

Diagnostic Teaching of Chemistry for Economic Enhancement

Bruce, Olive Agbonma

*Department of General Studies
Education,
Federal College of Education -
Ekiadolor, Benin City*

Article DOI:

10.48028/iiprds/esjprcd.v13.i1.23

Keywords:

Diagnostic teaching,
Learning difficulties,
Chemistry.

Abstract

This study examined the effect of diagnostic teaching on students with learning difficulties in Chemistry in Delta State, Nigeria, with a view to enhancing academic performance and supporting economic development through science education. A quasi-experimental pre-test, post-test design with non-equivalent groups was adopted. A sample of 200 Senior Secondary School One (SSS1) students was selected and assigned to experimental (diagnostic teaching) and control (conventional method) groups using purposive sampling. Data were collected using the Basic Chemistry Diagnostic Test (BCDT) and analyzed using mean, standard deviation, and t-test at the 0.05 level of significance. Findings revealed that students exposed to diagnostic teaching showed significant improvement in their areas of weakness and performed better than those taught using conventional methods. The study concludes that diagnostic teaching enhances learning outcomes in Chemistry and recommends its adoption in secondary schools to improve students' performance and engagement in science.

Corresponding Author:

Bruce, Olive Agbonma

Background to the Study

Science and technology remain the cornerstone of economic growth and sustainable development in modern societies. Nations that have achieved significant industrial and economic advancement have done so largely through deliberate investment in science education and the effective teaching of scientific concepts (*Ediftwood, 2022*). This is because Science education plays a significant role in technological advancement and economic productivity. In Nigeria, Science education has evolved over the years with increasing emphasis on its role as a strategic tool for achieving global competitiveness, promoting entrepreneurship, enhancing employability, and improving the overall well-being of citizens (Federal Republic of Nigeria 2019). In addition, the general importance of science education in fostering critical thinking, innovation, and societal development is highly emphasized (*Ediftwood, 2022*). Consequently, strengthening science education, particularly at the basic and secondary school levels, is essential for the acceleration of economic enhancement and national development (*Chinyere, 2011*).

Among the science subjects taught in schools, Chemistry occupies a central position due to its wide applications in areas such as health, agriculture, energy, manufacturing, and environmental sustainability (*Gordon, 2023; Adesoji, 2008*). It serves as a foundational subject for many professional disciplines including medicine, pharmacy, biochemistry, and engineering (*Avaa, 2011; Bugaje, 2013*). Regardless of its importance, the teaching and learning of Chemistry in Nigerian secondary schools, particularly in Delta State, have continued to face significant challenges and *Its* potential is not fully realized due to persistent learning difficulties among students. Even with various reforms, the quality of science instruction remains inconsistent, particularly in public secondary schools where inadequate teaching strategies and limited instructional resources hinder effective learning (*Edomwonyi & Avaa, 2011; Ibrahim et al., 2017*). Many students demonstrate low interest, poor achievement, and a tendency to avoid Chemistry and other core science subjects at the senior secondary level (*Bruce & Odili, 2020; Oyelade & Abiolade, 2017*). Early analyses of science education development in Nigeria highlight persistent structural and pedagogical challenges that continue to affect learning outcomes (*Babajide, 2015; Erinosh, Adesanya, & Oguyemi, 2000*). Studies have attributed this trend to weak foundational knowledge, ineffective teaching methods, abstract nature of Chemistry concepts, and lack of student engagement (*Allen, 2022; Shirazi, 2017; Sadeq et al., 2023*). These persistent structural and pedagogical challenges have continued to affect learning outcomes in chemistry.

A critical issue underlying students' poor performance in Chemistry is the presence of learning difficulties arising from inadequate prior knowledge (*Mohammed, 2009*). Concepts such as atomic structure, mole concept, chemical equilibrium, radioactivity and others are inherently abstract and require strong foundational understanding (*Shaik, 2016*). *Poe, (2023)* observed that Some students enter senior secondary school without adequate preparation for the cognitive demands of Chemistry, which contributes to misconceptions and low academic achievement. Due to their misconceptions or insufficient background knowledge, they struggle to assimilate new concepts, leading to frustration, loss of interest,

and eventual withdrawal from science-related subjects (Reardon, 2018; Coppens, 2020). Additionally, the teaching of Chemistry is often perceived as difficult due to its abstract nature and the ineffective pedagogical approaches commonly adopted in classrooms. Studies have shown that many science teachers struggle with selecting appropriate instructional methods, which negatively affects students' comprehension and interest (Coppens, 2020).

The constructivist learning perspective, as advanced by Piaget, provides a useful framework that offers strong support for addressing learning challenges through learner-centered approaches. It posits that learners actively construct knowledge based on prior experiences and cognitive structures (Daodu, Elegbede, & Adedotun, 2024; Deng, 2024). When these prior structures are weak or incorrect, meaningful learning becomes difficult. Therefore, addressing students' misconceptions and learning gaps early is essential for improving learning outcomes in Chemistry. Recent literature further reinforces that the application of constructivist principles enhances students' active engagement and knowledge construction in the classroom (Implementation of Jean Piaget's Theory of Constructivism in Learning, 2024). This suggests that teaching strategies should be designed to identify and correct learners' prior misconceptions.

One promising instructional approach that systematically identifies students' learning difficulties for addressing these challenges is diagnostic teaching. Diagnostic teaching involves the meticulous detection of students' strengths, weaknesses, and learning needs through continuous assessment, followed by targeted instructional interventions (Burke, Brummitt-Yale, & Taccone, 2023; Longe, 2024). Scholars have described diagnostic teaching strategy as an essential component of effective teaching, that can help educators adapt instruction to students' needs (Nardin, 2024; Tophat, 2023; Erinosh, 2005). Unlike conventional teaching methods that often adopt a one-size-fits-all approach, diagnostic teaching is learner-centered and responsive, enabling teachers to meet individual learner at their identified area of needs. This approach has been shown to help students overcome misconceptions, improve conceptual understanding, and enhance academic performance (Kambe, 2020; Rajeev & Singh, 2022; Vidhyanidhi Education Society, 2023).

Despite its potential, there is a paucity of empirical studies, particularly in Delta State, that compare the effectiveness of diagnostic teaching with conventional teaching methods in improving the performance of students with learning difficulties in Chemistry. Furthermore, limited attention has been given to the use of diagnostic teaching as an early intervention strategy at the Senior Secondary School One (SSS1) level, where students are first exposed to core science subjects before making subject choices (Delta State Ministry of Basic and Secondary Education, 2018). This study therefore addresses this gap by investigating the effectiveness of diagnostic teaching in improving the performance of students with learning difficulties in Chemistry in Delta State. Specifically, the study seeks to determine whether diagnostic teaching can significantly enhance students' understanding in their areas of weakness and improve their overall academic performance compared to conventional teaching methods.

Objectives of the Study

The main objectives of this study are to:

1. Determine the difference in students' performance in identified areas of weakness in Chemistry before and after exposure to diagnostic teaching.
2. Compare the performance of students with learning difficulties in Chemistry who are taught using diagnostic teaching and those taught using conventional methods.

Research Questions

The study was guided by the following research questions

1. What would be the mean difference in students' performance in their area of weakness before and after the treatment?
2. What would be the mean difference in the performance of students exposed to diagnostic teaching and those who were not?

Hypothesis

The study tested the following hypothesis at 0.05 level of significance.

1. There would be no significant difference in student's performance in their area of weakness before and after the treatment.
2. There would be no significant difference in the performance of students exposed to diagnostic teaching and those who were not

Methodology

This study adopted quasi-experimental research design, specifically the pre-test and post-test of non-equivalent groups. This design was applied because intact classes were used as the school authority did not permit them to randomize. The design compared two groups (experimental and control) to ascertain the effects of the treatment. The two groups were pre-tested, then the experimental group was exposed to the treatment package while the treatment was withheld from the control group. The population of the study consisted all SSI students in public secondary schools in Udu Local Government Area of Delta State, numbering 14 schools with a total of 3700 students in the first Term of 2025/2026 academic session. The sample of this study was 200 SSI students randomly selected from two public secondary schools with two intact classes. The researchers purposively selected the schools and randomly assigned them to the instructional groups in intact classes. School A which had 107 SSI students in an intact class was used as the experimental group, while School B which had 93 students in an intact class was used as the control group.

The instrument for data collection was "Basis Chemistry Diagnostic Test (BCDT)" developed by the researchers to test students' knowledge and difficulties in the basic level of chemistry. The content of the test focused on classification of living things into metals and non-metals, chemicals, crude oil and petrochemicals and radioactivity which are the major chemistry topics contained in basic science from JSS1 to JSS3 scheme which forms the foundation for chemistry in the senior secondary school.

To determine their relevance and appropriateness, the instruments for data collection in this study (BCDT) was submitted to two experts in the chemistry department, and two experts from measurement and evaluation Department of faculty of Education, Delta State University to ascertain its validity. This process was particularly to enable the validator ascertain the face and content validity of the instrument. Meanwhile, the Chemistry Lesson Plan for Teaching was vetted and edited by the head of department of chemistry in the school of the experimental group before use. And to ensure the accuracy, the test of stability (test-retest) method was used to establish the reliability of BCDT. This reliability method was considered appropriate because it demonstrates the consistency of the scales and describes the extent to which the results of measurement of a single test from the same respondents remain stable. The researchers first administered the BCDT to a group of SSI students in one of the schools not selected to participate in the research, assessed their performance and re-administered the same BCDT to the same group of students after two weeks, computed and correlated the two sets of scores using Pearson Product Moment Correlation (PPMC) to obtain the test-retest stability coefficient. The test-retest stability coefficients of 0.72 was considered very strong and was deemed reliable for administration in the main study.

The researchers further prepared a marking scheme which was used for the scoring of the items in the instrument. The instrument was made up of twenty questions. Five (5) question on classification of living things into metals and non-metals, five (5) On chemicals, five (5) on crude oil and petrochemicals, five (5) radioactivity. The question carried 100 marks which were shared between the four topics tested: The behavioral objectives for both groups were the same except that the plans for the experimental group were based on diagnostic teaching. Two teachers were recruited, one each from two of the schools selected for the study to serve as research assistants. One teacher was from school A (experimental), while the other teacher was from school B (control). These teachers were holders of (B.Ed in chemistry. Only the teacher of the experimental group was trained on the use of diagnostic teaching method. The research assistant was trained for three days. Two hours were used for each training session, totaling 6 hours for the three days training. The training took place at school A after the school hours. The lesson for the experimental group was planned by the researcher. After the training, the researcher engaged the research assistant in micro teaching while the researcher listened to ensure that he had mastered the use of diagnostic teaching strategy before going into the class to teach the students. The research assistant for the control group, on the other hand, was not given any training because he was to teach the group using the conventional method. However, he was encouraged and supervised as he taught the topic in the scheme of work that was given to him. The experimental group was taught using diagnostic teaching strategy to revise chemistry related topics only in the junior secondary school curriculum. while the control group was taught the same topics using the conventional method within the treatment period of four weeks. The research assistants were made to adhere strictly to the method designed in the lesson plan for the treatment which involved diagnostic assessment tools such as, unit pretest, surveys, questionnaires, checklists, impromptu quiz, and entry slips.

Participants in the experimental and the control group met four times in a week for two weeks in their respective schools. This provided a total of eight meetings. The duration for each meeting was 1 hour 20 minutes (double period), making the total number of 10 hours 40 minutes. With the help of the research assistants, the pre-test was administered to the students in the first week of the exercise. After the test, the scripts were retrieved from the students and marking was done with the help of the research assistants. The scripts were kept till the post-test was administered to be able to compare the two results and determine if there was any difference in the ability of the students in the post-test as a result of the treatment. Like the pre-test, post-test was BCDT for both the experimental and control groups at the end of the fourth week of the treatment. There was no difference in the item in the post-test. The test was allotted the combined duration of 1 hour 20 minutes (40 minutes each), and it tested the basic knowledge of chemistry from junior secondary basic science and technology. Mean and standard deviation was used to answer the two research questions raised and t-test was used to test the null hypotheses at 0.05 level of significance.

Results

The data collected were analyzed and interpreted based on the two research questions and the two corresponding null hypotheses formulated.

Research Question One: What would be the mean difference in student's performance in their area of weakness before and after the treatment?

Table 1: Descriptive Statistics for the Mean Difference in area of weakness before and after treatment

Group	Pretest			Posttest		
	N	Mean	SD	Mean	SD	Mean gain
Experimental	107	40.1	23.2	67.5	22.6	29.4
Control	93	41.7	23.5	42.4	18.33	0.7

Table 1 shows that there were 107 students on the experimental group. The mean score for the experimental group was 40.1 with a standard deviation of 23.2 during the pretest, while after the treatment, in the posttest, their mean score was 67.5 with a standard deviation of 22.6. The mean gain between the experimental groups pretest and its posttest is 29.4 in favour of the posttest in the experimental group. Thus, there was a mean difference in the scores of students after being treated with diagnostic teaching method and before their exposure to the treatment.

Research Question Two: What would be the mean difference in the performance of students exposed to diagnostic teaching and those who were not?

Table 2: Descriptive Statistics for the Mean Difference in performance of students exposed to diagnostic teaching and those who were not

Group	N	Pretest		Posttest		Mean gain
		Mean	SD	Mean	SD	
Experimental	107	40.1	23.2	67.5	22.6	29.4
Control	93	41.7	23.5	42.4	18.3	0.7
Mean Difference		-1.6		25.1		28.7

Table 2 shows that there were 107 students on the experimental group and 93 students in the control group of diagnostic teachers. The mean score for the experimental group was 40.1 with a standard deviation of 23.2 during the pretest, while the posttest, their mean score was 67.5 with a standard deviation of 22.6. The students in the control group had a mean score of 41.7 with a standard deviation of 23.5 at the pretest and a mean score of 42.4 with a standard deviation of 18.3 at the posttest. The mean difference between the experimental group and control group was -1.6 at the pretest in favour of the control group and 25.1 at the posttest in favour of the experimental group, while the mean difference between the two groups using their mean gains was 28.7 which was also in favour of the experimental group. Thus, there was a mean difference in scores between students taught using diagnostic teaching strategy and those who were not.

Hypothesis.

Ho,1: There would be no significant difference in student's performance in their area of weakness before and after the treatment.

Table 3: The t-test analysis comparing students' difference in performance in their area of weakness before and after the treatment.

Group	N	Pre-test		Post-test		DF	t-cal	t-crit	Remark
		Mean	SD	Mean	SD				
EXP	107	40.1	23.2	67.5	22.6	105	7.35	1.96	SIG.
CON	93	41.7	23.5	42.4	18.3	91	1.05	2.0	N. SIG.

From table 3 above the calculated value of $t = 7.35$ is greater than the critical value of $t = 1.96$ at 0.05 level of significance. Therefore, the non-hypothesis was rejected. It is then clear that the performance of students in their area of weakness with a mean of 67.5 after being treated with diagnostic teaching is significantly higher than when they did not undergo the treatment, with a mean score of 40.1.

Ho 2: There would be no significant difference in the performance of students exposed to diagnostic teaching and those who were not

Table 4: The t-test analysis comparing difference in performance of students exposed to diagnostic teaching and those who were not.

Group	N	Mean	SD	DF	t-cal.	t-crit.	Remark
EXP	107	67.5	22.6	198	8.66	1.96	SIG.
CON	93	42.4	18.3				

From table 4 above, the calculated value of $t = 8.66$ is greater than the critical value of $t = 1.96$ at 0.05 level of significance. Therefore, the non-hypothesis was rejected. It is then clear that the performance of students exposed to diagnostic teaching with a mean of 67.5 is significantly higher than those who were not exposed to the treatment, with a mean score of 42.4.

Discussion of Results

This study examined the effect of diagnostic teaching on students with learning difficulties in Chemistry in Delta State. The findings of this study revealed that students taught using the diagnostic teaching methods performed significantly better in their identified areas of weakness compared to their performance before exposure to the treatment. The post-test improvement observed in students suggests that diagnostic teaching effectively addressed learning gaps and areas of misconceptions, thereby enhancing students' understanding of fundamental Chemistry concepts. The rejection of the null hypothesis is an indication that the difference in performance was statistically significant. This finding is consistent with previous studies of Longe (2024) and Burke, et.al. (2023) who observed that diagnostic assessment enables teachers to gain insights into students' prior knowledge and areas of weakness, thereby informing appropriate instructional strategies. Similarly, Kambe (2020) and Rajeev, et. al. (2022) argued that diagnostic teaching helps teachers to tailor instruction to learners' specific needs, leading to improved comprehension and academic performance. The findings also align with the report by Vidhyanidhi Education Society (2023), which highlighted that diagnostic teaching supports students in detecting and correcting misconceptions, thereby enhancing learning outcomes.

The study also demonstrated that, diagnostic teaching was more effective than the conventional teaching method in improving the performance of students with learning difficulties in Chemistry. Students in the experimental group consistently outperformed those in the control group, indicating that the learner-centered and responsive nature of diagnostic teaching provides a more effective alternative to traditional instructional approaches. This result corroborates the findings of Kambe (2020), Rajeev and Singh (2022), and Vidhyanidhi Education Society (2023), who all reported that diagnostic teaching promotes deeper understanding, active engagement, and improved academic achievement compared to conventional teaching methods. The effectiveness of diagnostic teaching observed in this study can also be explained within the framework of constructivist learning theory. According to constructivist principles, meaningful learning occurs when new knowledge is built upon existing cognitive structures (Daodu, Elegbede, & Adedotun, 2024; Deng, 2024). Diagnostic teaching aligns with this principle by identifying students' prior

knowledge and misconceptions, and then providing instructional support that facilitates knowledge reconstruction. By addressing difficulties in foundational understanding, diagnostic teaching enables students to better assimilate and accommodate new concepts, thereby improving their overall performance in Chemistry.

In addition, findings from the study revealed that diagnostic teaching creates an interactive and supportive learning environment that motivates students, reduces anxiety, and fosters positive attitudes toward learning. This may explain why students exposed to diagnostic teaching improved academically and also demonstrated greater engagement with the subject. Overall, the results of this study provide strong empirical support for the use of diagnostic teaching as an effective instructional strategy for addressing learning difficulties in Chemistry through early identification and remediation of students' learning gaps, particularly at the entry point of senior secondary education, where foundational knowledge plays a critical role in shaping future academic choices and performance. Confirming the effectiveness of diagnostic teaching methods, Longe (2024) and Burke, Brummitt-Yale, and Taccone (2023) noted that diagnostic assessment enables teachers to gain insights into students' prior knowledge and areas of weakness, thereby informing appropriate instructional strategies. Similarly, Kambe (2020) and Rajeev and Singh (2022) argued that diagnostic teaching helps teachers to tailor instruction to learners' specific needs, leading to improved comprehension and academic performance. The findings also align with the report by Vidhyanidhi Education Society (2023), which highlighted that diagnostic teaching supports students in detecting and correcting misconceptions, ultimately enhancing learning outcomes.

Furthermore, the findings support earlier assertions that ineffective teaching methods contribute significantly to students' poor interest and performance in Chemistry (Allen, 2022; Shirazi, 2017). In contrast, it showed that diagnostic teaching was more a result-oriented teaching method as Students in the experimental group consistently outperformed those in the control group, indicating that the learner-centered and responsive nature of diagnostic teaching provides a more effective alternative to traditional instructional approaches. This result corroborates the findings of Kambe (2020), Rajeev and Singh (2022), and Vidhyanidhi Education Society (2023), who all reported that diagnostic teaching promotes deeper understanding, active engagement, and improved academic achievement compared to conventional teaching methods. The effectiveness of diagnostic teaching observed in this study can also be explained within the framework of constructivist learning theory posits that meaningful learning occurs when new knowledge is built upon existing cognitive structures (Daodu, Elegbede, & Adedotun, 2024; Deng, 2024). Diagnostic teaching aligns with this principle by identifying students' prior knowledge and misconceptions, and then providing instructional support that facilitates knowledge reconstruction. By addressing gaps in foundational understanding, diagnostic teaching enables students to better assimilate and accommodate new concepts, thereby improving their overall performance in Chemistry.

Conclusion

This study investigated the effectiveness of diagnostic teaching in improving the performance of students with learning difficulties in Chemistry, particularly at the Senior Secondary School One (SSS1) level in Delta State. The aim was to determine whether early identification of students' learning gaps, followed by targeted instructional interventions, could enhance their understanding and academic performance in Chemistry. The findings of the study revealed that diagnostic teaching significantly improved students' performance in their identified areas of weakness. Students who were exposed to diagnostic teaching demonstrated notable learning gains compared to their initial performance levels. In addition, the study established that diagnostic teaching was more effective than the conventional teaching method, as students in the experimental group consistently outperformed their counterparts who were taught using traditional approaches. The study contributes to existing knowledge by providing empirical evidence supporting the effectiveness of diagnostic teaching as a learner-centered instructional strategy in Chemistry education. It further reinforces the relevance of constructivist learning principles by demonstrating that addressing learners' prior knowledge and misconceptions can significantly enhance meaningful learning. Importantly, the study highlights diagnostic teaching as a viable early intervention strategy capable of improving students' engagement, performance, and retention in science subjects. From a policy and practical standpoint, the findings highlight the need for educational stakeholders to embed diagnostic teaching into classroom practice, particularly at the entry point of senior secondary education. Integrating diagnostic assessment strategies within the curriculum could strengthen foundational knowledge, reduce learning difficulties, and ultimately increase students' participation in science-related disciplines, thereby supporting national goals of scientific and technological advancement.

However, the study is not without limitations. The use of a quasi-experimental design with intact classes limits the extent to which findings can be generalized. Additionally, the study was confined to a specific geographical area and a relatively small sample size, which may not fully represent the broader population of secondary school students. In conclusion, diagnostic teaching is a relevant teaching strategy that offers a practical and effective approach to addressing learning difficulties in chemistry. Its adoption in the teaching-learning system has the potential to transform science education by enhancing learners understanding, foster unwavering interest, steady engagement and contribute to the development of a scientifically literate and economically productive society.

Recommendation

Based on the findings, the following recommendations were made;

1. Teachers should adopt diagnostic teaching strategies, especially during the early weeks of SSS1, to identify and address students' learning gaps.
2. Professional development programs such as workshops and seminars should be organized to equip teachers with the skills required to implement diagnostic teaching effectively.

3. Curriculum developers should consider incorporating structured diagnostic assessment components into Chemistry lesson plans especially for senior secondary one (SS1)1.
4. Future research should explore the long-term effects of diagnostic teaching on students' academic achievement and retention in science subjects. Studies could also examine its applicability across other science disciplines and educational levels, as well as investigate the role of technology in enhancing diagnostic teaching practices

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