UTILISING CONTEXT-BASED LEARNING TO PROMOTE STUDENTS' CONCEPTUAL UNDERSTANDING AND PERFORMANCE IN ORGANIC CHEMISTRY

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ABSTRACT

Organic chemistry is believed to be one of the difficult branches of chemistry taught at the senior high school level, especially in Ghana. This study investigated context-based learning approach in promoting students' conceptual understanding and academic performance in organic chemistry. The context of the learning approach in this study was within the students' immediate environment. A quasi-experimental design, specifically, a two-group pre-test and post-test nonrandomized control group design was used in this study. Purposive sampling technique was employed to select 80 research participants, who were senior high school students from two selected schools organised into intact classes at the time of this study. Organic Chemistry Achievement Test (OCAT) was the instrument used to collect quantitative data from the participants. The OCAT developed by the researchers was in the form of a pre-test and a post-test. The reliability coefficients for the pre-test and the post-test were 0.78 and 0.81 respectively. The data were analyzed using descriptive statistics (line graphs) and an independent-samples t-test. The findings from the study showed that context-based learning significantly improved students' conceptual understanding and academic performance in organic chemistry. It was revealed that the magnitude of the effect on students' academic performance in organic chemistry due to the context-based learning was large. Students had a better understanding and appreciation of the concepts in organic chemistry as the teaching approach was contextualised within their immediate environment through collaboration, critical thinking and creativity. Conclusion of this study indicates that teaching organic chemistry concepts within the context of learners' immediate environment promotes understanding and appreciation of the subject leading to improved performance. On the other hand, traditional teaching method remains an ineffective teaching pedagogy for enhancing students' conceptual understanding and performance in organic chemistry among senior high school students in the selected schools where this study was conducted. It is recommended that chemistry teachers should contextualise the teaching of chemistry by taking advantage of students' immediate environment and what is already known to them to promote better understanding and appreciation of the subject.

Keywords: Improved performance, context-based learning, critical thinking, environment.

INTRODUCTION

Science as a discipline is meant to prepare students for science-related careers such as medicine, industry and the teaching profession, unfortunately, in some instances, there is a mismatch between scientific content taught and science-based occupation (Aikenhead, 2005; Duggan & Gott, 2002). It is worrisome when there is a disconnect between concepts taught in the classroom and the application of those concepts in the learners' immediate environment. Most chemistry teachers do not take advantage of the numerous scientific concepts embedded in everyday activities happening within the learners' immediate environment to teach the subject. Sadly, such teachers hastily resort to teaching concepts in abstract, ultimately at the peril of the students. It is noted that among the many difficulties confronting science education, one of the issues is linked to an ineffective teaching strategy on the part of science teachers because they are not well-prepared and innovative to teach (McFarlane, 2013; Shukla, 2005).

How could any nation develop if its early learners are discouraged from pursuing scientific fields due to the methods used to teach science at such levels? Many science topics taught are unlikely to be retained by students because of inappropriate teaching approaches (Shreirer & Sjoberg, 2004). When the lessons taught in schools are relevant to the students' context and their regular activities within the learners' surroundings, this difficulty can be reduced. Chemistry as a subject is a crucial requirement in any science-related programme at higher institutions of learning as it aids in the formation of scientific habits that can be applied to various spheres of life and help students become valuable and integrated members of modern society (Achor & Kalu, 2014; Aksela, 2005). There is the need for innovative teaching strategies that make the learning of chemistry student-centred, meaningful and more stimulating to promote lifelong learning. Students easily get interested and are eager to imbibe chemical concepts that have direct link to everyday life experiences within their immediate environment.

The focus of this study is on organic chemistry because of the numerous challenges associated with its learning. Students view organic chemistry as a significant barrier to pursuing chemistry as a discipline and they do have a lot of difficulties developing accurate mental images of its concepts (Coll et al., 2006; Hanson, 2017). The challenges associated with the teaching and learning of organic chemistry are the reasons for adopting teaching strategies that make it easy for students to develop accurate mental images and connect the chemical concepts to their applications in the learners' environment. Many organic chemistry students find it extremely difficult to explain functional groups in detail and consider the subject generally difficult, which make them to come up with a range of alternate notions describing it as an obscure, challenging subject that necessitates memorization of many principles (Bhattacharyya & Bodner, 2005; Stieff, 2007; Strickland et al., 2010).

Studies have shown that in different nations, contextual learning strategies have had a favourable impact on students' interests and learning outcomes due to the association between real-life experiences and what they learn in the chemistry classroom (Bennett et al., 2003; Broman & Parchmann, 2014; Frechner, 2009; Kirman & Yigit, 2017). In Ghana, specifically in the study area, where this current study was conducted, to the best of the researchers' knowledge, this is the first time context-based learning approach is explored in determining its effect on students' performance in organic chemistry. Taking into consideration the challenges students encounter in learning organic chemistry in the selected schools engaged in this study against the background that context-based learning has proven effective in promoting students' learning outcomes, it has become necessary to consider its application in this study. Context-based learning offers students the platform to develop problem-solving skills, think critically and creatively as they learn between the classroom and the immediate environment.

Many methods used to teach chemistry in senior high schools do not connect what students have experienced in real-world settings to the concepts taught in the classroom. As a result, students may boast of receiving outstanding grades but are unable to understand and apply the chemical principles taught in the classroom in real life situation. It is observed that students cannot understand the link between what they learn in organic chemistry in their everyday lives and in the world in which they live (O'dwyer & Childs, 2017). What is compounding the problem that calls for this study is the worrying trend of students' poor academic performance in chemistry in general and specifically the organic chemistry aspect at the senior high school level in Ghana. It is established that one of the major causes of low aca demic performance of students in organic chemistry is due to poor teaching techniques (Adu-Gyamfi et al., 2013; Hanson, 2017). If this situation is not given a priority and the needed attention, further study of the subject, will suffer setbacks at the tertiary level. If students lack the requisite understanding of concepts in organic chemistry at the senior high school level, how will they be adequately prepared to work in industries that use organic chemistry concepts after their tertiary education?

It is on this basis that this study sought to investigate the effect of context-based learning within students' immediate environment on their conceptual understanding and performance in organic chemistry in selected senior high schools in Ghana. Consequently, the following research questions guided the study.

1. To what extent does context-based learning approach promote students' conceptual understanding of organic chemistry**?**
2. What is the effect of context-based learning approach on students' performance in organic chemistry?

LITERATURE REVIEW

Literature review was done along three main areas: Theoretical review, conceptual review and empirical review. The theoretical review sought to establish the foundation on which this current study is anchored. The conceptual review portrayed the relationship between the independent variable and the dependent variable, whilst the empirical review laid emphasis on previous studies in relation to the key variables in the research questions of this current study.

Theoretical Review

The theory that underpinned this study is the social constructivist theory developed by Lev Vygotsky (Vygotsky, 1978). Russian psychologist and educator, Lev Vygotsky created a theory on how social interactions affect cognitive development. The concepts in Lev Vygotsky's social constructivism theory are more compatible with this study. According to social constructivists, knowledge is a human product that is created through social and cultural processes (Kukla, 2000). When people are actively participating in social activities by linking concepts learnt in the classroom to real life experiences in the learners' environment, meaningful learning takes place. What students learn is a direct replication of what they see in their environments, but it also results from their thought processes, reflections, and information processing (Steele, 2005).

Constructivist principles hold that learners bring with them pre-existing beliefs about a variety of events throughout learning situations, which frequently conflict with those accepted by science, and some of these beliefs become ingrained and difficult for them to modify (Taber, 2006). In this regard, teachers act as facilitators in choosing conceptual change teaching strategies that guide students to resolve their conflict between their pre-existing knowledge and knowledge that is scientifically accepted. In the social constructivism classroom, students are encouraged to interact with one another, participate in group discussions, and work in teams, whilst teachers use instructional techniques to help them comprehend concepts and information that can provoke disagreements with their initial hypotheses (Watson, 2001). In the classroom, a teacher who holds the principles of constructivism should emphasize real-world problem-solving scenarios, collaborative learning and the development of higher-order thinking abilities (Larson & Keiper, 2007). A well-designed constructivist classroom that provides a variety of activities to encourage students to embrace individual differences and employ tangible learning experiences that are related to the learners' actual surroundings is a key component of effective chemistry teaching and learning (Cakir, 2008; Taylor, 2002).

Conceptual Review

Figure 1 represents the conceptual framework of this study. It shows how the key variables are related in this framework.

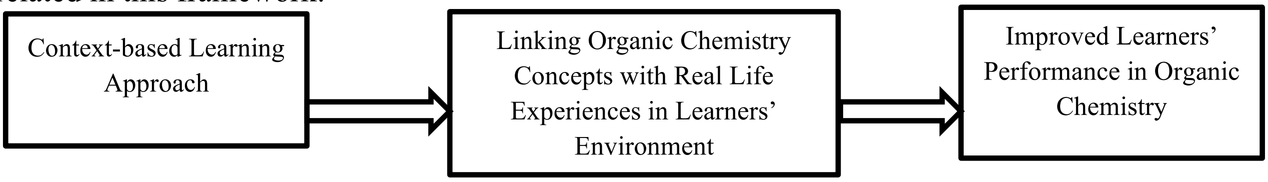

Figure 1: Conceptual framework showing the relationship between the variables in this study

In this framework, the context-based learning approach serves as an independent variable, in which the processes involved in teaching organic chemistry connect the concepts with real life experiences within the learners' environment. The outcome of these processes leads to improved learners' performance in organic chemistry that serves as a dependent variable.
Context-based learning is unique in helping students apply their classroom knowledge and skills to a variety of in- and out-of-class circumstances to address hypothetical or real-world problems that make them become substantially more invested in their school learning activities (Berns & Erickson, 2001; Plate, 2003). Contextual learning methods are used by teachers because they enable them to link the academic material that students learn with everyday experiences that they typically have. This aids students in connecting what they learn to their own lives. Therefore, context-based curriculum and instructions are designed to promote the five learning elements of relating, experiencing, applying, cooperating, and transferring whatever that the students learn.
In the contrary, traditional teaching methods are limited in promoting meaningful learning among students. Traditional methods are content-focused, and the instructor continues to be the most dynamic, subjective, and ineffective factor, thus focusing on reviewing accurate material and largely ignore higher levels of rational outcomes (Rao, 2011; Sigh, 2004). With this approach, the instructor frequently teaches students by employing a chalkboard presentation strategy, a voice explanation, or a lecture instead of allowing the students to explore their environment through innovative ways of learning.

Empirical Review

This review directly relates to the research questions under investigation. The focus is on students' conceptual understanding of organic chemistry concepts and the effect of context-based learning on students' performance in organic chemistry. Previous literature in these areas plays a major role in discussing the findings of this current study.

Students' Conceptual Understanding of Organic Chemistry

A study conducted in Singapore revealed that majority of students found organic chemistry to be a challenging subject, and they particularly struggled with hydrocarbons, various subtopics of organic chemistry, such as isomerism and the reactivity of alkanes and alkenes, as well as the reactivity of benzene rings (Bryan, 2007; Kay & Yiin, 2010). Similarly, other studies pointed out the following topical areas of organic chemistry as challenging to students; petroleum, natural and synthetic polymers, functional groups, benzene, drawing and representation of organic compounds, natural and synthetic polymers as well as aromatic hydrocarbons (Donkor, 2017; Uchegbu et al., 2017). The abstract nature of some of these topics in organic chemistry is a barrier to students' conceptual understanding and appreciation of the subject in daily life experiences. Not until the subject is taught in a more practical way that directly links the concepts to phenomena that occur within the learners' immediate environment, many students will be left in a dilemma to appreciate organic chemistry in a more meaningful manner.

Most students within the Ghanaian context are unable to comprehend organic chemistry concepts, particularly in IUPAC nomenclature of organic compounds, which showed that Ghanaian high school students had weak performance in naming and writing structural formulae of alkenes, alkynes and alkanols (Adu-Gyamfi et al., 2013; Hanson, 2017). The students' problems are brought on by their inability to determine the exact amount of carbon atoms in the parent chain and substituents or functional groups (Donkor, 2017). In terms of students' attitudes towards organic chemistry that impede their conceptual understanding of the subject, they purposefully avoid performing organic practical because they have the mindset that they are working with toxic and easily ignited organic solvents (Hanson, 2017). Generally, students may do well when it comes to describing organic chemistry problems, but due to memorization-focused teaching strategies, the outcome is low conceptual understanding level (Decocq & Bhattacharyya, 2019).

Effect of Context-based Learning Approach on Students' Understanding of Organic Chemistry

To better understand the connections between chemistry and society, as well as between research and practice, it is best to use a contextual learning approach. The adoption of a constructivist approach with a social basis sets contextual learning apart from other learning theories. For students to recognize the connection between concerns and science, contextualization aims to draw their attention to science in everyday events (Bennet et al., 2003). Utilizing a teaching strategy that enables students to apply what they have learned in many life circumstances and dispels their misconceptions about organic chemistry is essential to teaching the subject effectively. Students should feel that what they are learning in organic chemistry is relevant to some areas of their lives and be able to create a cogent mental model of the subject since the contextual learning technique gives the subject significance (Gilbert, 2006).

Contextual learning approach is a method of connecting chemical knowledge to students' daily lives that is closely based on learner-centered teaching and learning pedagogy. A study by Bilgin and Geban (2006) found that using a contextual learning approach led to a significant improvement in students' understanding of many organic chemistry concepts compared to when they were taught using a traditional teaching approach. The design and tenets of contextual learning approach are helpful in evaluating how well students apply their content knowledge and place an emphasis on real-world issues that encourage students to solve problems (Broman & Parchman, 2014). Similarly, a study on improving students' performance in organic chemistry through context-based learning and micro activities revealed that students' attitudes about studying organic chemistry were more favourable and that resulted in an improved performance of the subject (Hanson, 2017).

METHODOLOGY

Research Approach

The research approach adopted for this study was quantitative research method. Quantitative research studies generally involve the systematic collection of numeric data about a phenomenon, using standardized measures and statistical analysis. A quantitative research approach was chosen for this study because the data collected for the study were numeric in nature. The quantitative research approach was suitable for determining the effect of the context-based learning on senior high school students' performance in organic chemistry. The key variables in this study, namely, performance (dependent variable) and context-based learning (independent variable) resulted in the collection of continuous numerical data that were not nominal or categorical in nature, hence quantitative research approach was suitable for this study.

Research Design

This study utilised a quasi-experimental two-group pre-test – post-test nonrandomized control group design. The participants were non-equivalent since members of the groups involved were not randomly assigned but were drawn from pre-existing intact classes. Two groups were engaged in this study. One group was designated as an experimental group, where the context-based learning approach was implemented and the other group designated as a control group, where a traditional teaching approach was carried out.

Both groups were given a pre-test to have initial information about their pre-existing knowledge in terms of their performance in organic chemistry and to obtain base line information to guide which group or selected school should be designated as experimental, and which one should be assigned a control group. The research participants from two selected senior high schools were all final-year students offering the general science programme of which chemistry was taught as an elective subject. Also, after the intervention, both the experimental group and the control group undertook the same post-test to determine if there were changes in their performance in organic chemistry due to the context-based learning and the traditional teaching approaches.

Population

This research was conducted by engaging science students in two selected senior high schools in the Upper East Region of Ghana. The target population were all pure science students in senior high schools within the Upper East Region of Ghana. The accessible population were all students offering pure science in the two selected senior high schools in the Region.

Sample and Sampling Technique

Purposive sampling technique was employed in obtaining the sample for this study. Purposive sampling is used when the researcher chooses the sample based on who has the trait or the expertise that would be appropriate for the study. Once the study's focus was on organic chemistry, not every student in senior high schools within the Region could be part of this study. The general science students in this regard at the time of the study had the appropriate traits and were selected for the study. The participants were selected into two groups, the control group, which was an intact class in one of the selected schools and the experimental group, which was also an intact class in the other selected school. The sample size for the study was 80 from these two intact classes of which 41 students were in the experimental group and 39 were in the control group.

Based on the chemistry syllabus for senior high schools in Ghana, organic chemistry is a year-three topic, that is, it is taught at the final year as the students are about to exit senior high school (Ministry of Education, 2010). Consequently, the final-year students were more suitable for this study. In this regard, first-year and second-year students were not part of the selected participants.

Research Instrument

The research instrument used for this study was 'Organic Chemistry Achievement Test' (OCAT), which was developed by the researchers. The OCAT was designed as a pre-test and a post-test. The post-test was a modified form of the pre-test and each of them consisted of twenty (20) multiple-choice questions. To ascertain the students' understanding of organic

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chemistry concepts in term of their performance, each multiple-choice question had a follow-up question, which allowed the students to explain why the choice of their option was correct. The purpose of this was to avoid students just guessing correct options which may not accurately assess their performance in the subject. A correct option in each multiple-choice question attracted one mark and a correct explanation for the option also attracted one, giving a total of two marks for each question. The total score for the twenty questions was forty (40).

Validity and Reliability of the Instrument

To ensure validity of the instrument, the test items were compared to standardized questions in organic chemistry textbooks at the senior high school level and questions set by the West African Examination Council (WAEC) for the West African Senior School Certificate Examination (WASSCE). The test items were constructed to cover all the topics in organic chemistry that the students were taught through the context-based learning and the traditional approach. The test items were also scrutinised by lecturers with expertise in chemistry education. This was to guarantee both face and content validity of the instrument.

The reliability of the instrument was checked through trial testing with 20 senior high school students, who were not part of the participants of the study but shared similar characteristics with them. The results were subjected to Kuder-Richardson formula 20 (KR-20) to determine the reliability coefficient. The reliability coefficient of the pre-test was 0.76 while that of the post-test was 0.81.

Data Collection Procedure

The data for this study were gathered from the pre-test and the post-test scores. The selected schools for the study were given the pre-test to ascertain the baseline for assigning them to the control and the experimental groups. Each selected school was taught the fundamentals of organic chemistry in their previous lessons before the commencement of this study. It meant that students selected for the study already had prior knowledge of organic chemistry concepts at the level of the senior high school. The two selected schools were given the same pre-test by the researchers and assisted by chemistry teachers in the selected schools to monitor the administration of the test.

The pre-test comprised 20 multiple-choice questions and students needed to select options from the multiple-choice questions and justify their answers, which were used to determine their conceptual understanding and performance in organic chemistry. The pre-test scores were collated and analysed. The mean scores of the students in the two selected schools were compared to establish the baseline that informed the placement of the students into an experimental group and a control group. The researchers therefore assigned one of the selected schools (School A) with a low mean score according to the analysis as the experimental group and the other school (School B) with a high mean score as the control group. As part of the data collection procedure, the teaching of students in both groups lasted for four weeks before post-test test was conducted and scores of the test collated as data for analysis.

In this study 'School A' students received the intervention which was the context-based learning approach while 'School B' students received the traditional teaching approach. The teachers in both schools where this study was conducted had similar training and professional qualifications in chemistry education. They taught the same organic chemistry topics as stipulated in the senior high school chemistry syllabus. While the control group teacher taught the students through the traditional teaching method, the experimental group teacher taught the students through the context-based learning approach.

Traditional Teaching Method

The traditional teaching method was characterised solely by the classroom approach type of teaching, where the teacher dominated the teaching and learning process using prepared lesson plans. The teacher was seen as a repository of knowledge making students recipients of all that the teacher has to tell them about organic chemistry concepts. The activities of the teacher dominated the teaching and learning process making students passive learners in the entire process. Organic chemistry concepts were explained to the students using the marker and markerboard approach. Teaching and learning materials were mainly the available organic chemistry textbooks and illustrations on the markerboard. Assessment mode, both formative and summative, was more of class exercises, take home assignments and tests. Teaching by connecting concepts in organic chemistry to life experiences and chemical phenomena in the learners' environment hardly happened through this traditional teaching method.

Context-based Learning Approach

As the purpose of this study was to investigate the effectiveness of context-based learning approach on students' performance in organic chemistry, the teaching of students in the experimental group was directed by this approach. The teacher who implemented the context-based learning approach had to link the organic chemistry concepts with activities taking place within the learners' immediate environment. Thus, organic chemistry concepts were presented in context of the learners' environment for better understanding and appreciation to ascertain how this approach influences students' learning in the Ghanaian context.

With the context-based learning approach, students had the opportunity to explore, learn, and appreciate the application of various organic chemistry concepts. These concepts included but were not limited to the concept of alkane as applied in liquified petroleum gas, alkyne as applied in welding, saponification as applied in local soap preparation and esterification as applied in preparation of perfume spray. Other concepts were alkanols directly linked to distillation of alcohol from the malt of guinea corns, extraction of fat and oil from Shea butter, being extracted from the nut of the African Shea tree as well as extraction of dye from leaves etc. Interestingly, in each of these processes, the students got the opportunity to link the organic chemistry concepts taught in the classroom with what they were already familiar with in the environment and that facilitated their understanding of the concepts.

As part of the processes involved in learning the organic chemistry concepts from the learners' environment, the students in groups were taken to various manufacturing sites per how the lessons were planned to incorporate the field visits. Some of the manufacturing sites included welding sites, local soap preparation sites, alcohol preparation sites and shea butter extraction sites. The content of the lesson given to the experimental group and the teaching and learning resources were within the learners' immediate environment which they lived with and used in their day-to-day activities.

Formative assessments such as group work, exercises and assignments consequent to the field visits were given to the students in the teaching and learning processes to ascertain the achievement of the lesson objectives. The implementation of the context-based learning approach lasted for four weeks.

Pre-study Visit Activities

A sensitization session was organised in the selected school, which was designated as the experimental group to discuss the process of context-based learning in teaching the organic chemistry component of the senior high school chemistry curriculum in the Ghanaian context. The discussion led to the alignment of the organic chemistry topics within the senior high school chemistry syllabus with their applications within the learners' immediate environment. Some of the topics and their applications in the environment included saponification (production of soap), esterification (perfume production), alcohol preparation (local drink production from guinea corn malt), the extraction and purification of organic compounds, the use of liquefied petroleum gas (from alkanes), the joining of metals with ethyne (from alkyne) and others.

Visit to Study Sites

Carefully planned, contextualized organic chemistry instructions were incorporated into the field visits as part of the teaching and learning process. The implementation process involved collaborative group work and group presentations in the classroom consequent to the filed visits. Students were engaged through interactions with producers and manufacturers of various organic products during the field visits to link organic concepts taught in the classroom with real life experiences.

Figure 2 shows engagement of students with experts in their immediate environment whose daily work activities are embedded with organic chemistry concepts.

Welding of metals using ethyne   Preparation of alcohol from guinea corn

Figure 2: Field study illustrating organic chemistry concepts in learners' environment

Post-visit Activities in the Classroom

Each study visit was followed by a post-visit in-class exercise, in which students were divided into groups to discuss their experiences, with guided questions. Each group had to describe how the production site activities are connected to the organic chemistry concepts taught in the classroom. At the conclusion of each field visit, group discussion, classroom activities, group assignments, group presentations, and individual tasks were completed. As part of the roles of the chemistry teacher as a facilitator, he was to facilitate the learning of the organic chemistry concepts by connecting classroom instructions to application of the concepts in the students' immediate environment. Figure 3 illustrates a demonstration lesson by the chemistry teacher as part of the context-based learning process.

Demonstration of how ethanol is distilled

Figure 3: Demonstration of ethanol distillation through context-based learning

Administration of Post-test

After the intervention, both the students from the experimental group and the control group undertook the same post-test, which was the ‘Organic Chemistry Achievement Test’ (OCAT). The post-test was administered by the assistance of the chemistry teachers in the control group and the experimental group. The test took 60 minutes to complete. The ‘OCAT’, which comprised multiple -choice questions from which respondents were supposed to select the correct option after which they were to explain further why they thought that was the correct answer.

Depending on their responses, they were classified into no understanding, partial understanding and sound understanding. No understanding meant that the participants got both the multiple-choice question and its explanation wrong. On the other hand, partial understanding meant that the respondents got the correct option of the multiple-choice question but had the explanation for the correct option wrong. Participants who had sound understanding were those who got both the option for the multiple-choice questions and the explanation for the option correct. The ‘OCAT’ was then scored based on the participant’s responses for final analysis. There was 100% retrieval of the research instrument from the respondents.

Data Analysis Procedure

Statistical Package for the Social Sciences (SPSS) version 26.0 was used for the analysis of the data. Descriptive statistics in the form of line graphs were used to analyse the data and display the results on students’ conceptual understanding of organic chemistry concepts after teaching through the context-based learning approach and the traditional mode. To assess the level of students’ understanding of the organic chemistry concepts, open-ended questions were attached to the multiple-choice questions that allowed students to explain the reasons for options they selected as correct answers. For accurate evaluation and validation of students’ scores and responses based on the test items, Necor's (2018) concept-evaluating system was used. Students’ responses were checked based on the scientific explanations to identify the levels of conceptual understanding. Students who provided answers that aligned with the validated scientific concepts were considered to have a sound understanding. Responses that included at least one of the components of validated scientific concepts but not all of them were classified as partial understanding. If the answers were blank or unclear that does not conform to the validated scientific concepts, they were deemed to have no understanding. Table 1 presents the criteria for determining the level of students’ conceptual understanding of organic chemistry after being taught through context-based learning and traditional mode.

Table 1: Level of students’ conceptual understanding and criteria for scoring

Level of Understanding	Criteria for scoring
Sound Understanding	Responses are fully validated as scientifically correct (multiple choice option selected as well as explanation given for the option is correct)
Partial Understanding	Responses are partially validated as scientifically correct (multiple choice option selected is correct, but explanation given for the option is incorrect)
No Understanding	Responses are completely scientifically incorrect (multiple choice option selected as well as explanation given for the choice is in correct)

An independent-samples t-test was employed to analyse the data to determine the effect of the context-based learning approach on students’ performance in organic chemistry. Consequently, effect size for the independent-samples t-test was calculated by employing eta squared formula:

Eta squared = $\frac{t^2}{t^2+(N1+N2-2)}$. This was meant to determine the magnitude of the effect the context-based learning has on students' performance in organic chemistry. The guidelines for interpreting the eta squared values are such that 0.01 denotes small effect, 0.06 indicates moderate effect and 0.14 onwards shows large effect (Cohen, 1988).

Ethical Consideration

Research ethical consideration refers to scientific integrity, human rights, dignity, and collaboration between science and society. To ensure that the research was ethical, no participant was forced to participate in the study. Participants' consent was sought, and they willingly participated in the study. The responses participants provided to the questions in the achievement test were kept confidentially without disclosing their gender, name, and class to any student or a second party. Data collection and analysis procedures as well as presentation of findings were anonymous and void of biases.

RESULTS

Preliminary Analysis (Baseline Data)

The basis for assigning one school an experimental group and the other school as a control group to determine the effectiveness of the context-based learning approach was ascertained by preliminary analysis of baseline data using the students' pre-test scores. Independent-samples t-test was applied to analyse the pre-test scores of the students in the two selected schools before assigning the schools as experimental group and control group. The school with the higher mean score in the pre-test was assigned as the control group, while the other school with the lower mean score was assigned as the experimental group. The results of the independent-samples t-test for the mean scores of the experimental group and the control group are shown in Table 2.

Table 1: Independent-samples t-test of the students' scores in the pre-test

School	*N*	*M*	*SD*	*df*	*T*	*p*
School A	41	30.24	14.90	78	4.37	0.000*
School B	39	41.73	7.03			

Significant at p < 0.05
Source: Field data (2024)

From Table 2, the independent-samples t-test was carried out to determine the students' performance in organic chemistry in 'School A' and 'School B'. There was a significant difference in the mean scores for 'School A' (M = 30.24, SD = 14.90), and 'School B' (M = 41.73, SD = 7.03; t (78) = 0.050, p = 0.000). The study found that the students in the 'School B' performed significantly better than the students in 'School A'. 'School B' had a mean score of approximately 42% compared to 'School A' with a mean score of about 30%. Although the performance in one school was better than the other school, none of them had a mean score of 50%, which was the pass mark of the test as the total score of the test was 100%. The researchers, therefore, chose to assign 'School B' that had the higher mean score as the control group and 'School A' with the lower mean score as the experimental group.

Research Question One

To what extent does context-based learning approach promote students' conceptual understanding of organic chemistry**?** The results showing the extent to which context-based learning approach promote students' conceptual understanding of organic chemistry are indicted in Figure 4. Students in the experimental group were taught through the context-based learning approach while their counterparts in the control group were taught through the traditional mode. The extent of students' conceptual understanding of organic chemistry was based on sound understanding, partial understanding and no understanding.

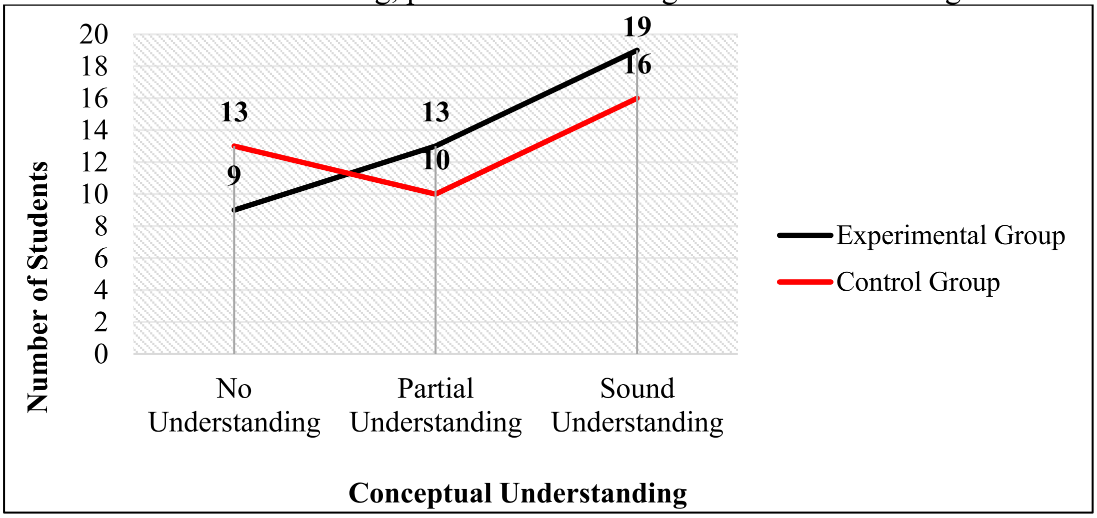
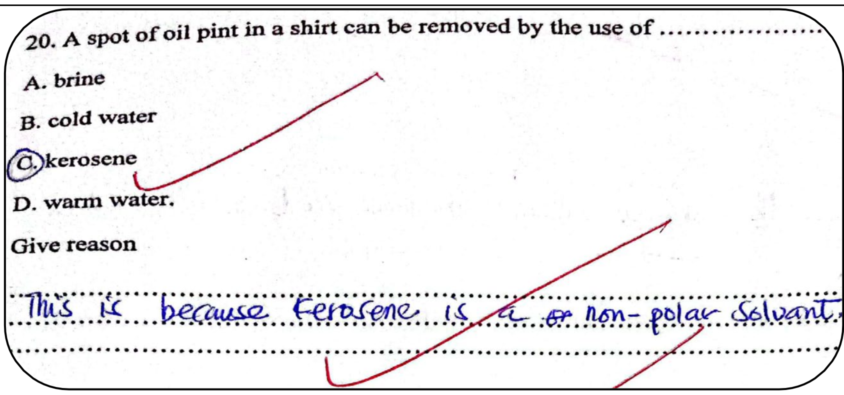


Figure 4: Levels of students' conceptual understanding of organic chemistry
Source: Field data (2024)

As shown in Figure 2, the results revealed that students in the experimental group improved in their understanding of organic chemistry concepts as many of them (19 students) had sound understanding of the concepts compared to their counterpart in the control group (16 students). Again, fewer students (9) in the experimental group demonstrated no understanding of the concepts compared to relatively higher students (13) in the control group who showed no understanding of the concepts. The results showed steady increased in understanding of organic chemistry concepts among students in the experimental group from no understanding to partial understanding and then to sound understanding. The trend in the control group differed from that of the experimental group. In control group, there was a drop in the number of students moving from no understanding to partial understanding and an increase in the number of students from partial understanding to sound understanding. Albeit, generally, the students in the experimental group showed better understanding of the organic chemistry concepts than their control group counterparts. Thus, the study found that context-based learning promotes students' conceptual understanding of organic chemistry than the traditional teaching method. Table 3 presents excerpts from students' responses to both closed-ended and open-ended questions to substantiate how their understanding of organic chemistry concepts was determined.

Table 3: Excerpts of Students' Responses based on their Conceptual Understanding

Level of Understanding	Excerpts from Students' Responses
Sound understanding	

Partial understanding	18. The process involved in the production of ethanol from sugar cane is A. esterification B. fermentation C. neutralization D. saponification Give reason ………………………………………… ………………………………………… …………………………………………
No understanding	20. Ethene is obtained from alcohol by A. dehydration B. hydrolysis C. Ozonolysis D. decomposition. Give reason ………………………………………… ………………………………………… …………………………………………

Source: Field data (2024)

From Table 3, a sound understanding of organic chemistry concepts was determined by the ability of the students to choose a correct multiple-choice option and to provide a correct explanation for the option chosen. A partial understanding of the concepts was ascertained if a correct multiple-choice option was chosen, but no explanation or a wrong explanation was given was given for the option chosen. In the case of no understanding of the concepts, a wrong multiple-choice option as well as no explanation or wrong explanation was given for the option chosen. The study shows that some students, especially those taught through the traditional mode continue to face challenges in understanding functional groups, basic reactions (addition, substitution, dehydration, esterification) in relation to organic compounds and application of organic chemistry concepts in everyday life.

Research Question Two

What is the effect of context-based learning approach on students' performance in organic chemistry? This research question sought to determine the effectiveness of context-based learning approach on students' performance in organic chemistry within the experimental group as compared to those in the control group who were taught through the traditional method. This research question was reformulated into a null hypothesis which was tested at a 5% significance level. Thus, the null hypothesis was stated as "Context-based learning approach has no significant effect on students' performance in organic chemistry".

The results of the independent-samples t-test for the post-test scores of the experimental group and the control group are shown in Table 3.

Table 2: Independent-samples t-test of the students' scores in the post-test

Group	*N*	*M*	*SD*	*df*	*t*	*p*	η^2
Experimental	41	65.24	9.40	78	3.28	0.002*	0.121
Control	39	58.27	9.63				

Significant at $p < 0.05$

Source: Field data (2024)

As indicated in Table 3, there was a statistically significant difference in the mean scores between the experimental group (M = 65.24, SD = 9.40), and the control group (M = 58.27, SD = 9.63; $t(78) = 3.28$, $p = 0.002$). Therefore, the null hypothesis was rejected. The magnitude of the difference in the mean scores was large (eta squared, $\eta^2 = 0.121$). The finding of this study shows that context-based learning approach is effective in promoting students' performance in organic chemistry than the traditional teaching method. The magnitude of the effect that the context-based learning approach had on the students' performance in organic chemistry is large due to the large effect size ($\eta^2 = 0.121$).

DISCUSSION

This study investigated the effectiveness of context-based learning approach in promoting students' conceptual understanding and performance in organic chemistry. The findings of this study reveal that context-based learning promotes students' conceptual understanding of organic chemistry than the traditional teaching method. This finding aligns with the study of Bilgin and Geban (2006), who found that using a contextual learning approach significantly improves students' understanding of organic chemistry concepts than traditional teaching approach. It implies that context-based learning approach should be one of the teaching and learning approaches that chemistry teachers need to adopt as they teach the subject. This approach enables students to learn chemistry in context of their immediate environment thereby making learning meaningful and enjoyable. It demystifies the abstract nature of chemistry concepts and the perceived difficulties that students encounter in learning the subject. By context-based learning approach, students can connect chemical concepts with everyday applications of the concepts in their environment. This learning approach fosters collaboration among learners and promotes critical thinking and creativity leading to improved understanding of concepts taught.

Conversely, some previous studies revealed that students find organic chemistry as a challenging subject, and struggle with hydrocarbons including isomerism and the reactivity of alkanes and alkenes, as well as the reactivity of benzene rings (Bryan, 2007; Kay et al., 2010). Other studies also found that students face difficulties in understanding organic chemistry concepts in relation to petroleum, natural and synthetic polymers, functional groups, benzene, drawing and representation of organic compounds, natural and synthetic polymers as well as aromatic hydrocarbons (Donkor, 2017; Uchegbu et al., 2017). These previous findings directly connect with aspect of the finding of this current study in relation to the control group, where students were taught through the traditional mode. With this approach, students in the control group struggled to understand organic chemistry concepts involving functional groups, basic reactions (addition, substitution, dehydration, esterification) and application of the concepts in everyday life. Unlike the context-based learning approach, with the traditional teaching method, students are not given the opportunity to directly connect concepts learnt in the classroom to everyday life experiences.

When organic chemistry concepts are not taught in the context of students' immediate environment and in relation to life experiences, it makes understanding difficult. It is not surprising that students taught by the traditional mode continue to face challenges in understanding most of the topics taught in organic chemistry as studies have indicated students' weak performance in naming and writing structural formulae of alkenes, alkynes and alkanols (Adu-Gyamfi et al., 2013; Hanson, 2017). As students understand chemical concepts of organic chemistry, it facilitates their performance in the subject. This study further found that context-based learning approach promotes students' performance in organic chemistry. This finding is in consonance with Hanson's (2017) study, which found that students' attitudes about studying organic chemistry through context-based learning were more favourable and that resulted in an improved performance of the subject. Similar findings showed that the design and tenets of

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contextual learning approach are helpful in evaluating how well students apply their content knowledge and place an emphasis on real-world issues that encourage students to solve problems (Broman & Parchman, 2014).
Still in harmony with the findings of this current study, it has been found that for students to recognize the connection between concerns and science, contextualization aims to draw their attention to science in everyday events leading to improved performance in the subject (Bennet et al., 2003). Additionally, study has shown that students should feel that what they are learning in organic chemistry is relevant to some areas of their lives and be able to create a cogent mental model of the subject as this is made possible through contextual learning (Gilbert, 2006). It is worth noting that for students to improve their understanding of organic chemistry concepts as well as enhance their performance in the subject, context-based learning approach is deemed appropriate.

CONCLUSIONS

This study concludes that teaching organic chemistry concepts within the context of learners' immediate environment promotes meaningful understanding and appreciation of the subject leading to improved performance. Context-based learning paradigm promotes collaboration, critical thinking, creativity and lifelong learning among students. Traditional teaching method remains an ineffective teaching pedagogy for enhancing students' conceptual understanding and performance in organic chemistry. The implication of this study for senior high school chemistry teachers is to consider the possibility of incorporating context-based learning approach into their teaching pedagogy. Curriculum developers could as well factor context-based learning pedagogy into the development of senior high school chemistry curriculum.

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CONFLICT OF INTEREST

In all aspects relating to this study, the researchers declare no conflict of interest.

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