Journal of Library and Information Management, Technology, Education
ISSN-Online: 2814-3558 |Print: 2814-3568
A publication of the Department of Library and Information Science, University of Maiduguri, Borno State, Nigeria
https://doi.org/10.5281/zenodo.16919472

Effect of Science Process Skills Teaching on Senior Secondary Students' Chemistry Performance in Maiduguri, Nigeria

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Abstract
The study examined the effect Science Process Skills Teaching on Senior Secondary Students' Chemistry Performance in Maiduguri and gender difference in academic performance of senior secondary school students taught through science process skills teaching strategy.
Methodology: Quasi experimental research design specifically pre-test post-test was used in this study. The population of the study consisted of 1,914 Senior Secondary School II (SS II) Science students. A sample of 223 (105 males & 118 females) were selected using stratified random sampling technique. Two intact classes from each school were used and assigned to the control and experimental groups. Science Process Skills Performance Test (SPSPT) was used to collect data. The reliability of the instrument was ascertained using cronbatch alpha which yielded a reliability coefficient of 0.86. The data collected were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA) for testing the null hypotheses.
Hypotheses: The study tested two null hypotheses, the hypotheses are as follows: Science process skills teaching strategy has no significant effect on senior secondary school students' chemistry performance in Maiduguri and there is no significant difference between male and female students` academic performance taught chemistry using Science process skills teaching.
Findings/Results: The findings revealed that Science process skills teaching strategy has significant positive effect on senior secondary school students' academic performance in Chemistry and the study also found significant difference between male and female students' academic performance taught Chemistry using Science process skills teaching strategy in favour of male.
Conclusion: The study concluded that Science process skills teaching strategy is effective at improving senior secondary school students' academic performance.
Recommendation: It was recommended that Chemistry teachers should use Science process skills strategy to teach Chemistry as an effective method to promote students' performance.
Keywords: Science Process Skills Teaching, Senior Secondary Students, Chemistry Performance

Introduction

Chemistry is a fundamental scientific discipline that has a substantial impact on society. It equips students with the necessary skills and knowledge to succeed in various professional fields, including chemical engineering, medicine, pharmacy, food Science and environmental studies. It has made a substantial impact on the daily lives of individuals worldwide and is

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crucial for the economic well-being of the nation, as well as for human health, food production, energy generation, security and sustainability. The essence of science is around the systematic investigation and understanding of the natural world by means of experimentation. To effectively conduct scientific experiments, one must undergo proper training through educational instruction.

Teaching Chemistry effectively cultivates students' critical thinking and reasoning skills, fosters curiosity and open-mindedness and eventually instills a desire and aptitude to solve issues. The National Policy on Education (2016) of the Federal Government of Nigeria clearly states that the objective of Science education is to instill in learners the capacity for creativity, inquiry and critical thinking by exploring the natural world and the environment, with the ultimate goal of enabling them to lead independent lives in the future. The strategy also stressed the importance of secondary school education in equipping students with the necessary skills to thrive in the contemporary era of Science and technology. Science education programs should be structured to facilitate the acquisition of problem-solving and decision-making abilities, as well as to help learners understand the practical applications of Science in their daily lives.

A successful approach for Chemistry learning is the utilization of practicum, which allows for the simultaneous integration of the three domains of intelligence: cognitive, psychomotor and affective. The American Association for the Advancement of Science (AAAS, 1971) classified Science process skills into fifteen (15) separate abilities. There are a total of eight (8) fundamental Science process skills and seven (7) integrated Science process skills. The fundamental Science process talents are crucial for making scientific discoveries. Examples of basic Science process skills include observation, measurement, classification, communication, prediction, inference, data analysis and inquiry. Integrated Science process skills are sophisticated proficiencies that form the basis for fundamental Science process skills.

Science process skills that are incorporated include creating hypotheses, conducting experiments, manipulating and controlling variables, analyzing data, setting operational definitions, formulating models and presenting information. This study assessed seven basic Science process skills, including observing, measuring, classifying, communicating, inferring, questioning and predicting, along with three integrated Science process skills: creating hypotheses, planning experiments and interpreting. The Science process skills were assessed because they are included in the curriculum for Senior Secondary Two (SS 2). The application of both fundamental and integrated Science process abilities was facilitated by practical experiences in the field of Chemistry. The Sciences employ these talents for problem identification, objective investigation, data collection, transformation, interpretation and communication. Science process skills (SPS) can be obtained and enhanced by training, such as active participation in scientific practical tasks. They are the remnants of scientific learning that remain even after cognitive understanding has faded.

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Academic performance is a measure of a student's accomplishment in school, typically represented by a score or percentage and can be classified as Distinction in terms of grades. Academic achievement is a crucial indicator for students, as it serves as the main objective of studying Chemistry globally. However, learners in comparable academic environments exhibit different degrees of academic achievement (Imomotimi, 2013). Academic performance refers to the level of achievement in education, indicating how well a student, instructor or institution has accomplished their educational objectives. It is often quantified through examinations or ongoing assessment tests. Academic performance is the primary criterion for measuring success in educational institutions. Nevertheless, the significance of Chemistry in relation to human existence, particularly in various academic disciplines within the school environment, cannot be overstated. However, the academic performance of students at the foundational level continues to decline.

Attaining academic success in Chemistry is crucial for science students' future achievements. This is because Chemistry is considered the fundamental basis of Science and Technology, which every nation aims to achieve. Stiff and Wilensky (2002) argue that Chemistry is commonly regarded as a challenging discipline due to students' perception that Science is tough to grasp. Consequently, Chemistry is often seen as one of the most arduous topics within the realm of science. According to Stiff and Wilensky (2002), the rationale behind this is that the process of learning Chemistry imposes challenges on both students and teachers. The Chief Examiner's findings from 2018 to 2022, regarding the performance of Nigerian students in the Senior Secondary Certificate Examination in Chemistry, indicate that their performance has been subpar. The findings from the Chief Examiner of WAEC provide evidence to support the assertion that Chemistry is a challenging subject to learn, which consequently lays high expectations on both students and teachers.

An issue of great concern for education stakeholders in Nigeria is the academic performance. The significant failure rate of students in Chemistry persists (Nja & Idiege, 2019). According to the Chief examiner's findings from WAEC (2018-2020), students demonstrated inadequate qualitative analysis skills, difficulty in drawing inferences from observations, weak mathematical abilities, incorrect use and omission of units (WAEC, 2018), failure to describe concepts and poor communication skills (WAEC, 2019). These discrepancies also manifest among Chemistry students, since their academic performance, although reasonably satisfactory, remains erratic across the years. The researcher is concerned about the inconsistencies in the performance of Chemistry students, which may be due to their lack of sufficient Science process abilities required for solving Chemistry practical issues. Despite the significant impact of science process skills on Chemistry learning and the development of problem-solving abilities and the academic performance of Chemistry students has continually been unsatisfactory.

Despite significant investment by stakeholders in Chemistry education, students' performance at the secondary school level is typically substandard due to various underlying problems. A

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study has uncovered several factors that contribute to students' underperformance in Chemistry, including ineffective instructional methods, negative teacher attitudes, lack of access to effective teaching and learning resources in the classroom, insufficient laboratory facilities and a weak foundation in Science (Agoro, 2002). Agroro has discovered several elements that contribute to students' academic performance, including the type of school and its facilities, the qualifications of teachers, the academic background of students, their attitude towards learning, the socio-economic milieu they come from and their parental background. This suggests that the reasons for students' inadequate performance in Chemistry exams are multifaceted.

The dismal performance of students in SSCE Chemistry has been attributed by other researchers and the Chief Examiner's reports from WAEC to some themes in Chemistry that have been deemed as difficult for students to understand (Okebukola, 2005 & Echekwube, 2009). The topics included in WAEC exams from 2018 to 2021 include acid-base reactions, chemical kinetics, electrochemistry, chemical equations, the mole concept, chemical thermodynamics and solubility of substances. Learning Chemistry helps students to possess specific skills and abilities in order to comprehend the abstract, theoretical and practical aspects of the subject. The absence or deficiency of certain skills and talents can impact the academic achievement of students in the field of Chemistry.

Statement of the Problem

The researcher observed students' low performance and weaknesses in Chemistry in the secondary schools is a strong indication of students' poor conceptual knowledge and inadequate skills acquisition which might have been caused by the teaching methods often employed by the Chemistry teachers. Teaching methods employed by Chemistry teachers in the secondary schools do not match with the needs of the 21st century learners, as they encourage rote memorization that leads to poor meaningful learning at the macroscopic level. Science process skills was recommended by the researcher for Chemistry teaching because it is inquiry activity oriented which involves active students' participation. However, the most commonly used methods are traditional and the teacher demonstration methods where students are often passive learners. Hence, students find some topics difficult to learn in Chemistry. It is against this problem that the researcher examined effect of science process skills teaching on senior secondary students' chemistry performance in Maiduguri, Nigeria

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Objectives of the Study

The objectives of the study were to determine:

1. effect of Science process skills teaching on senior secondary students' Chemistry performance in Maiduguri.
2. gender difference in academic performance of senior secondary school students taught Chemistry using Science process skill teaching.

Hypotheses

H_{O1}: Science process skills teaching has no significant effect on senior secondary school students' Chemistry performance in Maiduguri.

H_{O2}: There is no significant difference between male and female academic performance of senior secondary students taught Chemistry using Science process skill teaching.

Scope of the Study

The study was carried out in public senior secondary schools in Maiduguri, Nigeria. The study was delimited to ten (10) indicators of the Science process skills (observing, measuring, classifying, communicating, predicting, hypothesizing, questioning, inferring, experiment & interpreting) and it covered acid-base reaction.

Literature Review

Science process skills refer to the abilities that scientists employ to generate information, analyze problems and draw conclusions. These abilities are expected of every member in a Science-based community in order to be considered a Science literate person (Farsakoğlu, Sahin, Karsli, Akpinar & Ultar, 2008). The Science process skills are mutually reinforcing, enabling students to achieve significant learning objectives in Science. Science process skills are practical and cognitive skills that are utilized in resolving scientific problems. The concept of Science process skills offers a structured approach to how scientists engage in thinking, working and studying problems, while also pursuing solutions in a systematic and scientific manner (Idiege, Nja & Ugwu, 2017).

Studies have demonstrated that some teacher-related elements, such as instructional techniques, students' attitudes and gender, can significantly influence students' academic achievement. The study conducted by Sibomana et al. (2021) reveals that inadequate instructional materials, limited access to Science laboratories and the prevalent usage of teacher-centered approaches have a detrimental effect on students' motivation in learning, leading to poor academic performance. The study examined the elements that influence the

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academic performance of high school students in the subject of Chemistry. One of the factors that has been mentioned is the students' attitudes towards Chemistry (Sibomana, et. al., 2021). Hence, educators should endeavor to employ pedagogical approaches that inspire students to acquire knowledge, thereby creating a pleasant and captivating learning atmosphere.

Another variable considered in this study is gender. Gender is a major factor affecting the quality of learning on Chemistry students' acquisition of science process skills. Gender is a cultural construct that distinguishes the roles, behaviours, merits and emotional characteristics of females and males in the society (Yusuf & Adigun, 2010). Yusuf and Adigun had noted that many factors have been known to affect the academic performance of students in Science and Chemistry in particular; and among these factors is the difference between boys and girls or gender. Gender issues in the context of education refer to the differences, both real and perceived, between boys and girls and their relative achievements and opportunities. Gender in Science is the classification of the roles males and females play in science. This is the consequences of gender stereotyped which has classified different roles for male and female in the society.

Methodology

This study adopts quasi-experimental research design specifically pre-test, post-test non-equivalent control group design. The target population of this study comprised 1,914 Senior Secondary Two (SS II) Science students. Three senior secondary schools were chosen using a stratified random sampling procedure. A total of 223 Science students (105 males & 118 females) were selected from these schools. Intact classes were utilized and allocated to the control and experimental groups. Class A was designated as the experimental group, whereas class B was designated as the control group.

Science Process Skills Performance Test (SPSPT) was a test developed by the researcher to evaluate the knowledge learned on ten specific indicators of Science Process Skills (SPS). SPSPT consists of two distinct sections: Section A and Section B. Section A include hands-on activities that cover all of the fundamental and integrated Science process skills, such as observing, measuring, classifying, communicating, predicting, inferring, experimenting, questioning and testing hypotheses. Each ability was practiced through basic tasks performed by the students, whereas Section B consisted of multiple-choice questions.

The scores acquired from pilot testing of the SPSPT were used to determine the reliability coefficient, which was found to be 0.86 using the Cronbach Alpha. All the groups (experimental & control) were subjected to pre-test before the commencement of the actual treatment. During the treatment phase the experimental groups were taught using inquiry with frequent experiments in the laboratory and each lesson delivered followed process skills principles while the control groups were taught through conventional method (by talk, chalk & board) without experimentation. The collected data were analyzed using measures of central

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tendency (mean), dispersion (standard deviation) and a statistical technique known as Analysis of Covariance (ANCOVA).

Results

H_{O1}: Science process skills teaching has no significant effect on senior secondary school students' chemistry performance in Maiduguri

Table 1: Summary of Univariate Tests on the Performance of the Groups in Chemistry

	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Contrast	30852.519	2	30852.519	474.838	.000	.683
Error	14294.462	220	64.975			

Table 1 presents the results for the ANCOVA. The results indicated that there was significant difference in the performance of the groups in Chemistry at F (1,220) = 474.8, p=> 0.01 in favour of the experimental group. The estimated effect size was calculated at eta square .683 representing 68% of the variance in the dependent variable is explained by the independent variable. Therefore, students' performance in Chemistry varied. Thus, the null hypothesis was rejected and alternative hypothesis was accepted because of the difference in the performance.

H_{O2}: there is no significant difference between male and female academic performance of senior secondary students taught Chemistry through Science process skill teaching.

Table 2: Tests of Between-Subjects Effects between Science Process Skills Teaching Performance and Gender of SS II Science Students in Chemistry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2424.053[a]	2	1212.026	15.992	.000	.225
Intercept	21275.886	1	21275.886	280.729	.000	.718
Performance in Chemistry	664.435	1	664.435	8.767	.004	.074
Gender	1983.886	1	1983.886	26.177	.000	.192
Error	8336.673	110	75.788			
Total	292062.000	113				
Corrected Total	**10760.726**	**112**				

Table 2 presents the ANCOVA results determining the variance difference among the variables. This analysis was based on the linearly independent pairwise comparisons among

https://doi.org/10.5281/zenodo.16919472

the estimated marginal means. The result showed that there was a statistically significant difference in the performance of the experimental group by gender at F (1,1) = 26.177, p = 0.01. The estimated effect size was calculated at eta square =.192, which represented 19% of the dependent variable variance accounted for by the independent variable. The null hypothesis Ho_4 was rejected.

Summary of Findings

The following are summary of the findings:

1. Science process skills teaching strategy has significant effect on senior secondary school students' Chemistry performance in Maiduguri.
2. There was significant difference between male and female students' academic performance taught Chemistry using Science process skills teaching in favour of male.

Discussion

The study examines the effect of Science process skills teaching on senior secondary school students' Chemistry performance in Maiduguri, Nigeria. The results of hypothesis one indicate that the teaching strategy of Science process skills has a substantial effect on the academic performance of senior secondary school students in Chemistry in Maiduguri Metropolis, Borno State, Nigeria. This outcome aligns with the research conducted by Abungu, Okere and Wachanga (2014), which concluded that the utilization of the Science process skills method has a notable effect on students' performance in Chemistry. Furthermore, Chebii, Wachanga and Kiboss (2012) and Aktamis and Ergin (2008) demonstrated that students in the experimental groups achieved better results compared to the control groups. This study's findings indicate that the Science process strategy is effective in enhancing students' academic performance in Chemistry.

The results of hypothesis two indicated a considerable disparity in academic performance between male and female students who were taught Chemistry using the Science process skills teaching strategy, with male students performing better. This study contradicts the findings of Okere, Nyaka and Obuba (2021), which indicated that both boys and girls who were exposed to SPSTA fared equally well in Chemistry. Gender disparities in the comprehension of SPSs would lead to an imbalance in the distribution of interest and job options within society.

The research on the comprehension of SPSs among different gender varied and there is heterogeneity in their outcome. Certain research support females, while others support males and some studies indicate no substantial disparity between genders. A study conducted on Form four students in a Malaysian state found that there was no notable disparity in the amount of acquisition of overall, basic, or integrated SPSs (Mohamad & Ong, 2013). A quasi-experimental study conducted on secondary school students revealed that there was no

https://doi.org/10.5281/zenodo.16919472

discernible disparity between genders (Abungu, et. al., 2014). Gürses et al. (2015) discovered that male high school students in Turkey outperformed their female counterparts in basic SPSs. The study contradicts the findings of Zeidan and Jayosi (2014) who examined the level of self-perceived social skills among Palestinian secondary students and discovered a notable disparity, with females outperforming males. The variations can be ascribed to location, content scope and instrumentation.

Conclusion

The study concluded that Science process skills teaching strategy is effective at improving senior secondary school students' academic performance in Chemistry.

Recommendations

Based on the findings of the study, it was recommended that Chemistry teachers should increase active participation of secondary school students by organizing frequent practical sessions to create opportunity for students to share ideas as these activities will engage them effectively in the lesson.

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