

Effect of Individualised Creative Mapping on Students' Conceptual Understanding and Sustained Knowledge in Biology

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Abstract

Sustaining national development, which emerges from science and technology activities, is not dissociated from effective science education. This connection is anchored on adequate understanding of the concepts and processes of science. The quest for comprehensive scientific understanding and sustained knowledge by citizens necessitated the need to examine the effect of innovative teaching strategies in this wise. This study examined the effect of individualised creative map construction on students' conceptual understanding and sustained knowledge in Biology. Four null hypotheses, tested at 0.05

level of significance, guided the study. A pretest-posttest delayed posttest control group, quasi-experimental design with 2×2 factorial matrix. Sixty-two biology students were purposively selected from two secondary schools as participants. The instruments used for the study were Biology Conceptual Knowledge Test ($r=0.85$) and Teachers' Instructional Guides on Mindmapping strategy. Data were analysed using Analysis of Covariance and Estimated Marginal Means. The results revealed that treatment had a significant main effect on students' conceptual understanding ($F_{(1,57)} = 50.67$; $p < 0.05$, partial $\eta^2 = .47$) and sustained knowledge in biology ($F_{(1,57)} = 31.26$; $p < 0.05$, partial $\eta^2 = 0.082$). Treatment and gender had no interaction effect on students' conceptual understanding and sustained knowledge in Biology with $p > 0.05$. The study concluded that individualised creative map construction had significant positive effect on students' conceptual understanding and sustained knowledge in biology than lecture method. It was recommended that teachers and curriculum developers should employ creative cognitive maps which enable the students to plan, coordinate and regulate their learning to enhance improvement in biology learning and sustain scientific concepts for future generation.

Key words: Sustained knowledge, Creative map construction, Conceptual understanding, Gender, Biology.

Introduction

The key element in transforming the universe, also a way of probing nature is term Science. The activities of science range from advancing technology, promoting national wealth to improving health and industrialization (Agboghoroma, 2014) which result in national development. However, the trend in national development instigates the quest for sustainability. To sustain scientific development, an effective science teaching which exposes students to scientific concepts, processes, skills and attitudes becomes essential. The presentation of these concepts and theories is the heartbeat of science teaching in addition to the process skills and attitude. Science Education is included in the secondary school curriculum to enable citizens to develop scientific knowledge, skills, and positive attitudes towards science and technology

(Abungu, Okere & Wachanga, 2014). The need for this science education is to help individuals cope with the numerous changes incited by Science and to manipulate as well as contain the development resulting from science. With comprehensive understanding and sustained knowledge, citizens are better positioned to participate in decision making and scientific research having the interest of future scientists at heart. This, therefore, calls for adequate science teaching and learning which exposes students to in-depth understanding and absolute retention thereby preserving the current scientific paradigm for the future generation, as bedrock of their research.

The quest for sustained understanding is not separated from the teaching strategy employed by science instructors. These instructors are saddled with the task of a craftsman in presenting curriculum contents in a creative manner; however, the prevalent approach is the lecture method. Researches have shown that lecture method is not effective in enhancing students' knowledge (Olagunju & Babayemi, 2014; Owoeye, 2016, Akingbemislú & Babafemi, 2018) due to its passive, teacher-centred and information-seeking nature, hence, the need for a more active technique that features enhanced engagement and offers appropriate conceptual understanding of science. The quest for activity-based strategy necessitated the examination of mind map, an advance organiser, and its effect on students' conceptual understanding and sustained knowledge in biology.

Mind-map is a mental model of presenting thought and knowledge pictorially. This creative map was developed by Tony Buzan to support learning, memory and creativity (Buzan & Buzan, 2015) and to enable students construct meaning out of the "learnt material". Mind map offers students the avenue to communicate their opinions and using signs, symbols, colours, videos, pictures, texts among others. The map also allows students to self-regulate the learning process as they are mindful of the curriculum materials while contending with ideas, thoughts and concepts to produce a comprehensive map which depicts what has been learnt. Mind map then becomes individualised as each student produces a different map for the same lesson. An important part is the interpretation of the maps to other members in the classroom thereby triggering their brain in analyzing and criticising the constructed maps. Convenient for constructivist learning, mind maps may be used as an effective technique in teaching-learning as a form of note-taking and facilitator of remembrance with its colorful structure with links using both lobes of the brain actively (Erden, 2017).

Polat, Yavuz and Tunc (2017) examined the effect of mind mapping activities on the math and science skills of children 48 to 60 months of age and discovered a significant difference in the pretest and post-test scores in advantage of children in the mind map group in Turkey. Mohaidat (2018) revealed a positive impact of electronic mind map on students' reading comprehension as against the traditional method among two public schools in Jordan, and University students' comprehension of Narrative texts was enhanced after exposure to harmonic mind map in Peru (Novoa, Cancino, Flores, Nieto & Venturo, 2018). Likewise, Duyilemi and Babafemi (2019) conducted an experimental study to reveal the effect of mind map on students' mental ability after treatment administration for six weeks. Their result revealed a significant increase in students' mental ability with students in the low and medium ability level moving to high level. Although mind map is prevalent in language studies and foreign countries like Kenya, Turkey, Jordan and Cyprus, not much has been revealed on its effect in science courses and in Nigeria. A powerful tool, mind map, with the potency of improving citizens' analysing, synthesizing, critical thinking and creative thinking skills is worth investigating, as these skills are essential in keeping abreast with global development and its sustenance.

Theoretical Development

The use of creative maps, also known as mental or mind map, is rooted in Ausubel's theory of meaningful learning. This theory propounds that meaningful learning takes place when students can link new materials with previous knowledge. This link is identified in the connections between various concepts characterising the material to be learnt as seen in the mind map. Ausubel (1968) proposed that learning depends on understanding the relationship, finding out principles and making a link between stimuli and response. To adequately make a link, Ausubel identified advanced organizer, a tool used in structuring and presenting information in a concise and logical manner, as an indispensable assistant for meaningful learning to take place. Mind, Mental or Creative map, an advanced organiser was developed by Tony Buzan to enable its users construct meaning out of information using attractive components while annexing both hemispheres of the brain. Mind map usage may improve learners' problem solving and decision making (Buzan, 2006). Below is an exemplary mind map of the steps of creating a mind map.

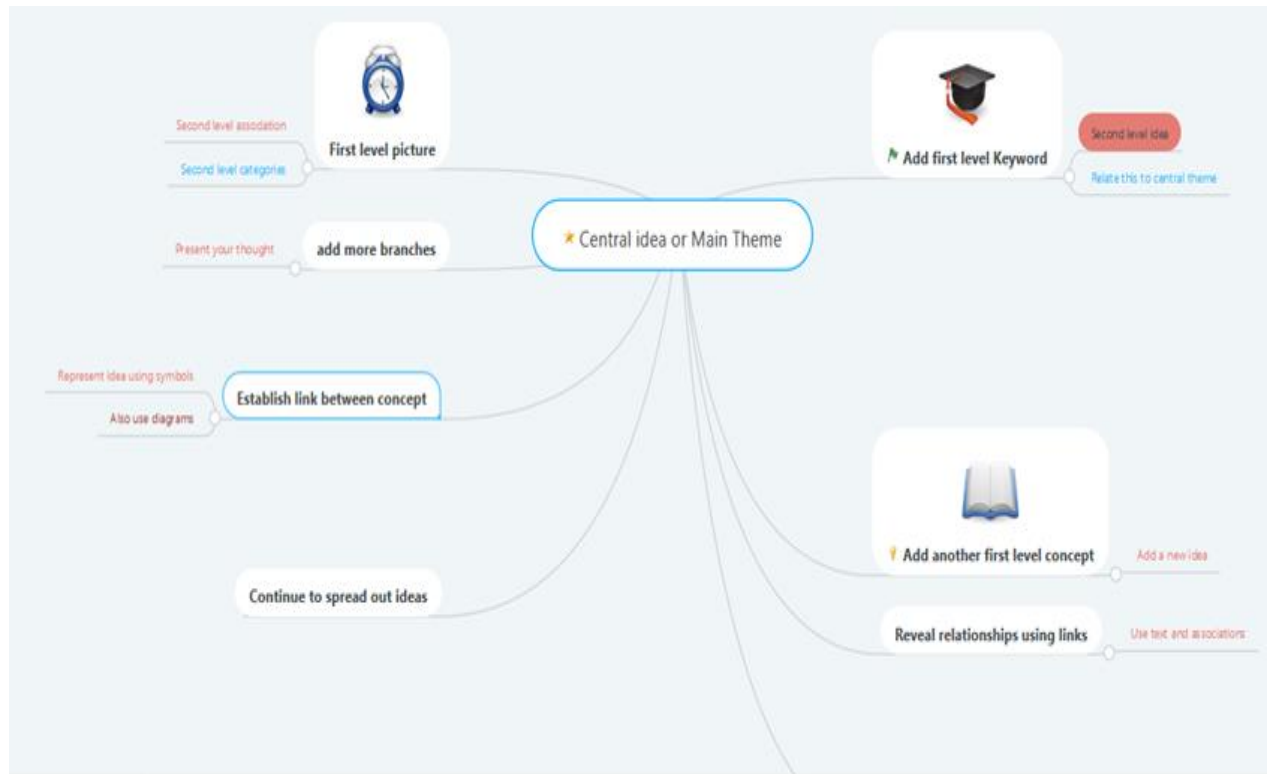


Figure 1: An example of a mind map

The figure above reveals the requirement of a creative map, starting with the central idea then proceeding with the generation of related idea. With emergent of keywords, colours, symbols and diagrams are added to depict the visual representation of the acquired information. Associations and relationships are revealed through lines around the central theme. Videos, texts and pictures can also be included for easy comprehension. Student exposed to creative mapping instruction design a pictorial representation of the meaning they have constructed from the “learnt materials” hence rooted in the theory of meaningful learning.

Objectives of the study

The objective of this study is to investigate the effect of individualised creative mapping on students’ conceptual understanding and sustained knowledge in biology in Ondo state, Nigeria. It also examined the interaction effect of individualised creative mapping and students’ gender on their understanding of biology concepts.

Hypotheses

The following null hypotheses were tested in this study at 0.05 level of significance:

H₀₁: There is no significant main effect of treatment on students’ conceptual understanding in biology concept.

H₀2: There is no significant main effect of treatment on students' sustained knowledge in biology concepts.

H₀3: There is no significant interaction effect of treatment and gender on students' conceptual understanding in biology concepts.

H₀4: There is no significant interaction effect of treatment and gender on students' sustained knowledge in biology concepts.

Methodology

The research design adopted the pretest-posttest delayed posttest control group quasi-experimental design. The delayed posttest was employed to capture students' retention. A 2 X 2 factorial matrix was adopted with instructional strategies with treatment at two levels (Individualized creative mapping and conventional lecture method) and gender at two levels (male and female). The population of the study consisted of all the SS2 Biology students in Ondo State, Nigeria from which Sixty-two (62) were purposively selected to participate in the study. One school was assigned to the individualised creative mapping (25 students) and the other school to conventional Strategy (37 students). The selected schools were based on the following criteria:

- i. The school should be a co-educational government-owned school.
- ii. The school should have at least a biology Teacher
- iii. Accessibility of the school

Three instruments were used in this study: the biology conceptual knowledge test (BCKT), teachers' instructional guide for mind mapping (TIGMM) and teachers' instructional guide for lecture method (TIGLM). The validated instrument was developed by the researchers using the mental map model proposed by Buzan. The BCKT contained 10 Essay items and participants are expected to supply answer to them. The instrument was trial-tested using test-retest reliability and Pearson Product Moment Correlation (PPMC) was used to obtain the reliability index at 0.85 coefficient.

Procedure for treatment Administration

The procedure was in five main phases and lasted for Eleven weeks. The phases include training of research assistant for the first week, administration of pretest for second week, application of treatment on experimental and control group from 3rd to seventh week, Administration of posttest for the eighth week and Administration of delayed posttest after three weeks (11th week).

Treatment Procedure: Experimental group (Individualized creative mapping)

Here, Students were engaged in self-regulated activities throughout the lesson. The Research Assistant acted as a metacognitive guide.

Step One: Research Assistant introduced the topic and guided the students in identifying the concepts in the topic

Step Two: Students embarked on individualised brainstorming activities to understand each concept.

Step Three: Students create a central idea (starting point of the Mind map)

Step Four: Students add branches and Keywords to their map (First level branches)

Step Five: Students Colour-code the branches and include images and symbol (connection) and add second-level branches

Step Six: Research Assistant request students to pause and reflect on the activities

Step Seven: Each student presents their maps in class while other students react to the constructed map.

Control group: Students in this group were taught as follows:

Step 1: The research assistant present the lesson in the form of lecture

Step 2: Students listen to the research assistant's explanation on the topic.

Step 3: Students write down chalkboard summaries.

Step 4: Students ask the research assistant on areas of the topic that is not clear to them.

Step 5: The research assistant summarised the lesson.

Step 6: The research assistant evaluates the students.

Step 7: Students were given take-home assignment

Data Analysis

The data collected were analysed using Analysis of Covariance (ANCOVA) to determine the significant main effects and interaction effects. Estimated Marginal Means (EMM) was used to find the direction of the difference among the groups with significant main effect.

Results

The data generated were presented below according to the earlier raised hypotheses

H01: There is no significant main effect of treatment on students' conceptual Understanding in Biology

Table 1: Summary on ANCOVA of Post conceptual understanding by treatment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5621.195 ^a	4	1405.299	18.130	.000	.560
Intercept	5055.860	1	5055.860	65.226	.000	.534
Pre Conceptual understanding	882.986	1	882.986	11.391	.001	.167
Treatment	3927.883	1	3927.883	50.674	.000	.471
Gender	219.721	1	219.721	2.835	.098	.047
Treatment * Gender	121.377	1	121.377	1.566	.216	.027
Error	4418.225	57	77.513			
Total	54914.000	62				
Corrected Total	10039.419	61				

a. R Squared = .560 (Adjusted R Squared = .529)

Table 1 showed that there was significant main effect of treatment on students' conceptual understanding in Biology ($F_{(1,57)} = 50.67$; $p < 0.05$, partial $\eta^2 = 0.47$). The effect size is 47.1%. This means that there is a significant difference in the pre-conceptual understanding mean score and post-conceptual understanding mean scores of students in Biology. Thus, hypothesis 1 was rejected. In order to determine the magnitude of the significant main effect across treatment groups, the estimated marginal means of the treatment groups was carried out and the result is presented in Table 2

Table 2: Estimated Marginal Means for Post-Conceptual Understanding by Treatment and Control Group

Dependent Variable: Post conceptual understanding

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Individualized Creative mapping	36.495 ^a	1.776	32.939	40.052
Lecture method	20.163 ^a	1.449	17.261	23.065

Table 2 revealed that Biology students exposed to creative mapping performed better ($\bar{x} = 36.49$) than those in the control group ($\bar{x} = 20.16$). This order is represented as ICMS > LM.

Ho2: There is no significant main effect of treatment on students' sustained knowledge in biology

Table 3: Analysis of Covariance (ANCOVA) of Sustained Knowledge by Treatment and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6751.479 ^a	4	1687.870	59.399	.000	.807
Intercept	871.911	1	871.911	30.684	.000	.350
Post conceptual understanding	1364.665	1	1364.665	48.025	.000	.457
Treatment	888.355	1	888.355	31.263	.000	.354
Gender	16.413	1	16.413	.578	.450	.010
Treatment * Gender	67.290	1	67.290	2.368	.129	.040
Error	1619.698	57	28.416			
Total	46177.000	62				
Corrected Total	8371.177	61				

a. R Squared = .807 (Adjusted R Squared = .793)

Table 3 showed that there was a significant main effect of treatment on students' sustained knowledge ($F_{(1,57)} = 31.26$; $p < 0.05$, partial $\eta^2 = 0.354$). The effect size is 35.4%. This means that there is a significant difference in the sustained knowledge scores of students in Biology. Thus, hypothesis 2 was rejected. The estimated marginal means reveals the mean scores of the two groups in table 4

Table 4: Estimated Marginal Means for Sustained Knowledge by Treatment and Control Group

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Individualized Creative Mapping	30.970 ^a	1.295	28.376	33.564
Lecture method	20.599 ^a	1.013	18.570	22.627

Table 4 revealed that students in the Creative mapping group displayed higher sustained knowledge ($\bar{x} = 30.97$) than students exposed to the lecture method ($\bar{x} = 20.59$).

Ho3: There is no significant interaction effect of treatment and gender on students' conceptual understanding in Biology

Table 1 showed that there was no significant two-way interaction effect of treatment and gender on students' conceptual knowledge in Biology ($F_{(1,57)} = 1.57$, $p > 0.05$). This implies that treatment and gender had no effect on students' conceptual understanding in Biology. Hence, the null hypothesis 3 was not rejected

Ho4: There is no significant interaction effect of treatment and gender on students' sustained knowledge in biology

Table 3 showed that there was no significant two-way interaction effect of treatment and gender on students' retention ($F_{(1,57)} = 2.37, p > 0.05$). Thus, the null hypothesis 4 was not rejected.

Discussion

The results of this study showed that the treatment had significant effect on students' conceptual understanding in Biology with the individualised creative mapping being more effective than the conventional strategy. The efficacy of the creative map could be linked to its potency of engaging the learners' mind in an active process as they wrestle with ideas, associations, and categories in creating a visual representation of their thinking processes. This finding agrees with Polat, Yavuz and Tunc (2017), Mohaidat (2018) and Duyilemi and Babafemi (2019) who reported in favour of mind mapping in improving students' science skills, reading comprehension and mental ability.

Students exposed to individualised creative mapping retained more than students in the control group. This means that creative mapping improves students' retention than lecture method since students in the treatment group sustained more knowledge as revealed in the result. The observed findings appear to be related to students use of colours, symbols and self-generated ideas while internalising concepts thereby triggering a better comprehension. This outcome is corroborated by Novoa, Cancino, Flores, Nieto and Venturo, (2018) who revealed an enhanced comprehension of Narrative text among university students after exposure to cognitive map instruction.

Another important finding of this study is that treatment and gender have no significant interaction effect on students' conceptual understanding of biology concepts. This means that creative mapping is gender-friendly as it offer equal opportunity to both male and female requiring the use of both lobes of the brain hemisphere during learning. The report of Bot and Emefo (2014) that cognitive maps assist in enhancing students' achievement irrespective of their gender agrees with this finding.

Finally, students' gender and treatment do not significantly interact to influence students' sustained knowledge. This position is associated with the usage of both lobes of the brain by both male and female students during map construction as each of the lobes functions optimally in the different sexes. The result further reveals that creative mapping instruction, when utilised in

teaching, can help make for the identified gender-gap in the sciences. The findings of this study negate the findings of Anyichie and Onyedike (2012) who reported that there is interaction effect between learning strategy (self-instructional strategy) and gender on students' achievement in Mathematics with female performing better than male.

Conclusion and Recommendation

The study indicated that individualised creative mapping enhanced students' conceptual understanding and sustained knowledge than the lecture method and students' gender had no interactive effect with treatment on students' understanding and retention knowledge. This conclusion is based on the efficacy of creative mapping instruction to engage students' minds, sustain students' interest and allow students to self-pace their learning process. The study also concluded that creative map instruction is participatory and learner-centred since students present their understanding of concepts. The implication of this study is that creative mapping usage in science teaching may spur up innovative ideas and thoughts which may play critical roles in achieving the desired sustainable development, especially in Nigeria.

Based on the above, the study recommended that curriculum designers and biology teachers should facilitate the use of creative mapping which gives the students room to comprehend better the concepts that characterise their disciplines through self-directed activities hence sustaining scientific knowledge for the future to come. Also, educational administrators should organise training and seminar to enable teachers become conversant with creative map techniques. Furthermore, Co-educational schools should utilise creative map in instruction to give male and female students an equal platform to proceed with learning because of the gender-friendly nature of the map.

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