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ORIGINAL ARTICLE

Efficacy of Jigsaw Model in Improving Pre-service Teachers' Performance in Selected Functional Group Organic Compounds

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ABSTRACT

The focus of this study was to find out the effectiveness of the jigsaw model on improving pre-service teachers' performance in selected functional group organic compounds. The study employed the quasi-experimental non-randomized pre-test/post-test intact class design. The sample was 144 pre-service teachers comprising 72 in the experimental class and 72 in the control class. The jigsaw model was implemented in the experimental class while the conventional teaching method was implemented in the control class. The "Organic Chemistry Concept Achievement Test" was used as the research instrument to collect the data. The instrument was pilot tested, and the reliability index was found to be 0.724. The findings of the study revealed that the jigsaw model was effective in yielding significantly better performance in the selected functional group organic compounds among the pre-service teachers in the experimental group than their counterparts in the control group who were taught through the conventional method. It was found that the jigsaw model laid a good foundation for the pre-service teachers to develop problem-solving skills and creative minds leading to their improved performance in the selected functional group organic compounds.

KEY WORDS: Performance; pre-service teachers; organic compounds; conventional method

INTRODUCTION

Chemistry is important as one of the cornerstones of science and plays a significant role in national development through technology and industry in the world at large (Bugaje, 2013; Emendu, 2014; and Jassem, 2014). The importance of chemistry hinges on the many chemical industries that operate and thrive on its application. It suffices then to note that chemistry is such a unique subject that is worth studying in educational institutions. Its exceptional role in chemical industry is beneficial to the development of any nation, particularly developing nations. In the African continent, there is much desire for the application of chemistry to accelerate industrial growth to close up the development gap between developing nations and those that are already developed. Emendu (2014) argued that "without chemical industry there is no productivity and without productivity there is no development" (p. 16).

Regarding the benefit of chemistry in national development, key actors in education need to be more proactive in ensuring that the study of chemistry catches the needed attention in educational institutions. Research has indicated that chemistry in school is part of the total education provision (Holbrook, 2005). The school serves as a preparatory ground, where students studying chemistry gain the knowledge necessary for applications in the various chemical industries after leaving school. As intimated by Çağatay and Demircioğlu (2013), one of the main objectives of chemistry education is to help students use school knowledge to explain chemical phenomena that occur in everyday life. Siew Li and Arshad (2014) shared a similar view as they indicated that chemistry is about understanding and application of chemical concepts. The study of chemistry in school is therefore the beginning of the acquisition of scientific knowledge that forms the basis for improved life through technology.

It is instructive to note that students generally have difficulties studying chemistry even though its importance abounds. Ozmen (2004) stated that "chemistry is one of the most important branches of science and has been regarded as a difficult subject for young students by chemistry teachers, researchers, and educators" (p. 148). It is common knowledge that most chemistry concepts are difficult for many students. Chemistry has many components including both organic and inorganic. Organic chemistry in particular is a challenging area for students who study it. O'Dwyer and Childs (2017) reported that much research has identified organic chemistry as an area of difficulty for learners. In support of this assertion, Ogembo (2017) reiterated that students and teachers perceived organic chemistry to be complex. Studies have shown that most chemistry students see formulae of organic compounds such as CH_3OH or C_2H_6O as just combination of letters and numbers rather than chemical formula (Wu et al., 2001, cited in Adu-Gyamfi et al., 2017). Similarly, Hanson (2017) indicated that students exhibit many challenges regarding building authentic mental models in organic chemistry.

The problem in this study focused on the low achievement in organic chemistry among pre-service teachers in the

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Tamale College of Education and Evangelical Presbyterian College of Education, Ghana. In Ghana and beyond, there are studies that indicated the existence of low achievement of students in organic chemistry due to the difficult nature of the subject and the poor attitudes of students toward it. Belachew et al. (2018) maintained that pre-service teachers encounter difficulties in organic chemistry owing to the general abstract nature of its concepts. This problem was identified through classroom practice with science pre-service teachers in the colleges mentioned. The purpose of this study therefore was to determine the efficacy of the jigsaw model in improving the performance of pre-service teachers in selected functional group organic compounds. The null hypothesis tested was "there is no statistically significant difference between the performance of the pre-service teachers taught through the jigsaw model and those taught through the conventional method."

LITERATURE REVIEW

The theoretical foundation for this study was the constructivist approach. On the philosophical and psychological foundations of the constructivism learning theory, Lutz and Huitt (2004) believed that the developmental theories of Dewey, Piaget, Vygotsky, and Bruner provided the basis for the educational application of constructivism. According to Taber (2011), within science education, constructivism has been considered as the accepted paradigm for thinking about learning. Constructivist pedagogy is one such approach where activities are proposed to students that are meaningful for them and they have the opportunity to reflect, search, and use their capacity for taking initiatives and being creative (Dagar and Yadav, 2016).

The complex nature of organic chemistry and the difficulty associated with its learning by students have kept many science educators all over the globe finding teaching and learning strategies that can arrest the situation. Researchers have therefore identified some teaching strategies that are learner centered and have proved effective, and a few of them include problem-based learning, jigsaw strategy, and context-based learning (Hung, 2008; Mari and Gumel, 2015; and Hanson, 2017). The paradigm of present-day teaching places the learner at the center of the learning process, which is consistent with the constructivist approach to learning. In the constructivist approach, the teacher assumes the position of a facilitator instead of being a repository of knowledge (Kibos et al., 2015). In this approach, learners have ample time to construct their own knowledge of what they are learning such that the meaning and understanding that they arrive at is consistent with what has been scientifically tested and accepted. Chu (2014) claimed that one of the purposes of modern education practices is to help students acquire critical and creative thinking.

This study explored the effectiveness of the jigsaw model as a teaching strategy. Aronson (2000) explained that a jigsaw is a cooperative learning approach that allows each student assigned to a group known as the "home" group to master one aspect of a learning unit so that they can teach the other group members. Aronson further indicated that in the jigsaw strategy, students meet with members from other groups who are apportioned the same aspect of a topic and, after mastering the material, return to their "home" group as the "experts" and teach this material to their group members. According to Isa and Muhammad (2019), a study which was conducted in Zaria Education Zone in Nigeria, revealed that the jigsaw strategy improved students' performance in organic chemistry compared to the conventional method of teaching. The study of Çağatay and Demircioğlu (2013) in Turkey also indicated better performance of students in organic chemistry who were taught through the jigsaw strategy than their counterparts who were taught through the traditional instruction. However, in the Ghanaian context, particularly at the level of the colleges of education, there was no literature found indicating the use of the jigsaw model as a strategy in teaching organic chemistry. It was therefore necessary to explore its efficacy in improving the performance of pre-service teachers in selected functional group organic compounds in Tamale College of Education, Ghana.

METHODOLOGY

Research Design

The methodological approach of this study was quantitative research, which was situated within the constructivist theoretical framework. The design was a quasi-experimental, non-randomized, control group, pre-test/post-test, intact class design. A research design according to Garg and Kothari (2014) is the conceptual structure within which research is conducted and that it establishes the plan for data collection, measurement, and analysis. In this study, the quasi-experimental design employed the intact class approach where research participants were already organized into existing classrooms at the time the study was conducted. Table 1 presents the non-randomized control group pre-test and post-test intact class design.

In this design, both the experimental group and the control group took the "Organic Chemistry Concept Achievement Test" (OCCAT) as a pre-test before the treatment. The pre-test was meant to establish a baseline that ensured that no group was disadvantaged in terms of their prior achievement in the selected functional group organic compounds before the treatment. Again, after the treatment, both the experimental group and the control group took the OCCAT as a post-test, which was meant to find out the comparative effect of the jigsaw model and the conventional method on the pre-service

Table 1: Non-randomized control group pre-test and post-test intact class design

Groups	Pre-test	Treatment	Post-test
Experimental group	OCCAT	Jigsaw model	OCCAT
Control group	OCCAT	Conventional method	OCCAT

OCCAT: Organic Chemistry Concept Achievement Test

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teachers' achievement in the selected functional group organic compounds.

Sample and Sampling Procedure

Tamale College of Education and Evangelical Presbyterian College of Education in the Northern Region of Ghana participated in the study. The two colleges were selected through convenience sampling. This sampling method was necessitated by easy accessibility, geographical proximity, availability, and the willingness of the participants to participate in the study. The experimental group was in Tamale College of Education, Tamale. Two intact classes from each college with 36 pre-service teachers in each class participated in the study. The sample size was 144 pre-service teachers whose consent was sought, and they voluntarily participated in the study. The males were 113 and the females were 31 as this was the gender representation in the intact classes used for the study. Generally, there were few female pre-service teachers studying chemistry at the time this study was conducted. The pre-service teachers were in the 2^{nd} year (level 200) at the time of the study, and they were within the age range of 15–32, but the predominant age range was 21–26.

Research Instrument

The instrument used for the study was the OCCAT, which was designed in the form of pre-test and post-test. The pre-test and the post-test each comprised 40 test items, of which 20 were multiple-choice questions and 20 were essay questions consisting of short-structured questions and fill-in-the-gaps. The instrument was developed by the researchers and pilot tested. The reliability index was determined using the Kuder–Richardson formula 20 (KR20). The reliability values were found to be 0.721 for the pre-test and 0.724 for the post-test, which were considered appropriate for use. The validity of the instrument was ascertained as the test items covered different areas of the selected functional group organic compounds. Experienced colleagues who are chemistry educationists also scrutinized the test items to ensure face and content validity.

Data Collection and Analysis

The jigsaw model was implemented in the experimental class while the conventional teaching method was implemented in the control class. The implementation of the two teaching methods was based on the following organic chemistry concepts: Alkanes, alkenes, alkynes, alkanols, alkanals, alkanones, alkanoic acids, and alkyl alkanoates. The conventional teaching method was implemented following the usual lecture method, textbook approach of teaching, giving of individual assignments, class exercises, and the question-and-answer method of teaching as the teacher engaged the pre-service teachers in the lesson's delivery.

The implementation of the jigsaw model followed the two groups' formation, as shown in Figure 1. This design was modified from the jigsaw design in the study of Karacop (2017). In the design (Figure 1), members in their respective home groups (HGA, HGB, HGC, HGD, HGE, and HGF) were each assigned one of the following organic chemistry concepts (alkanes, alkenes, alkynes, alkanols, alkanals/alkanones, and alkanoic acids/alkanoates). Those with the same concepts were regrouped to form the jigsaw groups: JG1, JG2, JG3, JG4, JG5, and JG6 for alkanes, alkenes, alkynes, alkanols, alkanals/alkanones, and alkanoic acids/alkanoates, respectively. Members in the jigsaw groups did thorough research using the library, internet, and other resource materials on the organic chemistry concepts assigned to them. There was a face-to-face discussion among them to master the subject matter and returned to their home groups as an expert to teach their group members the concepts assigned to them.

Subsequent to the implementation of the jigsaw model and the conventional teaching method in the experimental and control groups, respectively, the data obtained from the OCCAT were collated and analyzed quantitatively using z-test with the help of SPSS version 22.0 and Microsoft Excel. The results were presented using tables and figures.

FINDINGS

Figure 2 presents the mean scores of the pre-service teachers' performance in the selected functional group organic compounds. The performance of the pre-service teachers focused on the results of the pre-test and the post-test in both the experimental and the control groups.

The results (Figure 2) revealed that in terms of the pre-test before the implementation of the jigsaw model and the conventional method, the mean scores of both the experimental group (M = 14.49) and the control group (M = 14.08) were below the pass mark of the test, which was 20 because the total score of the test was 40. On the other hand, the results with respect to the post-test after the implementation of the jigsaw model and the conventional method, indicated that the mean score of the experimental group (M = 29.07) was more than the pass mark and the mean score of the control group (M = 15.29) was still below the pass mark.

Table 2 presents the comparison of the mean score performance of the pre-service teachers in the selected functional group organic compounds using the z-test. Afthanorhan et al. (2015) intimated that in the discipline of statistics, once a large sample size is used preferably >30 to obtain quantitative data, a z-test is implemented in the analysis of the data rather than t-test to compare the means of the samples. In this study, the samples drawn from each population were independent of one another. A sample size of 72 pre-service teachers were drawn from Tamale College of Education, which was independent of another sample size of 72 pre-service teachers drawn from Evangelical Presbyterian College of Education.

Table 2: z-test comparing the mean scores of pre-service teachers' performance in post-test

Group	*n*	M	SD	*Z*	*P*
Experimental	72	29.07	4.95	14.291	0.000
Control	72	15.29	6.51		

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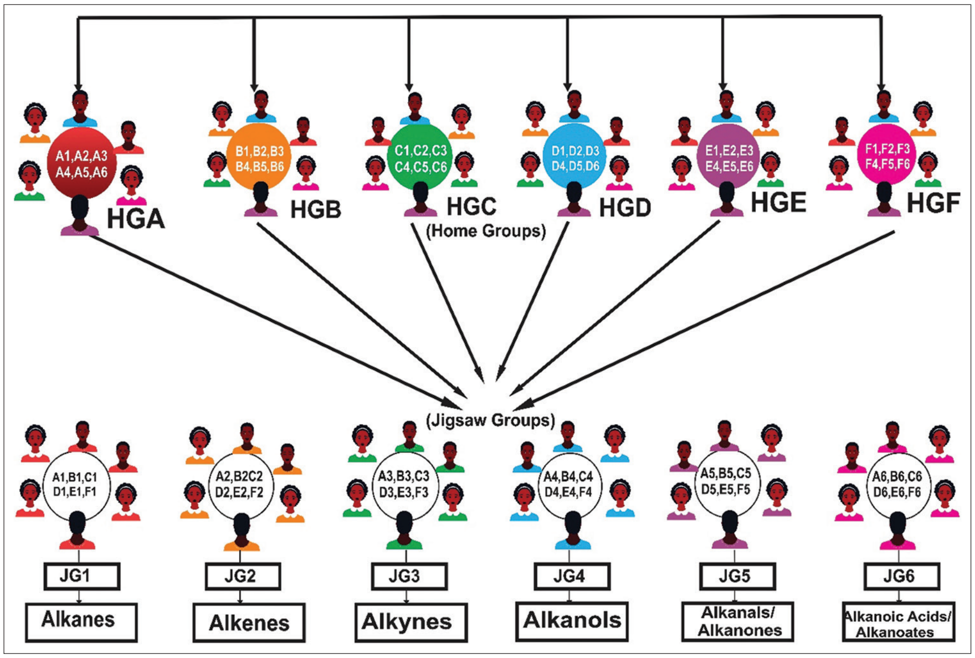

Figure 1: Pictorial formation of jigsaw groups from home groups

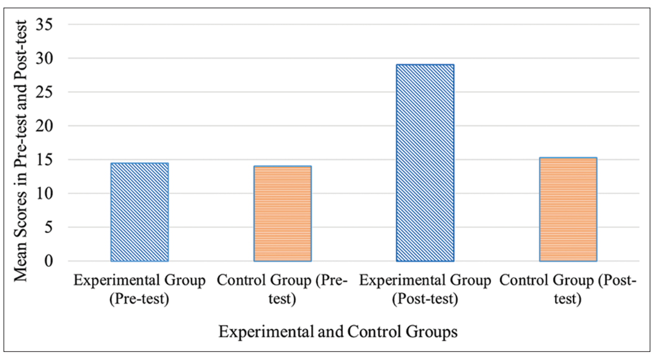

Figure 2: Comparison of mean scores of experimental and control groups

The results (Table 2) showed that there was a significant difference between the mean scores of the experimental group taught through the jigsaw model (M = 29.07, SD = 4.95, Z = 14.29, P < 0.05) and the control group taught through the conventional method (M = 15.29, SD = 6.51, Z = 14.29, P < 0.05). Therefore, the null hypothesis was rejected. Consequently, the findings revealed that the pre-service teachers in the experimental class had significantly higher performance in the selected functional group organic compounds compared to their counterparts in the control class who had lower performance.

DISCUSSION

Regarding the pre-service teachers' performance in the selected functional group organic compounds, the study's findings showed that the jigsaw model produced higher performance than the conventional teaching method. The outcome of this study using the jigsaw model was confined to science pre-service teachers in Tamale College of Education, Ghana. Nevertheless, this study's results supported several other studies' results that used the jigsaw model, which was effective at different institutional levels, different course areas, and different geographical locations beyond Ghana.

Students' performance in Arabic language was improved using the jigsaw model in upper basic schools in Ilorin Metropolis, Nigeria (Abdullahi and Salisu, 2017). Again, students' achievement in secondary school mathematics became better through the jigsaw model in Laikipia East district in Kenya (Mbacho and Githua, 2013). In the area of science, Middle East Junior High School students in Indonesia had a positive influence on their ability to problem solving by the jigsaw model (Suendartia, 2017). Prospective science teachers had higher achievement in physics topics when taught through the jigsaw model (Karacop, 2017). Similarly, sixth-grade students in Kahramanmaraş/Turkey were taught through the jigsaw technique in terms of force and motion and they had higher academic success (Ural et al., 2017). In organic chemistry as the focus of this study, students' understanding about basic organic chemistry concepts in Turkey was much improved with better achievement as they were introduced to the jigsaw model (Çağatay and Demircioğlu, 2013). In Zaria Education Zone in Nigeria, students who were taught organic chemistry by the jigsaw model had better achievement than their counterparts who were taught with conventional method of teaching (Isa and Muhammad, 2019).

As this study's findings are consistent with the findings of the aforementioned studies in the area of students' academic achievements using the jigsaw model in different settings, it suffices to say that the jigsaw model is effective in teaching various subject disciplines irrespective of the level and geographical area. In the context of institutions in Ghana, specifically at the level of the colleges of education, the jigsaw model has further shown its effectiveness in teaching organic chemistry. The outcome of this study additionally attests to the fact that little attention should be given to the conventional method of teaching science as it has not yielded significant higher achievements by students as revealed in literature.

The uniqueness of the jigsaw model was manifested in this study as the learning pattern of the pre-service teachers was that of scaffolding where the weak ones were supported by the more able ones to achieve the set objectives of the learning materials. No pre-service teacher was left out in the learning process as each of them was actively engaged by teaching others his or her part of the learning unit. Creativity among the pre-service teachers who used the jigsaw model in learning was the engine that propelled their successful achievement.

CONCLUSION

The jigsaw model was comparatively highly effective in improving the performance of pre-service teachers in Tamale College of Education (experimental group) in the selected functional group organic compounds than the conventional teaching method. The conventional teaching method yielded low performance in the selected functional group organic compounds among the pre-service teachers in the control group, who were at Evangelical Presbyterian College of Education. The jigsaw model therefore laid a good foundation for the pre-service teachers to develop their problem-solving skills and creative minds as they positively interacted among themselves during group studies and that resulted in their improved performance in the selected functional group organic compounds.

The implication of the outcome of this study is that science teachers in the colleges of education in Ghana could consider using the jigsaw model as a cooperative learning strategy in the delivery of their science lessons since the model has stood the test of time as an effective teaching strategy. Science pre-service teachers could as well adopt the jigsaw model in their group studies as it has proven to be learner-centered teaching strategy, highly innovative in developing problem-solving skills and creativity among learners.

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