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Research Article

Effects of Graphic Organizers on Conceptual Understanding in Organic Chemistry

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ABSTRACT

This study investigated the effect of graphic organizers on conceptual understanding of organic chemistry. The study adopted a mixed-method design involving three intact classes that were purposively selected. A quasi-experimental design and focus group interview was adopted and data was gathered using a chemistry achievement test and an interview protocol whose reliability were 0.74 and 0.73, respectively. The quantitative data were analyzed using analysis of covariance while thematic analysis, with codes generated inductively, was used to analyze the qualitative data. Findings indicated that graphic organizers enhanced students' performance in organic chemistry. Furthermore, students' opined that using organizers facilitated their learning. Although, reports indicated that using them as advance organizers is more tasking and deter attention during instruction. It was concluded that graphic organizers are effective tools that improved students' performance in organic chemistry, however, their use as advance organizers should be carefully guided to ensure enhanced learning outcomes.

Keywords: graphic organizers, advance organizers, concept maps, mind maps, mixed-method

INTRODUCTION

Despite the importance of chemistry, its teaching and learning have been confronted with various challenges, a major one of which is the teacher-related factor. The teacher-related factor deals with the form of teachers' presentation of instruction to learners (Omorogbe & Ewansiha, 2013). It has been argued that chemistry lessons are presented in dogmatic styles which to a large extent inhibit meaningful learning. Such styles make students resort to rote memorization of scientific facts and concepts which leads to poor understanding of chemistry. Hence, students experience difficulties in learning chemistry especially, areas of organic chemistry. Such difficulties ranges from poor understanding of hydrocarbons, inability to draw structural isomers of organic compounds among others (Agogo & Onda, 2014; Chief Examiners' Report, 2019). One method of improving students understanding in chemistry the use of advance organizers. Advance organizer is information introduced in antecedent to learning to be used by the learner to organize and elucidate new learning material (Mayer, 2003). It is usually introduced prior to direct instruction for the purpose of bridging the gap between what learners are already familiar with and what they need to understand in a new lesson. The role of advance organizers includes providing insight into new learning materials by focusing on what is important in a lesson and promote learning and retention of new information (Woolfolk, 2001). Advance organizers are tools that motivates students to learn (Shihusa & Keraro, 2009). They are presented in formats of text, graphics, or hypermedia (Ausubel, 1968). The advance organizer exists in various forms and patterns that include graphic organizers among others (Gil-Garcia & Villegas, 2003; Hendron, 2003).

Graphic organizers are spatial representation of texts. They are pedagogical tools that can avail students with the opportunity to systematically layout and structure information or concepts to establish relationships between them (Zaini et al., 2010). The spatial arrangement of concepts is important since it allows students to identify the missing information or absent connections in their strategic thinking. They are, therefore, visual display, or templates that portrays the connections or relationships among the major concepts involved in a learning task (Braselton & Decker, 1994). This is in accordance with the view of Nousiainen (2012) who reported that the understanding of the key concepts and the relationship in terms of "how" and "why" is important in understanding the structure of scientific knowledge. In chemistry teaching for instance, graphic organizers are easy to adopt tools that allow chemistry teachers to probe into their

Table 1. Comparison of concept maps and mind maps graphic organizers (Adapted from Duffill, 2013; Longanathan, 2010)

Concept maps	Mind maps
Involves expressions of meaning of concepts in a user friendly manner	Meaning of concepts are expressed in graphical form (nodes in graphical form)
Connections between concepts are explicit	Connections between ideas are rarely explicit except one word per branch is used
All morphologies are used	Linear morphologies are involved
Every node-link-node triad forms meaningful propositions	Cannot form propositions
Cross-over are minimized	When cross-connections to hierarchical connections is high (1-10), cross over cannot be easily restructured
Clearly reads one proposition at a time	Propositions are only skimmed to give overview of concepts
Handles less volume of information and conveys information	Handles large volume of information and captures information

students' thinking and learning on a specific topic of study (Struble, 2007). Concept map and mind map are two examples of conceptual pattern of graphic organizer used to assess conceptual understanding of learners about a central idea of subject matter content. They present information in graphical ways, showing the relationship between concepts.

Concept mapping is premised on Ausubel's (1968) assimilation theory of cognitive learning (Ausubel et al., 1978). Concept maps are two-dimensional graphical representations of an individual's knowledge of a domain (Novak & Gowin, 1984). They are graphical tools that shows the organization of knowledge and contains concepts shown in boxes and arrows linking the boxes together. Each arrow or line shows relationship between the concepts, and they are explained using linking phrases (Usta & Ultay, 2012). The basic assumption of the theory is that meaningful learning take place when new knowledge is consciously and deliberately linked to an extant framework of prior knowledge. Concept maps, therefore, provides a visual layout of how concepts are connected giving illustration of the interconnectedness as a whole (Nousiainen, 2012). Mind maps are graphic organizers similar to concept maps, that utilize non-sequential approaches to learning and they require the learner to think and explore concepts in the learning material. Learners connect concepts in mind maps using symbols and images to help facilitate the recall of connections between the map (Akinoglu & Yasar, 2007). There are three basic features of a mind map: a core idea, the central core idea, and interconnections (Semilarski et al., 2021). In a mind map, the core idea or key concept is placed at the center of the map as opposed to being at the top as in the case of concept maps. The central core idea forms branches that emanate from the core idea. They usually form branches of more specific dimensions of knowledge which may or may not be interconnected. The interconnections are formed representing interrelated ideas using both horizontal and vertical interconnecting boxes; formation of hierarchies; and having network of dimensions of knowledge, connected with the core idea by arrows. While concept map includes hierarchy and connections between different nodes which describes the relationship between the nodes, mind map is used to structure a brainstorming process (Plotz, 2020). In the present study, both concept maps and mind maps are presented to students as advance organizers, and their views on their use were soughed (**Table 1**).

Studies show that students have difficulties in understanding organic chemistry. This difficulty stems from students' poor knowledge of hydrocarbon that is perquisite to learning other aspects of organic chemistry (Adu-Gyamfi et al., 2012; Agogo & Onda, 2014). Studies have generally focused on the use of graphic organizer to improve students' performance in chemistry (Ariaga & Nwanekezi, 2018; Arokoyo & Obunwo, 2014). These studies focused on using quasi-experimental design to determine effects of graphic organizers on students understanding of chemistry topics that are perceived to be difficult. There is need to understand the nature of these difficulties and reduce them to enhance deep conceptual learning. Less has been reported about students' opinion on their experience about using graphic organizers to learn chemistry. This prompted the present study to investigate senior secondary school students' opinion of their experience on the effect of use of concept map and mind map as advance organizers in learning organic chemistry.

THEORETICAL FRAMEWORK

The theory, which supports this study, stems from Jean Piaget's constructivism theory and Paivio's (1986) dual coding theory. A constructivist theorist views learning as one in which learners are the active agent in the process of acquiring knowledge. Advance organizers are credited to Ausubel (1960) who was inspired by the works of Jean Piaget. Ausubel (1960) believed in the idea of meaningful learning. It is claimed that the major factor that influences learning is what learners are already familiar with. This implies that construction of knowledge begins with learners' observation and recognition of events and concepts that already exist in their cognitive structure. It was also noted that knowledge is organized in hierarchy and new information is meaningful to the extent in which learners can relate it with what they already know. According to this perspective, learning proceeds in a deductive manner and advocating for the use of advance organizers will provide mechanism that helps link new materials with existing related ideas in the learners' cognitive structure.

Another theory that supported this study is the dual coding theory of cognition that was developed by Paivio (1986). The theory assumes that the brain consists of two separate but interrelated systems for processing information which is verbal association and visual imagery (Wills & Ellis, 2008). Each of the systems can be initiated independently and can be used to represent information. Visual and verbal information are processed differently in the human mind thereby creating separate representations for information processed in each channel in form of mental codes (analogue or symbolic codes). The mental codes corresponding to information are used to systematically order incoming information and can be retrieved for subsequent use while recalling information (Sternberg, 2006). The dual coded information is easier to retain and recall due to the presence of two mental representations. Therefore, students think and recall information better when they use both forms together (Marzano et al., 2001). This theory has a direct effect on the use of graphic organizers as a visual tool since it projects a non-verbal representation of the content of instruction to learners. This non-verbal representation makes it possible for learners to generate a verbal interpretation of the organizer. The graphic organizer as a visual tool enables students to process and remember contents of instruction by facilitating the development of mental images and creating verbal information thereby dual coding contents of instruction.

Research Questions

The primary aim of this study was to investigate the effect of graphic organizers on conceptual understanding of organic chemistry. Our investigation was conducted to answer the following research questions:

1. What is the effect of the use of concept map graphic organizer on secondary school students' achievement in organic chemistry?
2. What is the effect of the use of mind map graphic organizer on secondary school students' achievement in organic chemistry?
3. What opinion do students hold about the effect of use of concept map as advance organizers in learning organic chemistry?
4. What opinion do students hold about the effect of use of mind map as advance organizers in learning organic chemistry?

RESEARCH METHODOLOGY

The research is adopted an explanatory-sequential mixed method design that explored both quantitative and qualitative approach (Creswell & Clark, 2017). The quantitative aspect of this research, utilized quasi experimental design to establish the effect of the use of concept map and mind map graphic organizers in learning organic chemistry. While a qualitative approach, which is phenomenological in nature was used to elicit students' opinion about the effects of the use of either concept map or mind map graphic organizer. This provided opportunity for the researcher to understand the experiences of the respondents after being exposed to either concept map or mind map as advance organizers. The target population was all SS2 students in chemistry classes within the metropolis. Three intact classes were selected from three schools that were purposively selected within the metropolis and a total of 183 students from the selected classes served as the sample for the study. The criteria for purposive selection included the school must be approved by the state government, co-educational and must have presented students for external examination for at least a period of five years. The classes were randomly assigned into experimental group 1, 2, and control. The consent of the chemistry instructors in participating schools to serve as research assistants were sought by filling the consent form while the students took their form home for their parents to fill to enable them to participate as respondents in the research. The instructors were trained for a period of two weeks on the use of graphic organizer (as advance organizer) for instructional delivery. The respondents as well as the instructors were enlightened on the purpose of the study. They were further assured they would not be exposed to any risk throughout the period of the research and informed of their rights to withdraw at any stage in the research.

The experimental groups were taught using concept and mind maps respectively while the control group was taught with the conventional method. The concept map group was labeled experimental group 1, while the mind map group was labeled experimental group 2. Quantitative data was gathered using chemistry achievement test (CAT) as a pretest and reshuffled to form a post test. The CAT contained 50 multiple choice items with four options A-D. The items were adapted from previous West African Senior School Certificate Examination questions. Item analysis was conducted to ascertain the appropriateness of the items. Seven items considered to be too difficult and too easy were deleted while three items were revised. A pretest was conducted for students in each group to ascertain students' prior knowledge about hydrocarbons and also ascertain that the three groups are equivalent. The respondents in the two experimental groups were provided with concept maps and mind maps on hydrocarbons respectively to study ahead of the next lesson while the control group was placed on placebo. The instructors who served as research assistants taught with duplicate of the maps on flex during classroom instructions for individual groups for a duration of two weeks while, the control group was taught using the conventional method.

While the concept map group (experimental group 1) were studying organic chemistry, the instructor introduced the lesson by establishing relevant perquisite knowledge about the chemistry of carbon and hydrogen. Learners were given opportunities to respond to the classroom discussion, which was guided with their maps that was studied prior to the lesson. This enabled the teacher to remediate all forms of misconceptions that students held in the past. During the lesson presentation, the teacher made elaborate explanations about the concepts on the map while the students paid rapt attention, contributed and asked questions at intervals. The major concepts taught during the lesson were listed out on a section of the board for the purpose of reflection. As a result of classroom discourse, the teacher and the students, created a concept map of the concepts established during the lesson. This was used to compliment a duplicate of the map that was brought to teach the concept of hydrocarbons by the instructor. During the lesson summary, both the instructor and the learners referred to the contents of their maps to provide appropriate summary. As a form of evaluation, the teacher made a list of concepts related to hydrocarbons and requested that learners map them and state the relationship between the concepts and emphasis was made on providing the appropriate linking phrases. In the mind map group (experimental group 2), a similar procedure was adopted, however, the learners were provided with mind maps rather than concept maps. However, at the summary stage, the leaners were encouraged to brainstorm the relationships between the identified concepts during the lesson. At the evaluation stage, emphasis was placed on linking the identified concepts during the lesson appropriately with the most inclusive concept developed from the center of the map. This enabled the learners to express their views about the topic taught holistically.

The lessons were taught concurrently in the three schools and each of the students were provided with maps based in the content to be taught per week in the experimental groups while the control group were taught using the conventional method. The conventional method required that the instructor taught with the appropriate instructional material required for the lesson. The duration was considered adequate because the topic "hydrocarbon" was scheduled to be taught for two weeks in the scheme of work for the term for three contacts per week in four lesson periods. Hence, regular classroom activities were not disrupted, after teaching, a post test was conducted, and students' scripts were graded and recorded.

Qualitative data was gathered through a focus group interview. A group that contained 10 respondents who performed excellently and poorly in the post test constituted the focus group for interview in each of the groups. Hence, a total of 20 respondents were interviewed in the two groups. A semi-structured interview protocol was developed to elicit students' responses on their opinion on the effect of the use of the graphic organizer they were exposed to.

The interview protocol was developed using guidelines of interview protocol refinement (IPR) framework by Castillo-Montoya (2016). The protocol contains four closed ended interview questions and five follow-up questions. When developing the protocol, preference was given to using formulations that will enable respondents to present their own thoughts in their own way. This was important because the respondents who are secondary school students are not expected to have adequate vocabulary to distinguish between the terms of advance and graphic organizers.

In determining the reliability of the interview protocol, copies were given to two lecturers in the Department of Science education who were provided with an activity checklist adopted from Castillo-Montoya (2016), and an inter rater reliability which showed 0.73 agreement between the two raters was obtained. Each of the respondents were given a nametag that was labelled with alphabets, to ensure they are anonymous and get objective responses. The researcher along with the research assistant conducted the interview. The interview session lasted for 60 minutes for each group and responses gathered from the interview were transcribed, coded, and categorized into themes. The quantitative data gathered from the study was analyzed using mean, standard deviation, while analysis of covariance (ANCOVA) at 0.05 level of significance was used to establish significant difference between the experimental groups and the control using their pretest as covariates. Qualitative data were analyzed thematically with codes generated inductively.

RESULTS

To answer our research questions, we will first present the effect of concept map organizer on students' achievement in organic chemistry (research question 1) and then, establish if significant difference exists in the achievement of students when taught with concept map organizer and those taught with the conventional method (control group).

Table 2. Means & SDs of students' performance in the graphic organizer I (concept map) & control groups

Groups	N	Mean	SD
Concept map	77	21.12	7.17
Control	62	18.79	4.28
Total	139	20.08	6.14

Note. Mean difference=21.12-18.79=2.33; SD: Standard deviation

Table 3. Summary of ANCOVA of mean scores of students taught organic chemistry using concept map graphic organizer & conventional method

Source	Type III SS	df	MS	F	Sig.	$^{\eta}p^2$
Corrected model	860.41[a]	2	430.20	13.42	.00	.16
Intercept	1,562.07	1	1,562.0	48.75	.00	.26
Pre-test	674.50	1	674.50	21.05	.00	.13
Treatment	332.51	1	332.51	10.37	.00	.07
Error	4357.71	136	32.04			
Total	61,259.00	139				
Corrected total	5,218.12	138				

Note. SS: Sum of squares; MS: Mean square

Research Question 1- What Is the Effect of the Use of Concept Map Organizer on Secondary School Students' Achievement in Chemistry?

As we see in **Table 2**, the data gathered from the post-test of the experimental group 1 (concept map organizer) and the control group (conventional method) were analyzed using mean and standard deviation. An inspection of the mean scores indicated that students in the experimental group performed better (M=21.12, SD=7.17) than their counterparts in the control group with a difference of (M=18.79, SD=4.28).

To determine if there was a significant difference in the performance of students taught organic chemistry using concept map graphic organizer and those taught using the conventional method, ANCOVA was conducted using the pretest as covariates.

Table 3 revealed that $F_{(1,136)}$=10.37, p=.00, this indicates a p-value less than the significant value (.05) hence, the null hypothesis was rejected. Therefore, there is a significant difference in the achievement of students taught organic chemistry using concept map organizer and those taught using the conventional method.

Table 3 further revealed that the effect size is small showing a partial Eta squared value ($^{\eta}p^2$=.07) which indicates that 7% of the variance in the students' achievement was due to the treatment (concept map organizer).

Research Question 2-What Is the Effect of the Use of Mind Map Graphic Organizer on Secondary School Students' Achievement in Organic Chemistry?

Data gathered from the post-test of the experimental group 2 (mind map graphic organizer) and the control group (conventional method) was used to respond to this research question. Data were analyzed using mean and standard deviation as shown in **Table 4**. Results revealed that students in the mind map group performed better than their

Table 4. Means & SDs of students' achievement when taught organic chemistry using the mind map graphic organizer & conventional method

Groups	N	Mean	SD
Mind map	44	23.45	4.60
Control	62	18.79	4.28
Total	106	20.73	4.96

Note. Mean difference=23.45-18.79=4.66; SD: Standard deviation

Table 5. Summary of ANCOVA of mean scores of students taught organic chemistry using mind map graphic organizer & conventional method

Source	Type III SS	df	MS	F	Sig.	ηp^2
Corrected model	579.78[a]	2	289.89	14.83	.00	.22
Intercept	3,312.88	1	3,312.9	169.48	.00	.62
Pre-test	19.87	1	19.89	1.01	.31	.01
Treatment	549.78	1	549.78	28.12	.00	.21
Error	2,013.28	103	19.54			
Total	48,129.00	106				
Corrected total	2,593.06	105				

Note. SS: Sum of squares; MS: Mean square

counterparts (M=23.45, SD=4.60) that were in the control group with a mean difference of 4.66.

To determine if there exist a significant difference in the performance of students taught organic chemistry using mind map graphic organizer and those taught using the conventional method, ANCOVA was conducted, using pretest as covariates. Table 5 revealed that a statistically significant difference exists, showing an $F_{(1,103)}$=28.12, p=.00. The p-value of 0.00 which is less than the significant value of .05 and consequently, the null hypothesis is rejected. Hence, there is a significant difference in the achievement of students taught organic chemistry using mind map organizer and those taught with the conventional method. Table 5 further revealed that the effect size is small showing a partial Eta squared value (ηp^2=.21). This effect size indicates that 21% of the variance in the students' achievement was traceable to the treatment (mind map organizer).

Research Question 3-What Opinion Do Students Hold About the Effect of Use of Concept Map as Advance Organizers in Learning Organic Chemistry?

Findings revealed five themes, which were generated inductively, emerged out of ten subthemes from the students' responses to the interview. These themes are (i) providing support for cognitive development, (ii) identification of difficult areas, (iii) implications for affective domain of learning, (iv) support for use of maps, and (v) shortcomings for use of maps. These themes were generated inductively from emerging codes in the transcript. Results revealed that 80% of the students' held positive opinions on the use of concept map graphic organizers to learn organic chemistry for instance, they noted that the maps were able to support their learning through the use of linking phrases. Although they noted some shortcomings such as difficulties in understanding some new terms that are in the map while studying prior to the lesson even though they aroused their curiosity.

It can be deduced from finding of this study that students taught organic chemistry using concept map graphic organizer had better achievement than their counterparts did in the control group. This could be attributed to the fact that students in the concept map graphic organizer group utilized the maps as advance organizer which gave them an idea of what they should be doing in the next lesson. Also, students worked with the maps during lesson presentation and as such concretized their learning. Excerpts from the interview revealed that students identified that the maps when used as advance organizer were supportive to enable them to gain more from their teacher's explanation.

> Respondent G: "… I have noted my areas of concern that I want to ask my teacher while studying the maps alone."

> Respondent C: "… when I was studying with the maps, I think I understood it on its own because I was able to identify the examples and the various classes using the words on the arrows that were pointing at them."

Such is an indication that students in the concept map graphic organizer group were able to study the maps to identify relationships among various concepts in the map prior to instruction.

Research Question 4-What Opinion Do Students Hold About the Effect of Use of Mind Map as Advance Organizers in Learning Organic Chemistry?

Thematic analysis of students' responses on their learning experiences on the effect of using mind map organizer in learning organic chemistry revealed that five themes emerged from eight sub-themes that were inductively generated. The themes included (i) providing support for cognitive development, (ii) identification of areas of difficulties, (iii) implications for affective domain of learning, (iv) support for use of maps, and (v) shortcomings for use of maps. The results revealed that 90% of the respondents held positive opinion about the use of mind map graphic organizer in learning organic chemistry. For instance, responses revealed that students established relationships among concepts in the map. However, they claimed that they assumed understanding of the contents of the map when studied ahead of the class, as such, they paid less attention during the lesson.

Findings also indicated that students' in this group performed better than their counterparts in the control group. A possible reason for this is the ability of the students to familiarize themselves with information about the next lesson by studying their mind maps graphic organizer before coming to class and their encounter with the map during instruction. Excerpts from the interview sessions revealed that students' benefitted more from the lesson as a result of their prior exposure to mind maps graphic organizer before and also during instruction.

> Respondent T: "The maps I studied before the class made organic chemistry easy to understand. My understanding of some chemistry topics is low but with the map I worked with, I was able to understand better."

> Respondent A: "Umm… the classification of the organic chemistry was so complex … but the map put each of

> the classes in their various categories in a simpler form."

> Respondent Z: "I was able to avoid some misconceptions about the concept of saturated and unsaturated because they look similar. But the map has assisted me to clearly differentiate them."

These responses showed that mind map graphic organizer enhanced the students' achievement in organic chemistry when compared with students in the conventional method who were not taught using the organizer.

The findings of this study showed a significant difference existing between the achievements of students who were taught organic chemistry using concept map graphic organizer and those taught using the mind map graphic organizer in favor of the mind map graphic organizer group. This could be attributed to lack of linking phrases in the mind map graphic organizer which prompted students to brainstorm the relationships between the concepts on their map. This act of brainstorming could probably concretize their knowledge of organic chemistry much better than participants in the concept map graphic organizer group whose maps already made provision for the type of relationships that exists between the concepts in their maps through linking phrases. Besides, excerpts from the interview revealed that mind map graphic organizer spurred interest and arouse curiosity when used and this could also be one of the reasons for the improved achievement for the group of mind map graphic organizer.

> Respondent Q: "My encounter with the map spurred some excitement in me. Umm…in the first instance, I was curious and want to find out how my teacher will use the map. So, I think I paid more attention in the class."

It was the experience and view of the concept map graphic organizer group that details provided on their map in terms of linking phrases provided information about relationships among concepts in the maps. Hence, they assured confidence of understanding the content of the maps before the class, consequently, they paid less attention and showed less commitment in the class in contrast with students in the mind map graphic organizer group.

> Respondent T: "… the map deprived me of my attention in class because I was proud that I have idea of what he wants to teach and my concentration was divided in the class…"

Mind map has showed in this study that it is an effective tool for teaching chemistry because less information was provided, and more mental effort was required of the students than the concept map graphic organizer group. While both graphic organizers developed were to have pedagogical function, which serves as a technique for presenting instruction and assess students' understanding of information, mind maps are developed with intents to develop skills for brainstorming.

DISCUSSION

This study focused on investigating the effects of graphic organizers on students' understanding of organic chemistry. In this study, students were grouped into three (experimental group 1, 2, and a control group). After the treatment, students' opinions were soughed about their experience when they learned hydrocarbons using either concept maps or mind maps as advance organizer through a focus group interview. It is our believe that this study will add to the scanty research literature on students' experience when they learn with graphic organizers as advance organizer. In terms of respondents that were taught with concept map, findings revealed that the students in the concept map group outperformed their counterparts in the control group. This could be because of students' ability to make holistic deductions from the concept map due to the presence of linking phrases which gave explanation to relationship between concepts. Furthermore, majority of students held positive disposition about using it to aid conceptual understanding of hydrocarbons. They described concept map, as a potent tool that facilitates learning of hydrocarbons easily. This implies that concept map enhanced better understanding of hydrocarbons. This finding is consistent with the findings of Bamidele et al. (2013) who reported that mapping strategies when used as advance organizer enhanced students' performance in chemistry since it shows clarity in the relationship between key concepts that are on the map. Chawla and Singh (2015) had also reported that concept map is a significant tool in improving students' achievement in chemistry. However, few of the respondents reported that in spite of using concept maps, they still had difficulties understanding the topic.

Findings from this study revealed that students in the mind map group performed better than their counterparts in the control group. Also, majority of the respondents opined that mind maps facilitated their learning of hydrocarbons. Although reports from the focus group interview indicated that, more inclusive concept on the mind maps were difficult to process. This could be due to lack of linking phrases and as such, more brainstorming is required to understand the relationship between the concepts. In earlier studies, Adodo (2013) reported that mind mapping strategy has the capacity of improving students' critical thinking, creative skills as well as improving their performance in basic science. Finding from the present study had confirmed such supposition especially in the learning of hydrocarbons. Gagic et al. (2019) also made similar observation in physics, and reported that teaching with mind maps had greater efficiency in improving students' performance and engagement during physics lessons. However, contrary to the findings of this study, it was reported that using mind mapping helps to reduce mental efforts.

CONCLUSION AND RECOMMENDATIONS

Learning experiences of the students were categorized into five major themes in which three of the themes (support for cognitive development, implications for affective domain of learning, support for use of maps) provided strength for using concept maps graphic organizer to learn organic chemistry.

However, two of the themes (acknowledged areas of difficulties, and shortcomings for using maps) were directed towards the weakness of the map. It is important to note that the five themes were generated from ten subthemes out of which the theme (support for cognitive development) had four subthemes. It is, therefore, an indication that most of the responses from the participants focused on the positive role of concept maps towards understanding of organic chemistry. This implies that respondents found the use of concept map as effective tool in learning organic chemistry.

Students' learning experiences on the use of mind map graphic organizer were categorized into five major themes in which three of the themes; (support for cognitive development, implications for affective domain of learning, support for use of maps) were recognized to provide support for students' understanding of organic chemistry. However, two of the themes identified were directed towards the weakness of the map (acknowledged areas of difficulties, and shortcomings for using maps). It is important to note that the five themes were generated from eight subthemes out of which the theme (support for cognitive development) had three subthemes. It is, therefore, an indication that responses from the participants focused on the positive role of mind maps graphic organizer towards understanding of organic chemistry. This implies that mind map effectively engages students while learning organic chemistry.

It was therefore, recommended that chemistry teachers' use of graphic organizers should be encouraged especially in teaching of organic chemistry. Students should also adopt the use of graphic organizers as study tools to improve their achievement in chemistry. Textbook authors should also consider the use of graphic organizer in the presentation of information in chemistry textbooks. It is suggested that future research can probe into other areas of chemistry that learners perceived difficult, using a similar methodology. Furthermore, a qualitative study can be conducted using clinical interview to probe into the attitude of learners towards using graphic organizers rather than the conventional method.

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