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Comparative Effect of use of Graphic Organizers on Students' Learning Outcomes in Organic Chemistry

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Abstract

The purpose of this study is to determine the comparative effectiveness of the use of concept map and mind map graphic organizers on students' learning outcomes in organic chemistry. This research adopted a quasi-experimental design involving a 3X2 pre-test post-test non-randomized and non-equivalent control group design. The study is premised on the dual coding theory of cognition, and involved 183 respondents whom were purposively selected from three intact classes. Data for the study was gathered through an organic chemistry achievement test whose reliability was determined through a test retest method and a reliability index of 0.74 was obtained. Data was analyzed using t-test and Analysis of Covariance. Findings show that there was a significant difference between the achievement of students taught organic chemistry using concept map graphic organizers and those taught with the mind map graphic organizer ($F(1,118)= 7.04$, $p<.05$). Using t-test statistics, findings also indicated that there was no significant difference in the achievement of male and female students when exposed to either concept map ($t(75)= .47$, $p = .63$) or mind map graphic organizer ($t(42)= .64$, $p = .52$). Hence, it was concluded that mind map is a more effective tool for learning organic chemistry when compared to the concept map. Irrespective of students' gender, either of concept map or a mind map can help improve students' achievement in organic chemistry.

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INTRODUCTION

Organic chemistry refers to a branch of chemistry that addresses the study of compounds containing molecules of carbon and hydrogen, and could contain other elements. It is a sub-discipline in chemistry, which deals with the scientific investigation of the structure, properties, and reactions of organic compounds and organic materials. That is, matter in its diverse forms that contain carbon and hydrogen atoms with other elements (Clayden et al., 2012). Organic chemistry is a prerequisite to understanding the application of chemistry in other areas such as polymer chemistry, pharmaceutical chemistry and biochemistry. Organic compounds are important ingredients in production of most essential materials and homemade products. Hence, its teaching and learning should be accorded maximum attention to enable learners make maximum utilization of its knowledge.

The teaching and learning of chemistry has been confronted with a lot of challenges. Specifically in areas related to organic chemistry, learners have been reported to experience difficulties in building mental models of meaning of organic chemistry concepts due to previously held misconceptions (Sibomana, et al., 2021). Similarly, in a report by the West African Examination Council, it was established that learners' deviate from questions relating to organic chemistry and the few that attempt such questions performed poorly. Some of the reasons adduced were that students do not understand rubrics of questions based on structures of organic compounds; inability of learners to identify the functional groups and draw structures of organic compounds (Chief Examiners' Report, 2012; 2015; 2017).

One strategy that could be employed to remediate this difficulty is the use of graphic organizers. Research have suggested the positive effect of use of graphic organizers in areas such as biology and physics (Torres et al., 2014). More so, an earlier study have reported the effectiveness of concept maps and mind maps graphic organizer as effective tools teaching organic chemistry (Imam et al., 2022). It is against this backdrop that this study investigated the comparative effect of concept map and mind graphic organizer on students' achievement in organic chemistry. The following research questions were raised to guide this study: what is the difference in achievement of students in organic chemistry when taught using concept map graphic organizer and those taught using mind map graphic organizer?; what is the influence of gender on students' achievement in organic chemistry when taught using concept map graphic organizer?; what is the influence of gender on students' achievement in organic chemistry when taught using mind map graphic organizer?

Review of Literature/ Theoretical Framework

This study is premised on the dual coding theory of cognition, which assumes that the brain consists of two separate but interrelated systems for processing information that 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 directly influence 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 thereby creating verbal information thereby dual coding contents of instruction.

Graphic organizers are spatial representation of texts aimed at constructing knowledge through identification of relationship among concepts. They are non-verbal and visual tools that helps learners to construct knowledge by relating the new concepts to what they possess in their cognitive structures. Tayib (2015) described graphic organizers as a visual display of concepts that provides learners with structural framework of information to be learned. Hence, it helps to direct learners' attention to key concepts in the learning material. Chanshi and Daka (2020) noted that in graphic organizers, the concepts in the new learning material sequentially arranged usually from known to unknown in increasing order of difficulty. Graphic organizers are one of the various forms of advance organizers as depicted in Figure 1. Studies have revealed the existence

of graphic organizers in six patterns: hierarchical, conceptual, sequential, relational, evaluative and cyclical (Gil-Garcia & Villegas, 2003). The selection of any of these patterns is dependent on the complexity of the text and fitness to the curriculum content.

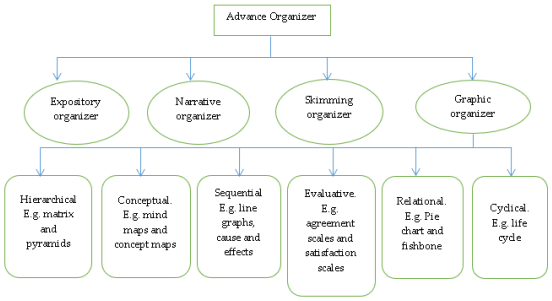

Figure 1. Forms and patterns of Advance Organizers

This study investigates the effect of graphic organizer on students' achievement in chemistry because graphic organizer puts the content of instruction in a precise form that helps students to differentiate between what is important to know and what is interesting in the learning material. Graphic organizer generally reduces information processing by the learner thereby reducing cognitive processing of the mind. This is feasible because the content of instruction is presented at more sophisticated and complex levels in contrast with other forms of advance organizers. Graphic organizer's advantage of the spatial representation of learning material facilitates understanding of new chemistry concepts among students especially those with learning disabilities. The use of graphic organizers promotes understanding and enhances organization as well as long-term retention of information (Tayib, 2015). The present study examined the conceptual pattern of graphic organizer that includes the concept map, mind map due to the similarities between the maps, and inconsistencies in scholars' opinion on which of the maps best enhance students' learning outcomes (Dufill, 2013; Frey, 2016; Struble, 2007).

Concept map is premised on the theory of meaningful learning. They are visual tools that display the relationships between concepts in either circles or boxes using connecting lines and linking phrases, which gives insight on the relationship among the concepts. In developing concept maps, two major parts are involved. That is, the concepts and the propositions (Novak, 2010). The concepts describes the perceived regularities in the context and are connected by linking phrases, which are referred to as propositions (Novak & Canas, 2008). While concept map include hierarchy and connections between different nodes that describes the relationship between the nodes, mind map focuses on structuring a brainstorming process (Plotz, 2020). It is evident in literature that concept map is a potent tool that is capable of improving students' achievement in chemistry (Singh & Moono, 2015; Talbert et al., 2020; Wang et al. 2021).

Mind maps are graphical tools that utilizes the non-linear approach that encourages learners to brainstorm and explore concepts using visual-spatial relationships from a central theme to peripheral branches that can be interrelated. They rely majorly on less written text, uses lines, symbols, colors and images (Arulselvi, 2017). Ideas or concepts in mind maps can be connected to any other related concept. They are termed association maps that is, they help learners to imagine and make connections between concepts (Davies, 2011). Mind maps contains three basic features. First, is a core or central idea that originates from the center of the map. Secondly, is a central core idea, which branches into one or more specific knowledge dimension and thirdly, formation of vertical or horizontal interconnections. The interconnections can include ideas, keywords, codes and symbols (Buzan & Buzan, 2007). This study assumes that teaching and learning of organic chemistry can be enhanced when graphic organizers are implemented. This is evident from reports in earlier studies that reported positive effect of use of either concept map or mind map graphic organizers (Gagic, et. al., 2019; Talbert, et. al., 2020; Wang, et. al., 2021).

Studies have reported the positive outcome comparative effectiveness of various types of graphic organizers with focus on students' attitude, efficacy and their learning outcomes (Ekenobi & Mumuni, 2015; Oloyede, 2011; Torres, et al. 2014). For instance, Torres, et.al (2014) investigated the effect of graphic organizers on the attitude of freshmen students in chemistry using venn diagrams, flow charts and pictorial forms of graphic organizers. Findings from the study revealed that using graphic organizers help developed positive attitude among the learners. Oloyede (2011) similarly compared the effect of pictorial and written organizer on students' achievement in the mole concept using a quasi-experimental design. Findings showed that both type of organizers improved students' learning outcome. However, a more positive effect was recorded for the pictorial organizer than the written. Few studies have explored the comparative

effect of conceptual patterns of graphic organizers in students' learning of science concepts, using concept and mind map organizer (Aydin, 2015; Mani, 2012). Hence, the present study explored the comparative effect of conceptual organizers of concept map and mind map organizers on students' achievement, specifically in organic chemistry.

In earlier studies, Mani (2012) in an expository study on the comparative effectiveness of concept mind and mind mapping strategies reported that both mapping strategies were capable of improving students' achievement in science. Conclusively, report indicated that while mind maps assist students to develop techniques for brainstorming, concept maps had a pedagogical function of presenting information and assessing learners understanding of information presented. In another study, Aydin (2015) explored the comparative effect of the use of technology-support mind map and concept map on students learning of science concept (systems in our body) using quasi-experimental design. Findings from the study showed that students had improved learning outcomes while studying "systems in our body" using technology-supported mind map when compared to the concept map group. There is dearth of research in the comparison of concept map and mind map in the learning of chemistry, especially in the area of organic chemistry. Hence, the present study seeks to compare the effect of using concept map and mind map on students' achievement in organic chemistry.

Influence of gender on students' learning in science has been a major concern of science educators over a decade. Studies have yielded inconsistent results on gender differences and students' achievement in chemistry. However, studies have indicated that students gender have an influence on their achievement while others noted the superiority of one gender over the other. For instance, Gerstner and Bogner (2009) reported the superiority of female students over their male counterparts in science learning, indicating that female learners produced more complex concept maps than their male counterparts. Contrarily, Veloo, Lee, Seung, (2015) submitted that male students achieved better in chemistry than their female equivalents. However, Gongden and Delmang (2016) and Chawla and Singh (2015) posited that male and female students do not differ in their achievement in chemistry when taught using concept map. Hence, there is no conclusive evidence on the influence of gender on students' achievement in chemistry especially in the use of graphic organizers. The present study, examined the influence of gender on students' achievement in organic chemistry taught using either concept map and mind map graphic organizers.

METHODS

Interventions

In this study, there were three major interventions: concept map, mind map and the control group.

Concept map

The concept map group formed the experimental group one. This group involved learners being taught using the concept map graphic organizer. The learners individually, worked with a hard copy of concept maps provided by their teacher prior to the next chemistry class. The whole class was briefed on what they are expected to do with the map and as such, it will guide them through the next lesson. The task of the students at that point was to go through the concept map, study it carefully and make notes against the next class. During class presentation, the learners made presentations of their understanding of the contents of the maps and this enabled the teacher to extract perquisite knowledge from them through which the major class activity was built. The teacher commenced the lesson using a similar copy of the maps provided to the class. There was emphasis on deploying the linking phrases available on the concept maps to teach the concepts of hydrocarbons and the reactions they undergo. The students contributed to the lesson in terms of citing examples and asking questions as the lesson progresses.

Mind map

As indicated in the intervention for the concept map group, the mind map group formed the experimental group two. The learners were provided with individual copies of a mind map graphic organizer and the learners were addressed as a whole class on their task against the next chemistry lesson. At this stage, they were informed to utilize the map they were provided with by brainstorming the relationship between the various concepts on the map and subsequently making notes. At the commencement of the next lesson, the teachers assessed the entry behavior of this group through the notes they made during their individual brainstorming activities. The teacher proceeded through the lesson by utilizing her copy of the mind map to teach the concept of hydrocarbons and the reactions they undergo. The learners contributed and asked questions as

the class activities progresses.

Control

This group were taught using the conventional method. The students were not provided with maps before the lesson. However, they are aware of the next topic in the next chemistry lesson. The students were not compelled to carryout a task before the next class. During the class, the teacher engaged the students using their perquisite knowledge. The teacher to buttress her explanation utilized a classroom chart on functional groups of hydrocarbon. The students paid attention, contributed to the lesson by citing examples and asking questions. The learners were engaged in formative assessments as the lesson progresses by asking them to sketch the structure of some hydrocarbons and balancing reactions involving hydrocarbons. At the end of the class the students were provided with assignments to complete ahead of the next lesson. This approach was repeated for subsequent lessons in this group while the study lasted.

Research Design

The study is a quasi experimental design involving 3X2 pre test post-test non-equivalent and non-randomized control group design. A diagrammatic representation of the research design is presented in Figure 2. The first "three" represents the three groups (experimental group I, experimental group II, and Control group) while, the last two represents the respondents' gender at two levels (male and female). Three intact classes were involved to ensure there is no bias in sample selection.

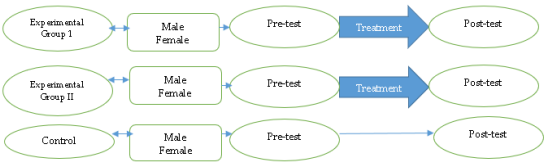

Figure 2. Research Design Layout

Population, Sample and Sampling Techniques

The population for this study consists is students from seventy-eight public secondary schools in Ilorin, Nigeria. A total of seven non coeducational schools were exempted, while three senior secondary schools were purposively selected. These schools are located in the peri-urban area and are attended by the wards of low and medium socio economic status. The schools were selected based on the fact that they are owned by the government, co-educational, have a qualified chemistry teacher and have registered students for the senior school certificate examinations for at least five years. The study involved a sample of 183 respondents in Senior School 2 (SS2) which constitute of 123 males and 60 females from the three intact classes that were purposively selected. The choice of SS2 becomes necessary because organic chemistry was scheduled to be taught at that level in the scheme of work for that term. The three selected schools were randomly assigned to experimental groups 1, 2 and the control groups respectively.

Instrumentation

Three research instruments were utilized in this study: 1) Concept map instructional Package; 2) Mind map instructional Package; 3) Organic Chemistry Achievement Test.

The chemistry teachers of the participating schools consented to participate as research assistants to teach the lesson during the periods which the treatment last by completing the consent form provided by the researcher . The students were provided with consent forms to give to their parents to enable them to participate in the study. The teachers were trained on the use concept maps and mind maps as advance organizers and teaching with such maps. The maps were developed by the researcher and were validated by three chemistry educators and experts in educational technology. The comments of the validators were harnessed and used to improve on the final draft of the maps. The experimental group I were taught using concept map graphic organizer, the experimental group II were taught using the mind map graphic organizer while the control group were taught using the conventional method. Prior to instruction, each of the respondents in experimental groups I and II were provided with copies of the maps to study ahead of class. The concept map and mind map were used to teach the experimental groups, while the control group was taught using the instructional material required for the lesson. During teaching, students in the experimental groups learned the concept of hydrocarbons by making reference to their maps while, the teacher taught with a copy of the map on a flex. Respondents saddled with the task of developing their own maps using concepts that were derived during the lesson.

The pretest and post-test are sets of organic chemistry achievement test that was an objective organic chemistry questions with options ranging from A-D. The questions were adapted from past West Africa Senior School Certificate Examinations. The test were subjected to item analysis and a total of 50 questions that were retained. The re-

liability of the test was done with test-re test method involving a sample of twenty students who did not participate in the study. The reliability was calculated using Pearson Product Moment Correlation statistics. A reliability index of 0.74 was obtained and considered reliable for the study. The questions in the achievement formed the pre test and reshuffled to form the post test. Each of the groups were exposed to a pretest before the treatment and were taught concurrently using their respective interventions (treatment) for a period of two weeks in three contacts per week, which was equivalent to four periods of 40 minutes per period. After instruction, the three groups were exposed to a post test and their scripts were marked and recorded. Data gathered was analyzed using t-test and Analysis of covariance (ANCOVA) using the pre-test as covariates. Table 1 presents a holistic view of the methods of data collection and analysis involved in this study.

Sample questions from of the chemistry achievement test:

- classification of aliphatic hydrocarbons is based on……..; (a) molecular formula of the compound (b) the number of bonds present in their structure (c) the valency of carbon and hydrogen atoms (d) the natural source of hydrocarbon
- during the laboratory preparation of ethyne, the reaction is performed on a heap of sand due to……. that is associated with the process; (a) the large amount of heat released (b) the smell of the gas released (c) the ethene produced is volatile (d) the presence of calcium carbide in the reaction mixture
- when bromine is added to ethene at room temperature, the compound formed is ……..; (a) 1,1,-dibromoethane (b) 1,1,-dibromoethene (c) 1,2,-dibromoethane (d) 1,2,-dibromoethene.

RESULTS AND DISCUSSION

This study explored the comparative effect of concept map and mind map graphic organizers, the data gathered in this study were subjected to statistical analysis of t-test and ANCOVA. As presented in Table 2, the number of valid responses is 183 from the three groups. This contained 77, 44 and 62 responses from the concept map, mind map and control group respectively.

To answer the research questions, the effect of use of concept map and mind map graphic organizers are presented as follows:

Research Question 1

What is the difference in the achievement of secondary school students that were taught organic chemistry using concept map graphic organizer and those taught using mind map organizer?

Table 3 presents analysis of data gathered from the post-test of the experimental group 1 (Concept map graphic organizer) and experimental group 2 (Mind map graphic organizer). Data was analyzed using mean and standard deviation revealed that students in the experimental group II (Mind map graphic organizer) had better achievement (M=23.45, SD=4.60) than their counterparts that were in experimental group I (Concept map graphic organizer) with a mean difference of 2.33.

Table 1. Summary of Research Data and Analysis

Stages	Phase	Procedure	Product
I	Pre-test data collection	Pre-test outcome from the experimental and control groups	Numeric data
II	Quantitative data analysis	Using descriptive and inferential statistics	Meaningful measures
III	Post-test data collection	Pre-test outcome from the experimental and control groups	Numeric data
IV	Quantitative data analysis	Using descriptive and inferential statistics	Meaningful measures
V	Integration of pre-test and post test results	Analysis of Covariance (ANCOVA) using pre-test as covariates	Discussion and implication for future research
VI	Analysis of Post-test data for experimental groups based on gender	t-test statistics	Discussion and implication for future research

Table 3. Mean and Standard Deviation of Students' Achievement when taught Organic Chemistry Using the Concept map graphic Organizer and Mind map Graphic Organizer.

Groups	*N*	Mean	*SD*	Difference
Concept Map	77	21.12	7.17	
				2.33
Mind Map	44	23.45	4.60	
Total	121	21.97	6.44	

In furtherance to establish if a significant difference exist in the mean score of the two experimental groups, Analysis of Covariance (ANCOVA) was conducted. A preliminary check was conducted to ensure the equality of variance and the assumptions of ANCOVA has not been violated. Hence, Table 4 presents the Levene's test for equality of variance with a significant value >0.05. Therefore, the equality of variance is assumed.

Table 4. Levene's Test of Equality of Error Variances[a]

Dependent Variable: post test			
F	df1	df2	Sig.
5.90	1	119	.07

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Pretest + treatment

Table 5 presents ANCOVA result for data gathered from the pre-test and post-test scores of students in experimental group 1 (Concept map graphic organizer) and experimental group 2 (Mind map graphic organizer) to find out if the difference was significant. Table 5 revealed that ($F_{(1,118)}$= 7.04, p=.00.) the p -value of 0.00 is less than the significant value (.05) and thus, the null hypothesis was rejected. This is an indication that there was a statistically significant difference in the achievement of students taught organic chemistry using concept map organizer and those taught using the mind map graphic organizer. Table 5 further revealed that the effect size is small showing a partial Eta Squared value ($^{n}p^{2}$=.05) this indicates that 5% of the variance in the students' achievement was traceable to the treatment (Concept map organizer).

Research Question 2

What is the influence of gender on secondary school students' achievement in organic chemistry when taught using concept map graphic organizer?

Preliminary checks was conducted to ensure there was no violation of assumptions of normality, linearity and homogeneity of co-variates. Findings from Table 6 revealed that the variance of data between the experimental and control group is homogeneous with a significant value of 0.09 which is greater than 0.05 level of significant (P>0.05). As a result of the homogeneity in variances, the column of equal variances assumed was used to interpret the t-value.

Table 7 shows the mean achievement of male and female students' achievement when taught organic chemistry using concept map graphic organizer. Results from Table 7 signified that female students had a higher mean gain score (*M*= 21.68, *SD*=5.72) than their male counterparts (*M*= 20.85, *SD*=7.18). This signifies that the students' achievement is in favour of the female students. Furthermore, Table 7 shows an Independent *t*-test analysis of male and female students' achievement in organic chemistry. Results revealed that there was no significant difference in male and female students' achievement at a *t*-value ($t_{(75)}$= .47, p = .63, two-tailed). Since the p -value of 0.63 was greater than .05 alpha level, the null hypothesis was not rejected. There is therefore no significant difference in the achievement of male and female students taught organic chemistry using the concept map graphic organizer.

Research Question 3

What is the influence of gender on secondary school students' achievement in organic chemistry when taught using mind map graphic organizer?

In order to ascertain whether there is equality of variance, Levene's test was conducted. A significant value with P>0.05 signifies that the variance of data between male and female respondent is homogenous. Hence, the column for equal variance assumed was used to interprete the independent t-test statistics as shown in Table 8.

Table 9 presents the mean of male and female students' achievement in organic chemistry when taught using mind map. Results from Table 3 revealed that female students had a higher mean gain score (*M*= 24.00, *SD*=5.75) than their male counterparts (*M*=23.08, *SD*=3.69). This indicates that gender positively influenced the students' achievement in favour of the female students. Table 9 also shows an Independent *t*-test analysis of male and female students' achievement in organic chemistry when taught with mind map organizer. The results revealed that there is no significant difference in the achievement of male

Table 5. Summary of Analysis of Covariance (ANCOVA) of Mean Scores of Students Taught Organic Chemistry Using Mind map Organizer and those Taught Using Mind map Organizer

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	ηp^2
Corrected Model	578.34[a]	2	289.17	7.75	.00	.11
Intercept	4479.24	1	4479.24	120.13	.00	.50
Pretest	425.33	1	425.33	11.40	.00	.08
Treatment	262.67	1	262.67	7.04	.00	.05
Error	4399.52	118	37.28			
Total	63366.52	121				
Corrected Total	4977.86	120				

Note. a. R Squared= .116 (Adjusted R Squared= .101)

Table 6. Levene's test for Equality of Variance

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	2.80	.09	-.47	75	.63	-.83	1.75	-4.33	2.66

Table 7. Independent Samples t-test of male and female Students Achievement Taught to Organic Chemistry Using Concept map graphic Organizer

Treatment	Gender	*N*	*M*	*SD*	*df*	*t*	Sig.	Remark
Concept map	Male	52	20.85	7.18	75	-.47	.63	NS
	Female	25	21.68	5.72				

Note. NS: Not Significant

Table 8. Levene's test for Equality of Variance

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Posttest	Equal variances assumed	3.15	.08	-.64	42	.52	-.92	1.42	-3.79	1.94

Table 9. Independent Samples t-test of male and female Students Achievement Taught to Organic Chemistry Using Mind map graphic Organizer

Treatment	Gender	*N*	*M*	*SD*	*df*	*t*	Sig.	Remark
Mind map	Male	26	23.08	3.69	42	-.64	.52	NS
	Female	18	24.00	5.75				

Note. NS: Not Significant

and female students at a *t*-value $t_{(42)}$= .64, p = .52. Since the p -value of .52 is greater than .05 alpha level, the null hypothesis was not rejected. There is therefore no significant difference in the achievement of male and female students taught organic chemistry using the mind map graphic organizer.

This study examined the comparative effect of graphic organizers on students' achievement in organic chemistry. The study adopted a quasi experimental design involving two experimental and a control group. It is in the view of the researchers that this study will provide insight on the comparative effectiveness of the two maps and provide empirical evidence on the effect of each of the maps by comparing them. This study established that graphic organizers of concept and mind map were able to improve students' achievement in organic chemistry by presenting the content of instruction in a more sophisticated form by showing the relationship between concepts. This relationship between concepts presented in spatial form is responsible for assisting learners to understand the various relationship that exist between the concepts in the organizers. Hence, meaningful learning was established and learning becomes more concretized. The findings from this study indicated a significant difference 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 favour of the mind map graphic organizer group. This finding 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. Mind map therefore has showed in this study that it is an effective tool for teaching chemistry due to the fact that less information is provided and as such, more mental effort is required of the students than the concept map graphic organizer group. This findings is consistent with the findings of Redhana, et. al (2021) and Abbas, et. al (2018) who in different studies reported the effectiveness of mind map over concept map in learning.

Furthermore, findings revealed that there was no significant difference in the achievement of male and female students when they were taught organic chemistry using the concept map organizer. This finding might not be unconnected with the fact that both male and female students were exposed to the same treatment and there was no preference for a particular group based on their gender. Both groups therefore had equal advantage towards using the graphic organizer. The pedagogical implication of this finding is that concept map graphic organizer can be used in classrooms that have both male and female students. This finding is consistent with that of Gongden and Delmang (2016) who reported that there was no significant difference in the performance of male and female students' when taught chemistry using concept mapping instructional strategy.

Findings also revealed that there was no significant difference in the achievement of male and female students that were taught organic chemistry using mind map graphic organizer. This finding could be adduced to the fact that the use of mind map graphic organizer allows active students engagement in terms of brainstorming in the lesson irrespective of their gender. This connotes that mind map graphic organizer can be adopted in a regular classroom setting that include male and female learners. This affirms the position of Mani (2012) who emphasized that mind map assist students to develop techniques for brainstorming. This finding is in agreement with the findings of Adodo (2013) that reported no significant difference in the performance of students taught basic science and technology using mind mapping strategy. On the contrary, findings of Okeke (2011) differ by reporting a significant difference in the achievement of male and female students taught chemistry using the mind mapping strategy which was in favour of the female students.

CONCLUSION

It was concluded from the findings of this study that mind map graphic organizer is a potent tool for effective learning organic chemistry when compared to concept map. This implies that students engage in active learning when studying with mind maps than concept maps. Furthermore, it was concluded that irrespective of students' gender either concept map or mind map graphic organizer can be adopted in learning chemistry as there was no report of significant difference based on the students' gender. The authors therefore recommend that mind map graphic organizers should be adopted for teaching perceived difficult concepts in chemistry. Chemistry instructors should also consider the adoption of either con-

cept map or mind map graphic organizers in their classroom irrespective of the gender combination of their classes.

REFERENCES

Abbas, S. S., Eldin, A. S., & Elsayed, A. (2018). *Effect of concept mapping and mind mapping utilization on students understanding level: An empirical study.* In Proceedings of the Eight International Conference on Concept Mapping, Medellin, Colombia.

Adodo, S. O. (2013). Effects of mind mapping as self regulated learning strategy in students' achievement in basic science and technology. *Mediterranean Journal of Social Sciences, 4*(6), 163-172

Arulselvi, E. (2017). Mind Maps in Classroom Teaching and Learning. *Excellence in Education Journal*, *6*(2), 50-65.

Aydin, G. (2015). The effects of technology supported mind and concept mapping on students' construction of science concepts. The effect of mind mapping in science education. *Anthropologist. 20*(1,2) 166-176

Buzan, T. & Buzan, B. (2007). *The Mind Map Book*. Edinburg, England: BBC Active.

Chanshi, C & Daka, P. (2020). Effect of graphic organizers on performance and retention in writing and balancing of chemical equations by grade II pupils at Temweni secondary school, Ndola. *International journal of Research and Innovation in Social Science* 4(8), 543-556

Chawla, J., & Singh, G. (2015). Effect of concept mapping strategy on achievement in chemistry among IX grader girls. *International Journal of Informative & Futuristic Research, 3*(3), 1036-1044.

Chief Examiners' Report (2012). The West Africa Senior Secondary School Certificate Examinations. Retrieved from www.waecheadquatersgh.org/intex.php

Chief Examiners' Report (2015). The West Africa Senior Secondary School Certificate Examinations. Retrieved from www.waecheadquatersgh.org/intex.php

Chief Examiners' Report (2017). The West Africa Senior Secondary School Certificate Examinations. Retrieved from www.waecheadquatersgh.org/intex.php

Clayden, J., Greeves, N., & Warren, S. (2012). *Organic chemistry (2nd Ed.).* New York: Oxford University Press

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? *Higher education*, *62*(3), 279-301.

Duffill, N. (2013).*Choosing and using mind maps and concept maps. A short conversation for mind mappers.* Harport consulting retrieved on August 18th 2017 from www.olympic-limited.co.uk

Ekenobi, T. N., & Mumuni, A. A. (2015). Efficacy of advance organizers strategies on chemistry students' cognitive achievements in redox reaction concept. *British Journal of Psychology Research, 3*(5), 16-27.

Frey, C. (2016). *Concept maps Vs mind maps.* Retrieved on 7th February, 2017 from http://www.mindmappingsoftwareblog.com/concept-maps-vs-mind-maps/

Gagic, Z. Z., Skuban, S. J., Radulovic, B. N., Stojanovic, M. M., & Gajic, O. (2019). The implementation of mind maps in teaching physics . Educational efficiency and students' involvement. *Journal of Baltic Science Education, 18*(1), 117-131.

Gerstner, S., & Bogner, F. X. (2009). Concept map structure, gender and teaching methods: an investigation of students' science learning. *Educational Research*, *51*(4), 425-438.

Gil-Garcia, A., & Villegas, J. (2003). *Engaging minds, Enhancing comprehension and constructing knowledge through visual representation.*A paper presented at Word Asssociation for Case Method Research and Application Conference. france (June, 29th- July, 2nd).

Gongden, E. J., & Delmang, T. K. (2016). The efficacy of concept mapping instructional strategy in remedying students' problem-solving difficulties in stoichiometry. *African Research Review. 10*(2), 144-157.

Mani, A. (2012). Effectiveness of concept mapping and mind mapping in science teaching. *TechnoLEARN. 2*(1) 77-82.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001). *Classroom instruction that works. Research-based strategiesb for increasing student achievement.* Alexandria: Alexandria, VA: Association for Supervision and Curriculum Development.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations*. London: Routledge.

Novak, J. D., & Cañas, A. J. (2008). *The theory underlying concept maps and how to construct and use them*. Available online at http://www.ssu.ac.ir/fileadmin/templates/fa/Moavenatha/Moavenate-Amozeshi/edicupload/olymp-3.pdf

Okeke, O. J. (2011). *Effect of mind mapping teaching strategy on students' achievement, interest and retention in secondary school chemistry.* Published (Ph.D. Thesis) University of Nigeria, Nsukka.

Oloyede, O. I. (2011). A meta-analysis of effects of the advance organizer in acknowledgement and retention of senior secondary school (SSS) chemistry. *International Journal of Education Science, 3*(2), 129-135.

Plotz, T. (2020). Are concept maps a valid measurement tool for conceptual learning? A cross-case study. *EURASIA Journal of Mathematics, Science and Technology Education*, 16(1), 1-22.

Redhana, I. W., Widiastari, K., Samsudin, A., & Irwanto, I. (2021). Which is more effective, a mind map or a concept map learning srategy?. *Jurnal*

Cakrawala Pendidikan, *40*(2), 520-563.

Sibomana, A., Karegeya, C., & Sentongo, J. (2021). Students' conceptual understanding of organic chemistry and classroom implications in the Rwandan perspectives: A literature review. *African Journal of Educational Studies in Mathematics and Sciences*, *16*(2), 13-32.

Singh, I. S., & Moono, K. (2015). The effect of concept maps on student achievement in selected topics in chemistry at tertiary level. *Journal of Education and Practice, 6*(15), 106-116.

Sternberg, R. J. (2006). *Cognitive Psychology* (fourth ed.). Wadsworth: Thompson Wadsworth.

Struble, J. (2007). Using graphic organizer as formative assessment. *Science Scope,* 69-71

Talbert, L. E., Bonner, J., Mortezaei, K., Guregyan, C., Henbest, G., & Eichler, J. F. (2020). Revisiting the use of concept maps in a large enrollment general chemistry course: implementation and assessment. *Chemistry Education Research and Practice*, 21, 37-50.

Tayib, A. (2015). The effect of using graphic organizers on writing (A case study of preparatory college students at umm-al-qura University) *International Journal of English language Teaching* 3(1), 11-31.

Torres, M. O., Espana, R. C., & Orleans, A. V. (2014). Integrating graphic organizers in facilitating learning chemistry. *International Journal of Educational Studies, 1*(1), 1-8.

Veloo, A., Lee, H. H., & Seung, C. L. (2015). Gender and ethnicity differences manifested in chemistry achievement and self-regulated learning. *International Education Studies*, *8*(8), 1-12.

Wang, Z., Adesope, O., Sundararajan, N., Buckley, P. (2021). Effects of different concept map activities on chemistry learning. *International Journal of Experimental Psychology, 41*(2), 245-260.

Wills, S., & Ellis, E. (2008). *The Theoretical and Empirical Basis for Graphic Organizer Instruction.* Alabama: University of Alabama.