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ENHANCING PRE-SERVICE TEACHERS' UNDERSTANDING AND ATTITUDES TOWARD NAMING AND REACTIONS OF ORGANIC COMPOUNDS USING JIGSAW APPROACH

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Abstract:
This study aimed at enhancing pre-service teachers' understanding and attitudes toward naming and reactions of organic compounds using the jigsaw approach. It was a descriptive study that used a quantitative approach in collecting the data for analysis. The research design was a quasi-experimental one, which adapted the non-randomised control group pre-test/post-test intact class design. A sample of 144 pre-service teachers, comprising 72 in the experimental group and 72 in the control group were engaged in the study. Intact classes were used for the study; thus, the sample selection was non-randomised. 'Organic Chemistry Concept Understanding Test' (OCCUT) in the form of a pre-test and a post-test as well as an 'Organic Chemistry Attitude Scale' (OCAS) were the instruments used for the study. The reliability indices of the pre-test and the post-test were 0.721 and 0.724 respectively, whereas, Cronbach's alpha reliability coefficient of the 'OCAS' was 0.899. This study found that in terms of the pre-service teachers' prior knowledge on naming and reactions of organic compounds, the experimental group and the control group both had more misunderstanding and partial understanding than a sound understanding of the concepts. The findings further revealed that the majority of the pre-service teachers in the experimental group had a sound understanding of the naming and reactions of organic compounds after they were taught through the jigsaw approach. Nevertheless, quite a large number of the pre-service teachers in the control group continue to show a misunderstanding of the concepts after they were taught through the traditional lecture-method. Again, the study found that the jigsaw approach enhanced the pre-service teachers' attitudes toward the organic chemistry concepts than the traditional lecture-method.

Keywords: misunderstanding, sound understanding, concepts, attitudes

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1. Introduction

The unique role of organic chemistry in national development makes it an important subject in the Ghanaian educational curricula such that every Ghanaian student in Senior High School either through elective chemistry or integrated science studies an aspect of it (Hanson, 2017). The rationale for teaching and learning chemistry in Ghana as indicated in the chemistry teaching syllabus is its importance in foods, clothing, medicine, shelter and in the transportation system (Ministry of Education, 2010). The knowledge of chemistry enables us to understand, explain, control and prevent phenomena like industrial pollution and the depletion of the ozone layer, which are concerns for every nation, particularly Ghana as a developing nation. Similarly, Ngozi-Olehi, Duru, Uchegbu and Amanze (2018) reported that chemistry occupies a central position in preparing students who have the desire to pursue careers in medicine, industrial chemistry, food science and engineering. Çagatay and Demircioglu (2013) also stressed that one of the main objectives of chemistry education is to help students use school knowledge to explain chemical phenomena that occur in everyday life. As students study organic chemistry, it prepares them for understanding natural phenomena that occur within their immediate environment and equips them with the requisite knowledge to take up job careers relating to chemistry.

However, students in school show negative attitudes toward organic chemistry and lack an understanding of basic concepts (Kurbanoglu, 2013). This is a worrying situation as it has the potential of jeopardising their progress with the course and the eventual fulfilment of their career goals. Students are easily frustrated when they lack an understanding of basic scientific concepts in the teaching and learning process. The real interest in learning is problematic when students face difficulties in comprehending basic scientific concepts. Organic chemistry in particular is noted as a subject that is complex, abstract and difficult accounting for students' lack of understanding and dislike for it (Ozmen, 2004; Ogembo, 2017; O' Dwyer & Childs, 2017). Owing to the difficult nature of organic chemistry as portrayed in research, many students exhibit negative attitudes toward the subject and they are losing interest in science subjects in general including chemistry (Ngozi-Olehi, Duru, Uchegbu & Amanze, 2018; Musengimana, Kampire & Ntawiha, 2021). Students' negative attitudes toward chemistry have an effect on their low achievement in organic chemistry (Kurbanoglu, 2013). The attitude with which students approach a learning material is as important as its understanding. Attitude is a strong determinant of what students can do and achieve in the learning paradigm. A positive attitude is a key to students' understanding of chemistry concepts.

Musengimana, Kampire and Ntawiha (2021) identified instructional methods as factors that contribute to students' attitudes toward chemistry. Instructional methods that are learner-centred, learner-friendly and effective will undoubtedly contribute to promoting favourable attitudes among students and improving their understanding of scientific concepts in the domain of chemistry. In this regard, effective teaching strategies, according to Karacop and Diken (2017), play significant roles in enhancing students'

attitudes, knowledge acquisition and learning outcomes. Identifying and applying effective teaching strategies in teaching science in the 21st century are concerns for every science educator. Suresh and Reddy (2017) asserted that teachers constantly face the problem of finding appropriate teaching methods and applying the most effective method to cater for students' diversity in the most heterogeneous classroom.

The joy of every teacher is to see that the students they teach in the classroom attain an understanding of the concepts taught and perform better when they are tested both cognitively and affectively. Learning outcomes will definitely be enhanced if students understand concepts that are taught in the classroom through the use of effective teaching strategies. However, the ineffective way of teaching chemistry in many educational settings is the problem confronting both teachers and learners in the present dispensation. As indicated in the study of Kay and Yiin (2010) "*the teaching of chemistry has traditionally been based on the objectivist view of knowledge; a largely teacher-centred approach where the students learn through rote learning and assessed through the ability to regurgitate facts*" (p.9).

In situations where students express their frustrations on perceived difficult subjects, teachers need to apply teaching methods that are learner-centred, learner-friendly and practical enough in conveying desired concepts for easy understanding. The need for a teaching and learning approach that promotes students' interest and positive attitudes toward organic chemistry is appropriate in this case. There are teaching strategies where the teacher becomes a repository of knowledge and simply transfers what he has to students without the active participation of the learners. This kind of teaching in the modern era with the kind of students that we have today is problematic and worrying. Opara (2013) asserted that teaching methods that encourage the direct transfer of knowledge from the teacher and memorisation on the part of the learners have become obsolete. What then is the way forward in addressing students' learning needs when they are confronted with subjects that are perceived to be difficult? Previous studies have identified learner-centred teaching approaches that include problem-based learning, jigsaw approach and context-based learning as effective in improving students' understanding of chemistry concepts as well as enhancing their attitudes towards the subject (Hung, 2008; Mari & Gumel, 2015; Hanson, 2017).

The problem in this study is based on the difficulties that pre-service teachers in selected colleges of education in Ghana encounter in understanding fundamental organic chemistry concepts that cut across naming and drawing of organic compounds, identification of functional groups and reactions. This has consequently affected their attitudes towards organic chemistry in general. The evidence of this problem is partly rooted in the Chief Examiner's Reports (2013), which indicated that some pre-service teachers in Colleges of Education in Ghana had difficulties in writing the correct structural formulae of organic compounds and difficulties in organic reactions. Belachew, Barke and Yitbarek (2018) also reiterated that pre-service teachers encounter difficulties in organic chemistry due to the abstract nature of its concepts. Research has further shown that students' low achievement in organic chemistry is attributed to their

misunderstanding of the concepts and poor attitudes towards the subject (Horowitz, Rabin & Brodale, 2013; Hanson, 2017; Adu-Gyamfi, Ampiah & Appiah, 2017).

Much as students' attitude towards organic chemistry is a challenge in recent times, Cheung's (2011) study indicated that studies on the attitudinal aspect in chemistry are limited. It has also been revealed in research that in the field of chemistry education, relatively little research has been done on the use of jigsaw strategies to teach chemistry (Tarhan & Sesen, 2012), hence the need to explore it in this study. Also, at the time of this study within the Ghanaian context, what was available on the use of the jigsaw approach to teaching organic chemistry at the colleges of education level in Ghana was a preliminary study (Yaayin, Oppong & Hanson, 2021).

The jigsaw approach is cooperative learning that involves organising students to work in small groups comprising five to six members where each student becomes an expert in the jigsaw group after mastering a particular learning aspect of the main topic. They then return to the home group to teach other counterparts the portions that they have mastered (Hamadneh, 2017). Adams (2013) observed that generally, a cooperative learning strategy allows students to follow a structured activity to work together in small groups such that individuals are accountable for their work, and the group as a whole is assessed based on its collective work. Çagatay and Demircioglu (2013) identified important components of the jigsaw approach as it ensures positive interdependence among learners, face-to-face encounters, promoting interaction among students, individual and group accountability, group interpersonal skills and group process skills development.

The purpose of this study was to enhance pre-service teachers' understanding and attitudes toward naming and reactions of organic compounds using the jigsaw approach in selected Colleges of Education in Ghana. The research questions that guided the study included the following.

1) What prior knowledge do pre-service teachers hold on naming and reactions of organic compounds?
2) What is the effect of the jigsaw approach on pre-service teachers' understanding of naming and reactions of organic compounds?
3) What is the effect of the jigsaw approach on pre-service teachers' attitudes towards organic chemistry concepts?

2. Material and Methods

2.1 Research Approach

This study employed a quantitative research approach, which was a descriptive study. Percentages and bar charts were used to describe and present the results. Selected pre-service teachers' responses to questions that test their understanding of the naming and reactions of organic compounds were presented and discussed.

2.2 Research Design

A quasi-experimental research design was used. A research design according to Garg and Kothari (2014) is the conceptual structure within which research is conducted and that establishes the plan for data collection, measurement and analysis. In this study, the quasi-experimental research design employed the non-randomised control group pre-test/post-test intact class design, which was adapted (Levy & Ellis, 2011) as shown in Table 1.

Table 1: Non-randomised Control Group Pre-test and Post-test Intact Class Design

Groups	Pre-test	Treatment	Post-test
Experimental Group	OCCUT	Jigsaw Approach	OCCUT / OCAS
Control Group	OCCUT	Traditional Lecture Method	OCCUT / OCAS

OCCUT – Organic Chemistry Concept Understanding Test; OCAS – Organic Chemistry Attitude Scale

As indicated in Table 1, the understanding of the pre-service teachers in the naming and reactions of organic compounds in both the experimental and control groups before their engagement with the jigsaw approach was determined using the OCCUT. Similarly, the understanding and attitudes of the pre-service teachers towards the organic chemistry concepts in both groups after their engagement with the jigsaw approach and the traditional lecture-method were determined using the OCCUT and OCAS respectively.

2.2 Sample and Sampling Procedure

Tamale College of Education (TACE) and Evangelical Presbyterian College of Education (EPCE) both in the Northern Region of Ghana were purposively selected for the study. The two colleges were selected purposively because they both study science programmes and the pre-service teachers in the said colleges have basic knowledge of organic chemistry. While the TACE is located in the Tamale Metropolis, the EPCE is located in the Nanumba North District of the Northern Region of Ghana. The two colleges are 112 km apart in terms of geographical locations. TACE was assigned to the experimental group by convenience sampling while the EPCE was assigned to the control group. The selection of TACE as the experimental group by convenience sampling was necessitated by easy accessibility, geographical proximity to the researchers and willingness of the participants to be engaged with the jigsaw cooperative learning approach (Dornyei as cited in Etikan, Musa & Alkassim, 2016).

Intact classes comprising two in the experimental group and two in the control group were engaged in the study. The sample size was 144, which consisted of 72 participants in each group. The consent of the participants was sought and they willingly and voluntarily participated in the study. In terms of gender disaggregation, the sample comprised 55 males and 17 females in the experimental group, whilst in the control group; there were 58 males and 14 females. The female representation was low because there were few females offering science at the time the study was conducted. The majority

of the participants were between the ages of 21-26 years. Few of them were within the age range of 15-20 years and very few were within the range of 27-32 years.

2.3 Validity and Reliability of the Instruments

The researchers developed the 'OCCUT' and 'OCAS' instruments, which were used for the study. The instruments went through face and content validity by experienced senior lecturers in the University of Education, Winneba, Ghana with the requisite expertise in chemistry education. Experienced chemistry tutors in TACE also validated the instruments. The reliability of the 'OCCUT' and the 'OCAS' was ascertained after they were trial tested by engaging 40 pre-service teachers of Bagabaga College of Education, which shares similar characteristics with the colleges that took part in the study. Kuder-Richardson Formula 20, which measures the internal consistency of the test items, was used to determine the reliability of the 'OCCUT' which took the form of a pre-test and a post-test. The reliability indices were 0.721 and 0.724 for the pre-test and the post-test respectively. The Cronbach's alpha reliability coefficient was calculated to show the level of internal consistency within the group of items contained in the 'OCAS' as a Likert scale-based questionnaire. The calculated reliability coefficient of the questionnaire was 0.899.

2.4 Data Collection Procedure

Quantitative data were collected using the 'OCCUT' as a pre-test before the pre-service teachers in the experimental group and the control group were taught through the jigsaw approach and the traditional lecture-method respectively. Quantitative data were also collected using the 'OCCUT' as a post-test and the 'OCAS' after the experimental group was taught through the jigsaw approach and the control group taught through the traditional lecture-method. The pre-test and the post-test were 40 test items in each case. Each test consisted of 20 multiple-choice items and 20 short-answer type questions. A correct response was scored one mark and a wrong response was scored zero mark. Also, the 'OCCUT' and 'OCAS' were constructed and administered in a way that ensured the participants' confidentiality and neutrality without any element of biasness in both the data collection and analysis.

In the experimental group, the jigsaw approach engaged six different groups with six pre-service teachers in each group within an intact class. Each intact class contained 36 pre-service teachers who were taught through the jigsaw approach. Figure 1 presents the formation of the 'jigsaw groups' and the 'home groups', which was adapted (Koc, Doymus, Karacop & Simsek, 2010).

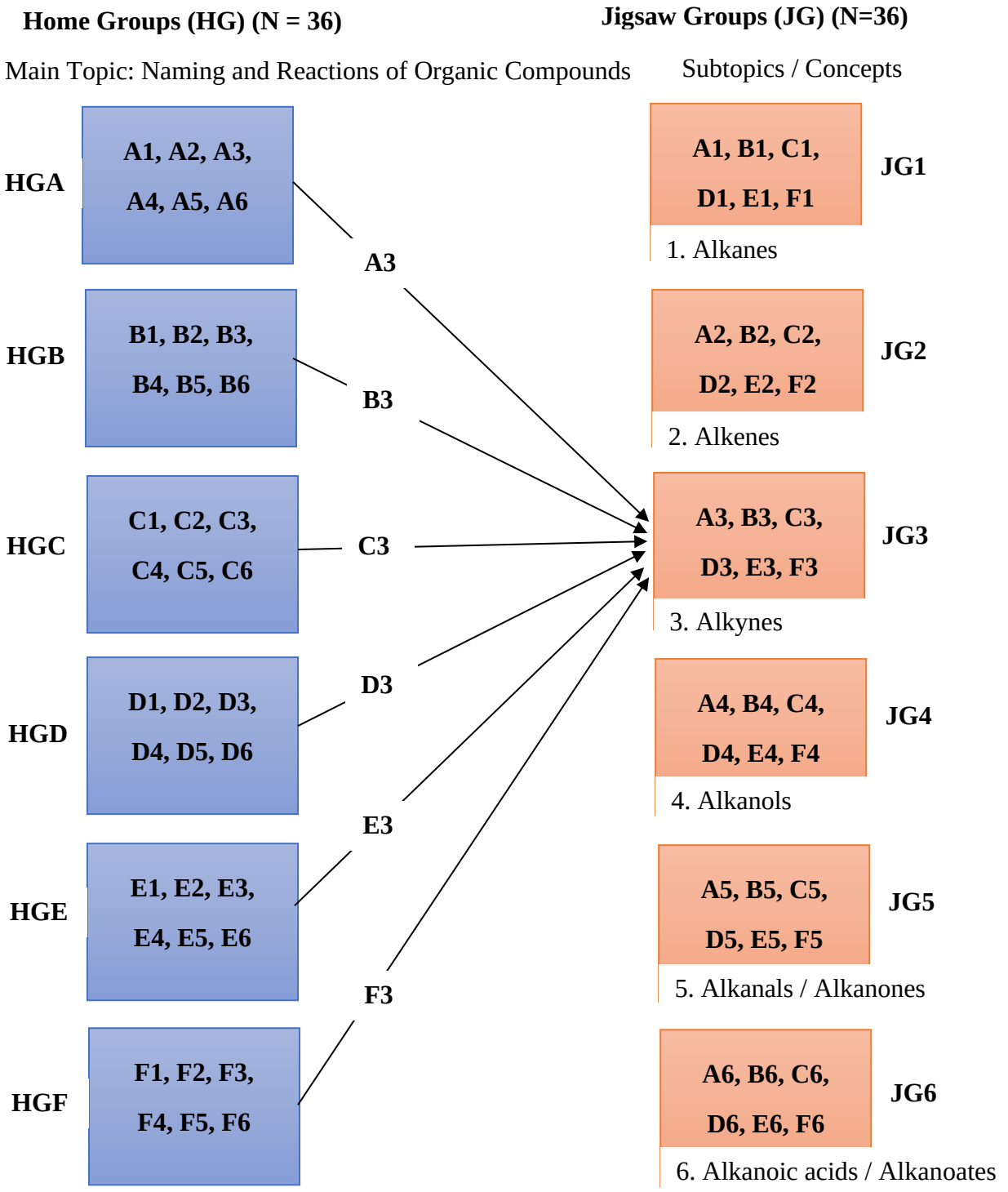


Figure 1: Formation of Home Groups (HG) and Jigsaw Groups (JG)

From Figure 1, two structured groups were involved in the study. The 'jigsaw group' (JG) was the group where the pre-service teachers met together to learn the same organic chemistry concepts assigned to them. For example, jigsaw group one (JG 1), JG 2 and JG 3 were assigned alkanes, alkenes and alkynes respectively. The group members in these groupings were to cooperate and learn among themselves to master the concepts

of naming and reactions of organic compounds in alkanes, alkenes and alkynes assigned to them with the object of returning to teach themselves in the 'home groups'. Thus, learning to master the concepts in the given sub-topics of the main topic was done at the 'jigsaw group' level and teaching one another of the sub-topics learnt was done at the 'home group' level as indicated (Figure 1).

For example, at the 'home group' level, pre-service teachers designated as A3, B3, C3, D3, E3 and F3 moved from 'home group A' (HGA), HGB, HGC, HGD, HGE and HGF respectively to form 'jigsaw group three' (JG3). The responsibility of the six pre-service teachers in this group (JG3) was to master the concepts of naming and reactions of organic compounds in alkynes and return to their respective 'home groups' to teach their counterparts all that they have learned. Similarly, other group members who were assigned alkanes, alkenes, alkanols and so on were also expected to take their turns after mastery of the concepts at the 'jigsaw group' level and teach the rest of the group members at the 'home group' level.

The control group was taught through the traditional lecture-method. Unlike the jigsaw approach, where structured group activities were carried out by the pre-service teachers, in the traditional lecture-method, no such group activities existed. Even though the pre-service teachers in the control group were taught the same content of the naming and reactions of organic compounds as in the experimental group, their approach to teaching was different from their experimental group counterparts.

2.5 Data Analysis

The total score of the pre-test and the post-test was 40, thus, the scores were categorised as indicated in Table 2.

Table 2: Categories of the Pre-service Teachers' Understanding of the Selected Organic Chemistry Concepts

Categories	Test Scores	Percentage (%)
Misunderstanding	0 – 13	0.0 – 32.5
Partial Understanding	14 – 27	35.0 – 67.5
Sound Understanding	28 – 40	70.0 – 100

From Table 2, the pre-service teachers' understanding of the naming and reactions of organic compounds was determined based on their performance in both the pre-test and the post-test. Per the researchers' operational definitions, pre-service teachers who scored the test from 0 – 13 were noted as showing a misunderstanding of the concepts. The partial understanding was within the range of 14 – 27 and sound understanding was within the range of 28 – 40 with their corresponding percentages. The results were analysed descriptively using percentage scores and presented using bar charts.

The attitudes of the pre-service teachers towards the organic chemistry concepts were determined using the 'OCAS', which was a five-point Likert scale-based questionnaire with ten attitude items comprising a mixture of four positively worded statements and six negatively worded statements. The scale was graded as strongly agree

(SA) = 5, agree (A) = 4, undecided (U) = 3, disagree (D) = 2 and strongly disagree (SD) = 1 for positive statements and SA = 1, A = 2, U = 3, D = 4 and SD = 5 for negative statements.

On analysis of the results, the scale was further modified to a three-point scale for the purpose of convenience. The 'strongly agree' and the 'agree' point values were combined as just 'agree'. The 'undecided' point values remained unchanged, but the 'strongly disagree' and the 'disagree' point values were also combined to represent 'disagree'. The point values were converted to percentages with the help of SPSS version 22.0.

If a positively worded attitude statement got a score of 50% and above as 'agree' point value, then the participants indicated a favourable attitude toward that statement. Again, if the same positively worded attitude statement got a score of 50% and above as 'disagree' point value, it also meant that the participants indicated an unfavourable attitude toward that statement. On the other hand, for a given negatively worded attitude statement, if the percentage scores of the 'agree' point value is 50% and above, then it is an unfavourable attitude for the pre-service teachers. However, if the 'disagree' point value of the same negatively worded attitude statement is scored 50% and above, then it is noted as a favourable attitude.

3. Results and Discussion

The results were presented based on the research questions.

Research question 1: What prior knowledge do pre-service teachers hold on naming and reactions of organic compounds?

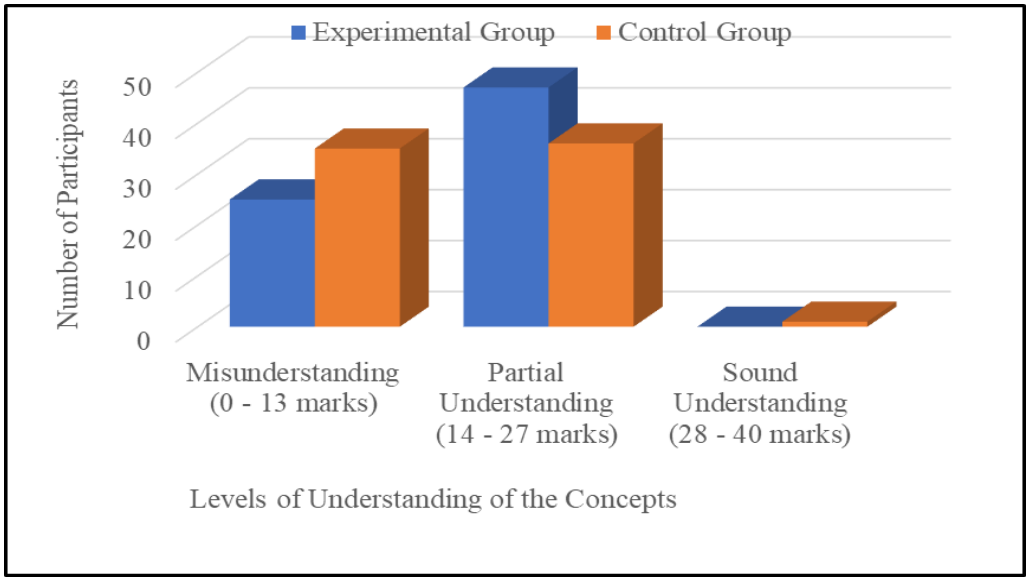


Figure 2: Pre-service Teachers' Levels of Understanding of the Organic Chemistry Concepts

As shown in Figure 2, the results revealed that the majority of the pre-service teachers in the experimental group and the control group had a misunderstanding and

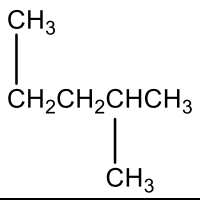
partial understanding of the naming and reactions of organic compounds before they were taught through the jigsaw approach and the traditional lecture-method. In the experimental group, 25 pre-service teachers representing 34.7% and 47 pre-service teachers (65.3%) of the total number of participants had a misunderstanding and partial understanding of the concepts respectively. Similarly, in the control group, 35 pre-service teachers representing 48.6% and 36 pre-service teachers (50%) also had a misunderstanding and partial understanding of the concepts respectively. The results (Figure 2) indicated only one pre-service teacher in the control group with a sound understanding of the concepts, but no one in the experimental group had a sound understanding of the concepts.

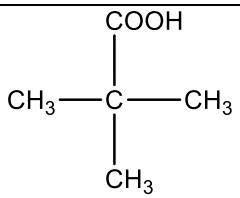
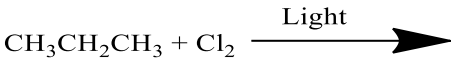
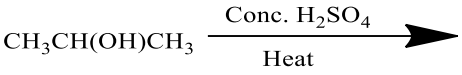
These findings support previous studies that found organic chemistry as an area of difficulty for many students as they struggle to understand the concepts of IUPAC nomenclature and basic organic reactions (O' Dwyer & Childs, 2017; Adu-Gyamfi, Ampiah & Appiah, 2017).

In view of the findings relating to the pre-service teachers' prior knowledge of the organic chemistry concepts, it is imperative that chemistry teachers begin the teaching of chemistry with diagnostic tests to identify students' difficulties or misunderstandings in the topics to be taught. This could assist the teachers to proffer appropriate solutions to the problems identified for effective teaching and learning. There is no doubt that students come to the chemistry classroom with varied ideas already stored in their long-term memory that conflict with the right concepts they are to learn (Sirhan, 2007).

Table 3 shows the kind of incorrect responses the pre-service teachers in the experimental group and the control group provided on some selected questions on naming and reactions of organic compounds. The incorrect responses clearly depict their misunderstanding of the concepts.

Table 3: Participants' Incorrect Responses on Naming and Reactions of Organic Compounds

Question asked	**Participants' incorrect responses**	**Expected correct Response**
Give the IUPAC name of the organic structure below" 	1, 3- dimethylbutane 2, 4- dimethylbutane 1, 4- dimethylbutane 1, 2- dimethylbutane	2- methylpentane
Give the IUPAC name of the organic structure below:	2 methyl alkanoate propanoic acid 2- methylpropan-2-ol 2- methylpropanol 2- methylpropanoic acid	2, 2- dimethylpropanoic acid

		
Copy and complete the reaction: 	$CH_3CH_2 + CH_3$ $CH_3(Cl_2)CH_2CH_3$ $CH_3CH_3 + CH_3Cl_2$ CH_3CClCH_3	$CH_3CH_2CH_2Cl + HCl$
Copy and complete the reaction: 	CH_3CHCH_3OH $CH_3CH_2SO_4CH_3 + H_2O$ $CH_3SO_4 + CH(OH)_2CH_3$	$CH_3CH = CH_2 + H_2O$

In Table 3, the incorrect responses of the pre-service teachers to questions on naming and reactions of organic compounds are classical evidence that they had more misunderstanding and partial understanding of the concepts than sound understanding. The pre-service teachers had a misunderstanding in the naming of organic compounds that cuts across identification of the longest continuous carbon chain in the parent structure, substituents and their correct positions on the parent structure and the appropriate functional groups of the parent structure. A lot of the pre-service teachers in the experimental group and the control group could not identify parent names of organic compounds that were not straight chains. Many could not also identify substituents that were attached to parent organic compounds as well as their correct positions on the parent structures.

In the area of functional groups and their structures, most of the pre-service teachers were only familiar with hydrocarbons such as alkanes, alkenes and alkynes, which were basic; however, functional groups like alkanols, carboxylic acids, aldehydes, ketones and esters were difficult areas for them. The confusion was centred on the identification of functional groups among alkanols, aldehydes and ketones because of the one 'O' which is common in their functional group structures. Also, between the carboxylic acids and the esters, the presence of the two 'Os' in their functional group structures was a challenge for most pre-service teachers when it comes to identifying these functional groups. This difficulty hindered their ability to name the said organic compounds correctly.

Organic reactions in particular posed the biggest challenge for most pre-service teachers. The findings showed that in most cases, the principle of the tetravalent nature of carbon was completely ignored by most pre-service teachers to the extent that in some cases one carbon in a chain could have about six elements bonding to it. They were just combining letters and numbers without minding the scientific principles involved in compound formation. To them, organic chemistry is complex, especially, when they have

to figure out the reaction pathways or conditions for given organic reactions. It is therefore not strange as Ogembo (2017) argued that students and teachers perceived organic chemistry to be complex.

Research question 2: What is the effect of the jigsaw approach on pre-service teachers' understanding of naming and reactions of organic compounds?

Figure 3 presents the results of the pre-service teachers' levels of understanding of the naming and reactions of organic compounds after they were taught through the jigsaw approach and the traditional lecture-method.

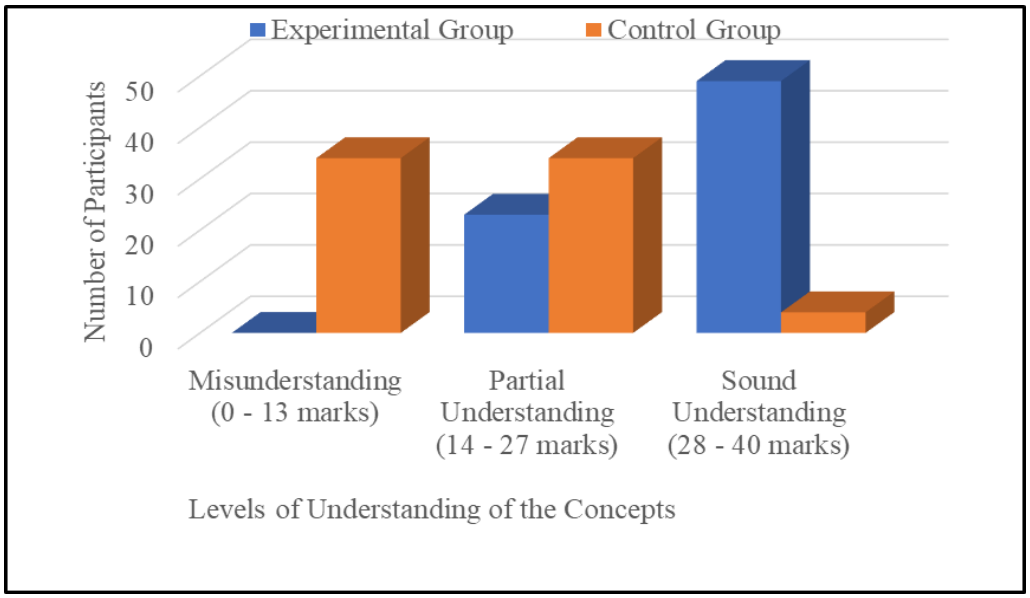


Figure 3: Pre-service Teachers' Levels of Understanding of the Organic Chemistry Concepts

In Figure 3, the results showed that the majority of pre-service teachers in the control group continue to indicate misunderstanding and partial understanding of the concepts after they were taught through the traditional lecture-method. Very few of them had a sound understanding of the concepts. On the other hand, the majority of the pre-service teachers in the experimental group had a sound understanding of the concepts after they were taught through the jigsaw approach. Few of them continued to show partial understanding of the concepts.

As shown in Figure 3, almost half of the pre-service teachers (47.2%) in the control group had both misunderstanding and partial understanding of the concepts, with barely 5.5% of them who indicated a sound understanding of the concepts. However, in the experimental group, as many as 49 pre-service teachers representing 68.0% of the total participants had a sound understanding of the concepts after they were engaged with the jigsaw approach. This notwithstanding, 32% of the pre-service teachers in the experimental group still had a partial understanding of the concepts.

Although there were challenges regarding the pre-service teachers' prior knowledge of the naming and reactions of organic compounds at the beginning of the study, the engagement of the experimental group with the jigsaw approach enhanced

their understanding of the concepts. The game changer therefore, was the jigsaw approach, which was found effective in improving the pre-service teachers' understanding of the organic chemistry concepts. This finding is consistent with early studies that found that the jigsaw approach is capable of enhancing students' understanding of chemistry concepts than the traditional lecture-method (Çagatay & Demircioglu, 2013; Hamadneh, 2017; Isa & Muhammad, 2019). As the pre-service teachers learnt together cooperatively through the jigsaw approach, their understanding of the organic chemistry concepts improved. The jigsaw approach facilitated the pre-service teachers' sound understanding of the concepts as it ensured positive interdependence among learners, face-to-face encounters, promoting interaction and group process skills development (Çagatay & Demircioglu, 2013).

Research question 3: What is the effect of the jigsaw approach on pre-service teachers' attitudes toward organic chemistry concepts?

The attitudes of the pre-service teachers towards organic chemistry were determined using the "OCAS' after the experimental group was taught through the jigsaw approach and the control group taught through the traditional lecture-method. Table 3 presents the results in percentages that show the responses of the pre-service teachers to various attitude items indicating their attitudes towards organic chemistry in the experimental group and the control group.

Table 3: Pre-service Teachers' Attitudes towards Organic Chemistry

S/N	Attitude Items	Experimental Group			Control Group		
		A (%)	U (%)	D (%)	A (%)	U (%)	D (%)
1.	I find organic chemistry as a difficult subject	12.5	1.4	86.1	61.1	5.6	33.3
2.	I fear organic chemistry because it is complex	15.3	0.0	84.7	63.9	8.3	27.8
3.	I feel comfortable learning organic chemistry	77.8	4.2	18.0	36.2	9.7	54.1
4.	I get nervous due to the many structures in organic chemistry	20.9	5.6	73.5	58.3	6.9	34.7
5.	I am always happy attending organic chemistry lessons	93.0	2.8	4.2	58.3	5.6	36.1
6.	I give more time for organic chemistry because it is interesting	88.9	1.4	9.7	43.1	6.9	50.0
7.	I always get bored with organic chemistry lessons	8.4	1.4	90.2	23.6	9.7	66.7
8	Reactions in organic chemistry are difficult for my understanding	50.0	6.9	43.1	77.7	2.8	19.5
9.	I get confused with the combination of letters and numbers in organic compounds	18.0	2.8	79.2	50.0	8.3	41.6
10.	Organic chemistry is easy for my understanding	75.0	6.9	18.1	29.2	9.7	61.1

From Table 3, the results showed that the jigsaw approach yielded favourable attitudes among the pre-service teachers toward the organic chemistry concepts in the experimental group than in the control group, who were instructed through the traditional lecture-method. For example, in response to the attitude item, "I find organic chemistry as a difficult subject", 86.1% of the pre-service teachers in the experimental group disagreed with this statement. However, 61.1% of the pre-service teachers in the control group agreed to it. Also, the statement that "I feel comfortable learning organic chemistry", 77.8% of the pre-service teachers in the experimental group agreed to it while 54.1% of the pre-service teachers in the control group disagreed. Similarly, with the statement that "Organic chemistry is easy for my understanding", 75.0% of the pre-service teachers in the experimental group agreed it, but 61.1% of their counterparts in the control group disagreed.

As regards this negatively worded attitude statement, "I fear organic chemistry because it is complex", 84.7% of the pre-service teachers in the experimental group disagreed whereas 27.8% of the pre-service teachers in the control group disagreed with the same statement. Again, in response to this positively worded attitude statement, "I give more time for organic chemistry because it is interesting", whereas 43.1% of the pre-service teachers in the control group agreed to it, as many as 88.9% of their colleagues in the experimental group agreed to it.

The attitudes that students put up in a teaching and learning situation are so critical that they cannot be overlooked in the choice of effective teaching strategies that enhance students' acquisition of scientific concepts. This current study found that the attitudes of the pre-service teachers toward organic chemistry in the experimental group were enhanced due to the effectiveness of the jigsaw approach. Due to the pre-service teachers' engagement with the jigsaw approach, they found organic chemistry interesting, so they gave more time to it and they were always happily attending its lessons. The pre-service teachers were also comfortable learning organic chemistry because they found its concepts relatively easier for their understanding.

On the other hand, the traditional lecture-method was not effective enough to improve the pre-service teachers' attitudes toward the organic chemistry concepts in the control group. Many of them who were taught through the traditional lecture-method still had challenges as they indicated that organic chemistry is a difficult subject and that they fear it because it is complex. Similar to the outcome of this current study on attitudes, other studies have found that cooperative learning strategies succeed in reducing students' anxiety towards chemistry significantly while the chemistry anxiety level of the students in the traditional-lecture group increased (Oludipe & Awokoy, 2010; Nwabueze & Igbinedion, 2013; Karacop & Diken, 2017).

Per the findings in this study regarding the pre-service teachers' attitudes toward organic chemistry concepts, it is important that learner-centred instructional strategies are incorporated into the teaching and learning of organic chemistry. This would go a long to reducing students' anxiety toward the subject and increase their interest and desire in it as indicated in the finding of this study.

4. Recommendations

Per the outcome of this study, it is recommended that chemistry teachers at Tamale College of Education as the experimental group could adopt the jigsaw approach as an instructional strategy for teaching chemistry. On the other hand, chemistry teachers in Evangelical Presbyterian College of Education as the control group could minimise the use of the traditional lecture-method and adopt effective cooperative learning strategies in teaching chemistry. It is also recommended that the prior knowledge of pre-service teachers in Tamale College of Education and Evangelical Presbyterian College of Education could be assessed through diagnostic tests before teaching any chemistry topic. This could guide chemistry teachers to select teaching methods that are capable of enhancing pre-service teachers' understanding of concepts in chemistry class.

5. Conclusion

Pre-service teachers who studied science at Tamale College of Education and Evangelical Presbyterian College of Education, Ghana had a misunderstanding and partial understanding of some chemical concepts in naming and reactions of organic compounds. However, when these pre-service teachers in Tamale College of Education were taught through the jigsaw approach, they demonstrated a sound understanding of the concepts than their counterparts in the control group, who were taught through the traditional lecture-method. Thus, the jigsaw approach was more effective in enhancing the pre-service teachers' understanding of the organic chemistry concepts than the traditional lecture-method. Again, the jigsaw approach improved the pre-service teachers' attitudes toward organic chemistry more than the traditional lecture-method.

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Conflict of Interest Statement

There is no conflict of interest in this study declared by the authors.

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