The Effect of Concept Mapping and Mind Mapping on Creativity in Ecology of Senior Secondary Schools' Students in Nigeria

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This study examined the effects of Concept Mapping (CM) and Mind Mapping (MM) on the creativity of the ecology of senior secondary schools' students in Nigeria. The study employed quasi-experimental, which adopted the Pre-test Post-test non-equivalent group design to achieve the research objectives. Three components of creativity (fluency, flexibility and originality) were used to test the level of the creative ability of the students by using the CM and the MM as pedagogy in the classroom. The two groups (CM and MM) were all experimental. A sample of 78 students in two intact classes of two different senior secondary schools in Plateau State, Nigeria, were used for the study. The collection of data was carried out using the Ibadan Creativity Assessment Scale (ICAS) as the instrument, and MANOVA was used for data analysis. The findings show that there is a significant difference between the two experimental groups; that is, there are variations among the students in terms of their creative ability on ecology in favour of the CM group. However, this study will serve as an instructional strategy for teachers in teaching Ecology and improve the creativity of students in Nigeria.

Key words: *Concept Mapping, Mind Mapping, Creativity and Ecology.*

Introduction

Biology is one of the natural science subjects in which other sciences are embedded. It also deals with the evolution, structures, functions and distribution of a living organism. It is also concerned with their relationship in the environment (Ebenezer, & Zoller, 1993). Biology as a subject provides a ground floor for other major science programs such as medicine, pharmacy, agriculture, soil science, nursing, genetics, zoology and botany (Nwafor, & Okoi,

2018). This significant nature of biology, coupled with its exclusive richness, makes it occupy a central position in every nation's curriculum framework. Again, the subject is rich with branches, part of which ecology emerges as an essential aspect of biology. Specifically, ecology comprises understanding the inner functions of natural ecosystems and the classes they encompass. It also involves a scientific study of the interaction of organism; likewise, the interaction between the living things and their environment (Ahmed, Oliver, Afolabi, & Danmole, 2018; Rakhimov, 2017).

In today's science and technology education, biology curricula are changing from knowledge sharing to more technical and dynamic skills that could help in producing creative ideas for new emerging ecological challenges (Anand, Gonzalez, Guichard, Kolasa & Parrott, 2010; Poff, 2018). Ecological education is the holistic human nature of world view in a quest of knowledge for a better environment (Mantere, 1992), and has the power to develop a person on how to organise his/her environment for his/her benefits. This is done through the learning process with proper orientation from secondary school ecology (Torkar, 2019). Research has shown that the ecosystems have always been dynamic, and have never been at the equilibrium level. Instead, imbalance occurs as a result of disasters, such as, fire outbreak, wind, and drought (DeFries & Nagendra, 2017). The current problems in the ecosystem now could not be solved without involving individuals' attitudinal orientation in the issue, which calls for creative ideas on how it could be handled.

Creativity is a process of thinking that assists individuals in building up new knowledge and novelty in order to apply it in solving difficult tasks in a more improved manner (Chien, & Hui, 2010; Pati, 2003). Thus, creativity is the most crucial access for human developmental skills, where innovations could be found from their prior knowledge (Brodin, 2018). Creativity is a very high level of meaningful learning which involves higher-order thinking skills to occur (Novak & Canas, 2006; Setiawan, Malik, Suhandi & Permanasari, 2018; Zubaidah, Fuad, Mahanal, & Suarsini, (2017). Creativity could be looked at as stages in producing a product or something new, useful and practical to provide solutions to severe problems or innovative and effective ideas (Amabile, 1996). New ideas that lack the potency for solving problems cannot be termed as innovative (Cropley, 2003); activity such as drama, dance, music are termed as creative arts in nature which suggests that creativity is a human activity that could be taught to students by teachers (Moses, Olokundun, Akinbode & Agboola, 2016). Sternberg (1999) and Bennich-Björkmann (1997) both elucidate that anything that cannot add value to humankind is not novel or creative. Therefore, creativity is the ingenuity that one establishes to break away from the usual classification of opinions.

This includes fluency, flexibility, and originality which are combined to form the three theoretical constructs of creativity (Akinboye, 1977; Torrance, 1990).

Fluency, flexibility and originality are the critical intellectual procedures that could be used to assess creativity (Almeida et al., 2008). They are the main structures of creativity (Torrance, 1990), which are defined as constituting the personality trait of that creative individual (Hu & Adey, 2002; Gralewski & Karwowski,2018). Thus, in this era of science and technology, creative education at the secondary school level is a necessity for the development of the individual and society (DeFries & Nagendra, 2017). The role of creative education in any nation is crucial (Yanitsky, (2019). It aids many nations for global environmental and economic development and job opportunities (Jung & Walker, 2018), to cope with global competition. Although creativity has been neglected for some time, it is now emerging as a fair value in the 21st-century education as the most important means of facing contemporary challenges (Azzam, 2009). Thus, creativity in secondary school ecology cannot be overlooked for this crucial role.

In this 21ˢᵗ century, nations with creative ideas and innovations, prosper more than those that have not because educationists and curriculum planners have realised the significance of creativity in improving science and technology in the global market (Yanitsky, (2019). However, creative education has been developed in the following countries, UK (Craft, 2008), Finland (Fulland, 2009), China (Pang & Plucker, 2012; Vong, 2008), USA (Guo & Woulfin, 2016), Singapore (Tan, 2004), etc. The goal of creativity in ecology is basically to inculcate creative skills in students, gearing towards improving biological activities, value, and fostering the protection of the environment (Jung & Walker, 2018). Building students' creativity education at an early age in secondary school is part of human capital development for the economic development of a nation (Walberg, 1988).

Creativity in the Nigerian context helps many individuals and communities to make significant progress. Thus, the current pedagogy is obsolete, not meeting the need of secondary schools' students for global competitiveness; most students rely on what the teacher teaches without any creative thinking or innovations (Okoye & Okoye, 2015; Onu, Eskay, Obiyo, Igbo & Ezeanwu, 2012). The Nigerian education policy lacks the pedagogy for developing creativity in students' minds but encourages memorisation (Bolaji, 2007), and is ranked one of the countries with the lowest ability for creativity, innovation, and competitiveness as compared to other nations (Dimnwobi, Ekesiobi & Mgbemena, 2016). Students could not intellectually think properly to synthesise knowledge on their own (Okoye & Okoye, 2015), and were just passive listeners. This left one without a doubt that the present Nigerian curricula cannot develop students for creative education and innovation due to poor creatively inclined pedagogy in the education system.

However, in this study, the researchers aimed at experimenting the use of Concept Mapping (CM) and Mind Mapping (MM) as an instructional strategy in fostering creativity in ecology among secondary schools' students in Nigeria. Hence this study focuses on pedagogy.

Concept mapping is a graphics tool that has been useful in experimental research as an approach for developing meaningful learning among students (Novak & Gowin, 1984). Creative ideas obtained through the use of concept mapping as an instructional strategy serves as a roadmap for students to think (Cañas, Novak, & Reiska, 2015), as it contributes meaningfully to the aspect of how students think skilfully before constructing the maps for the improvement of their creativity level (Novak, 2013). Mind Mapping (MM) is a graphics instrument that improves intelligent thought (human mind) and reveals the functions of the brain (Buzan, 1993). Consequently, Kotcherlakota, Zimmerman, and Berger, (2013) state that like CM, MM is an active learning strategy that could help students build or construct new ideas to their prior knowledge, to improve their understanding of creativity (Keles, 2012).

However, based on concept and mind mappings as pedagogy used for teaching ecology to improve the creativity of secondary schools' students in Nigeria, this study aims at whether the effect of concept and mind mappings on creativity of students towards ecology has taken part in concept and mind mappings as pedagogy in the creativity of secondary schools' students in Nigeria, to bring about significant difference in respect to students' creativity towards ecology. This insight led to the project of the research question of what creativity is from the pedagogical point of view.

The Objective of the Study

The purpose of this study was to assess the level of creativity among senior secondary schools' students in ecology in Nigeria, using concept and mind mappings as an instructional strategy to identified students' level of creativity. However, to achieve this objective, the following hypothesis was formed.

Hypothesis

There is no significant difference in the effect of concept and mind mappings on the linear combination of creativity sub-constructs which are flexibility, fluency, and originality among secondary schools' students in Nigeria.

Methodology

Design

This study employed the pre-test/post-test non-equivalent, quasi-experimental design to collect data for the effect of Concept Mapping (CM) and Mind Mapping (MM) on creativity in the ecology of senior secondary schools' students in Nigeria. These two groups of the mapping tools (CM and MM) have no control group; all are experimental groups. It involves

two different groups of intact classes from two different senior secondary schools. One group was exposed to concept mapping (Group A) and the other group was exposed to mind mapping (Group B). They were both tested before and after the intervention to determine the effect of CM and MM on the two groups; on creativity in the ecology of senior secondary school students in Nigeria.

Population Sample

This study was carried out on senior secondary school one (SSS1), tenth-grade students in the first term of 2018/2019 academic session for eight weeks. The experiment involved 78 students from two intact classes in two different senior secondary schools (consisting of 38 males and 40 Females), 40 students for experimental group A and 38 students for experimental group B. The sample population was an intact class of the senior secondary school of the students, who were not randomised (Gay & Airasian, 2000). Their age ranges from 15-17 years, and they were in their first term of 2018/2019 academic session; and they were all students of the schools, attending classes.

Procedure

This study, as stated above, engaged in a pre-test, post-test and non-equivalent group design. Data collected were in two different schools at different times. The researchers trained two biology teachers from the selected schools, for one week, on how to use the concept map and mind map in the classroom to help students to learn meaningfully. The schools officially accepted the engagement of the students for the experiment. The researchers revealed to the students that the results of the experiment would be confidential, especially from the intact classes that consented. The pre-test was administered for both experimental group A and experimental group B; after eight weeks of treatment, the post-test was administered to both groups. The items that were used for this study were eight topics in ecology, in the biology syllabus; and 80 minutes was used for each lesson period for both groups. The students from both experimental groups were given the opportunity for practical classwork to prove their level of understanding of the mapping tools.

Instrument

The instrument used for data collection was Ibadan Creativity Assessment Scale (ICAS) adapted from Jibrin (2014) and used for this study, with a reliability statistic of 0.91 using Cronbach's Alpha. The instrument was divided into three parts, Flexibility 20 items, Originality 24 items, and Fluency 23 items. This instrument was used in assessing the students' level of creativity. The scale (ICAS) has been recognised for the creativity test in Nigerians' senior secondary schools and has been proved appropriate (Jibrin, 2014). This

instrument used a 5-point Likert-type scale as follows: SD = Strongly Disagree, D = Disagree, N = Neutral, A= Agree, SA = Strongly Agree, for rating. This instrument was employed to measure the effect of concept mapping and mind mapping on creativity in the ecology of senior secondary school students in Nigeria.

Data Analysis

The data analysed using SPSS software version 24 for calculating the mean scores, standard deviation, and analysis of covariance. Since the distribution of pre-test/post-test was reasonable, and it is n>30, the parametric test was utilised (Pallant, 2013). Multivariate Analysis of Variance (MANOVA) was used to test the significant difference in the effect of concept mapping and mind mapping on the linear combination of creativity sub-constructs which are flexibility, fluency, and originality in secondary school students in Nigeria. The results obtained were tested at $P < 0.05$ level of significance. Multivariate Analysis of Variance (MANOVA) was run to determine whether there is a statistically significant difference between the variables after controlling the covariate.

Research Findings

There are statistical assumptions for using multivariate analysis of variance (MANOVA). To check for underlying assumptions, for the analysis of MANOVA, assumptions for normality, linearity, and homogeneity tests were observed. The application of MANOVA helps us to discover the differences between groups and also statistically monitoring another variable known as the covariate that may influence the scores on the dependent variable. Controlling for the covariates eliminates the variation in the result of the variable, and standard MANOVA was carried out on the scores. However, this adds to the power of the F-test and the tendency that the differences between the groups could be detected (Pallant, 2011).

The null hypothesis was tested using Pillai's Trace statistical test. The Pillai's Trace is a statistical test that is good for multivariate analysis of variance to test the means of identified groups of subjects on a combination of sub-constructs to check the existence of differences between them (Nimon, 2012).

Homogeneity of Covariance Matrices Test

Table 1: *Box's Test of Equality of Covariance Matrix*

Box's M	35.485
F	5.657
df1	6
df2	40677.194
Sig.	.000
Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.	

a. Design: Intercept + Group

The results of the Box's test of equality in Table 5.7 indicates the assumption of homogeneity of covariance matrices. The results have shown that the assumption of homogeneity of covariance matrices was violated. The *F* and *P*-value (*F = 5.657, p = 0.000*) is statistically significant. If the p-value could have been more than 0.05, the result on the assumption of homogeneity of covariance is statistically not significant, and it could be argued that the assumption is not violated (Pallant, 2011; Gay, Mills & Airasian, 2012).

Levene's Test of Equality of Error Variances

The test for equality of error variances established that the variables recorded significant values; thus, the creativity sub-constructs are not equal across the group. The p-values for the group test of significance observed as Flexibility: F = 5.400 with p-value 0.023; Originality: F = 3.426 with p-value 0.068 and Fluency: F = 0.082 with p-value.776, which are not significant, meaning the variances across the group are not equal. The assumption of the equality of variances were violated.

Table 2: Levene's test of equality of error variances

	F	df1	df2	Sig.
Flexibility	5.400	1	75	.023
Originality	3.426	1	75	.068
Fluency	.082	1	75	.776
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.				

a. Design: Intercept + Group

The test for equality of error variance establishes that the error variance for the dependent variables is not equal across the groups. The p-value for the test of significance observed as

flexibility 0.023, originality 0.068 and fluency was 0.776, which is not significant, meaning the variances across the group are not equal. The assumption of the equality of variances, therefore, is violated. This is because the flexibility construct attained a variance of 0.023, which is not significant, and makes dependent variables not equal across the groups. However, with this violation and if the participants are above 30, there is no problem (Pallant, 2013). With this violation, Pillai's Trace will be used in checking the results of MANOVA for the groups' effect on the linear combination of creativity sub-constructs.

Estimated Marginal Means

Table 3: Estimated marginal means of dependent variables

Group					
Dependent Variable	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Flexibility	Concept Mapping	4.432	.085	4.264	4.601
	Mind Mapping	3.583	.086	3.412	3.754
Originality	Concept Mapping	4.791	.122	4.548	5.034
	Mind Mapping	3.683	.124	3.437	3.929
Fluency	Concept Mapping	4.784	.130	4.525	5.042
	Mind Mapping	3.915	.132	3.653	4.177

The estimated marginal means in Table 3 help us to understand the concepts of expected estimated marginal means value. The mean value of flexibility in the concept map experimental group obtained at 4.432 and the mean value of flexibility in mind map experimental group was at 3.583. The mean value for originality in the concept map group was observed at 4.791 while that of mind map group achieved the mean of 3.683. The Table (Table 3) indicated that the mean value of fluency in the concept map group achieved 4.784 and the fluency in the mind map having the mean value of 3.915, respectively. The estimated marginal means value results are in favour of the concept map experimental group.

Manova Result for Groups Effect on the Linear Combination of Creativity Sub-Constructs Which are Flexibility, Fluency, and Originality

Table 4: The results of Manova for Groups Effect

Effect	Value	F	Hypothesis df	Error df	Sig	Partial Eta squared
Intercept Pillai's Trace	.988	1966.245	3.000	73.000	000	.988
Group Pillai's Trace	.500	24.357	3.000	73.000	000	.500

The significant p-value of 0.00 was observed, meaning that the covariance found across the linear combination on creativity sub-constructs in flexibility, originality and fluency are significantly different, the hypothesis is therefore rejected, and the assumption violated. However, with this violation of the assumption we can continue with the analysis because the F–test applied in MANOVA is robust against this violation (Glass, Peckham, & Sanders, 1972; Hair et al., 2006).

Tests of Between-Subjects Effects

Table 5: Tests of Between-Subjects Effects

Source	Dependent Variable	Type 3 Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Flexibility	1236.588	1	1236.588	4415.743	0.001	0.983
	Originality	1382.062	1	1382.062	2382.478	0.001	0.969
	Fluency	1456.363	1	1456.363	2213.014	0.001	0.967
Group	Flexibility	13.885	1	13.885	49.581	0.001	0.398
	Originality	23.606	1	23.606	40.694	0.001	0.352
	Fluency	14.518	1	14.518	22.06	0.001	0.227

The result of the test between the subject effects indicates that there is significant difference between the creativity sub-constructs in flexibility, originality, and fluency between students who were taught with concept mapping as an instructional strategy and those taught with mind mapping in favour of the concept mapping experimental group (Flexibility: F = 49.581 with p-value 0.001; Originality: F = 40.694 with p-value 0.001 and Fluency: F = 22.06 with p-value = 0.001).

Discussion of Findings

The MANOVA performed to investigate the effects of Concept Mapping (CM) and Mind Mapping (MM) on creativity in the ecology of senior secondary schools' students in Nigeria. The MANOVA result revealed that there is a significant difference in the mean scores of the

two experimental groups in favour of the concept mapping group. This experiment suggests that CM, as an approach, has shown that it can improve the creativity of students in ecology. This result is in agreement with Ajaja (2013), Cañas, Novak, and Reiska (2015), Novak (2013), Simper, Reveeve and Kirby (2016), which indicates that CM can improve learners' creative ability in ecology. Thus, this result is contrary to the study of Widiana, & Jampel (2016) which state that mind mapping is instrumental in helping students to think very well before carrying out their creative activity. In a nutshell, the mind map is useful in creativity and innovation in ecology.

The efficacy of CM in improving creativity skills in students about their environment is incomparable; this is because the knowledge developed by the learner is original (Daley, Morgan & Beman, 2016). Concept mapping has proved that it has the capacity for improving students' creative knowledge, as it helps students to think very well before taking action (Cañas, Hill, Carff, Suri, Lott, Gómez & Carvajal, 2004); this indicates that CM facilitates learning, especially in creativity (Coffey, Cañas, Reichherzer, Hill, Suri, Carff, Mitrovich & Eberle, 2003). The effect of CM and MM on creativity could be that the approach applied in MM is not vibrant enough to retain information among students (Wickramasinghe, Widanapathirana, Kuruppu, Liyanage, & Karunathilake, 2011), or the CM developed better and more understandable knowledge to students than the MM (Fry & Novak, 1990), though all approaches were experimental. Concept mapping as a constructivist way of learning allows students to collaborate and work as a team to achieve their goal successfully in the classroom (Rafaeli & Kent, 2015; Scogin, Kruger, Jekkals & Steinfeldt, 2017). This gives students the confidence for creative thinking as they engaged in CM construction with their peers (Hirashima, Yamasaki, Fukuda & Funaoi, 2015; Cañas, Novak, and Reiska (2015), because CM does not gives meaning in isolation but works with the context of propositions (Novak and Gowin, 1984; Okafor & Udeani, 2012).

This study explains the worth of CM in helping students to build their knowledge from prior knowledge, by shifting their mindset towards meaningful learning, better thinking skills, and creative ideas (Sundararajan, Adesope & Cavagnetto, 2018). The collaborative work of students in constructing CM in the class from the beginning to the end of this experiment, clearly shows the mapping experience through their understanding of ecological knowledge and its creative application that will help them in solving some of the ecological problems. The CM as an approach has a significant effect on the students' creativity in ecology because it improved students' understanding as well as increased their retention, as stated by Novak (1998), that meaningful learning needs relevant prior knowledge such as meaningful material, and the learner attitudinal behaviour in whether to learn or not to learn. This plays a significant role in the creative learning procedures. When students learn by rote, there will be no connections between their prior knowledge and the new ones, and they will fail to connect concepts; hence, creative innovation could not take place (Hwang, Chen, Sung & Lin, 2019; Nair & Narayanasamy, 2017). The use of CM as a learning approach has helped students alot in the CM group in understanding the main words and their relationships in creative ecological concepts, which eventually improves their creative abilities through acquiring new knowledge from their previous information.

Recommendations and Conclusion

 This result has enormous implications on ecology in terms of identifying students' creativity by teachers and how to help them develop it to their benefit and also the benefit of the host

community. Biology teachers and pre-service biology teachers should also be trained on how to use the concept map for building students' creative abilities that will bring about innovation to teaching and learning of creativity in the classroom. The result of the study shows that the CM performed better than the MM in terms of improving students' creativity in ecology. This supports other studies that show that CM is a practical instructional approach for causing meaningful learning to occur in students. The CM like other mapping tools is not the only solution; it may not match with all learners, in all creativity learning conditions, but it can help the biology teachers to learn about their students' understanding of creativity concepts taught in ecology (Fisher, 1997; Ramdiah, Abidinsyah & Mayasari, 2018; Kinchin, 2000; Yücel & ÖZKAN, 2015).

Based on the result of data analysis and discussion, the following suggestions can be made:

➢ The teachers should help students to develop their creative knowledge through prior knowledge by connecting concepts to the main idea using CM.
➢ The effect of CM in different aspects of creative ecology on students' cognitive, affective, and psychomotor domains should be encouraged in the context of Nigeria.
➢ The use of CM as an approach for teaching creativity in senior secondary schools should be encouraged by the government of Nigeria to develop students' creativity and innovation positively towards ecology.
➢ This study was limited to creativity in ecology in biology in a senior secondary school in Nigeria; it should be extended to other countries for a broader perspective.

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