T-test, the t-cal (1.887) is lesser than the t-crit (1.960). The null hypothesis (Ho) is thus retained and the Alternative Hypothesis (Ha) is rejected. Therefore, the Null Hypothesis (Ho) that there is no significant gender effect of multiple representation on the teaching and learning of Chemistry in Ondo state's secondary schools is hereby retained. The result shows a mean response of male respondent (3.39) which is close to the female respondent (3.32) and their standard deviation (0.596-0. 653) reveals that their responses were close to one another. This is evidence to deduce that there is no significant gender difference in student's choice of multiple representation approach of learning chemistry. Student regardless of their gender tends to prefer learning using multiple representation method than the use of conventional methods.

4. DISCUSSION OF FINDINGS

The students' opinion about the use of multiple representations on the teaching and learning of chemistry based on their gender was examined.

The findings of the study prove that students preferred to be actively engaged with representational challenges including role-plays, concept maps, flow charts, 3D models, particulate and graphical representations in learning chemistry. Collaborations and shared ideas in groups among the students make learning more student-centred compared with the conventional method of learning obtained in the schools. Some literature suggested that this type of classroom environment made the concept learnt easier to understand, real and accessible as the representations created during learning engages students in constructive and higher-order thinking Ainsworth, 1999; [18,19].

The teacher's role in the classroom is to facilitate students' learning not practising an authoritarian approach that results in a traditional teaching style which disengages students from learning and students feeling that they are not supported during lessons [20]. They further observed that when the opportunity is provided for students to engage in learning tasks, it develops their problem-solving skills and allows them to be more creative in life challenges.

The research has shown that gender has no significant influence on the effectiveness of multiple representations on the learning of chemistry. This finding conforms to research by Igboegwu and Okonkwo [21], who in their different studies found that gender does not significantly influence students' learning and achievement in chemistry.

Although, the effectiveness of the multiple representation among the gender showed that male students tend to be better in learning than female students. The finding agreed with Ekeh [22] who found in their studies, at various times, that male student achieved better than the female students in science subjects (chemistry).

Hence, lively and learning-friendly chemistry classrooms give learners the opportunities to express their understanding and interact among themselves and available resource materials. Student's perception of the chemistry of been difficult, because of its abstract nature and fundamental chemical expression of formulas, equations and reactions will be flipped into an interesting subject of learning. This will remediate the persistent decline in the academic achievement of chemistry students in public examination which has been a great concern to science educators, examination bodies and the general public.

5. CONCLUSIONS

Within the limits of this study, it can be concluded that the use of multiple representation in teaching and learning of Chemistry have high potency of enhancing students' interest and academic performance in the subject. Furthermore, students are more interested to be actively engaged with representational challenges that included activities such as role-plays, models, concept maps, particulate, graphical and flow chart representation of chemical reactions and participating in small group and whole-class discussions. It will improve students' academic achievement and learning of Chemistry regardless of their gender. However, female students tend to show more passion for the utilization of multiple representations in learning chemistry than male students.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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