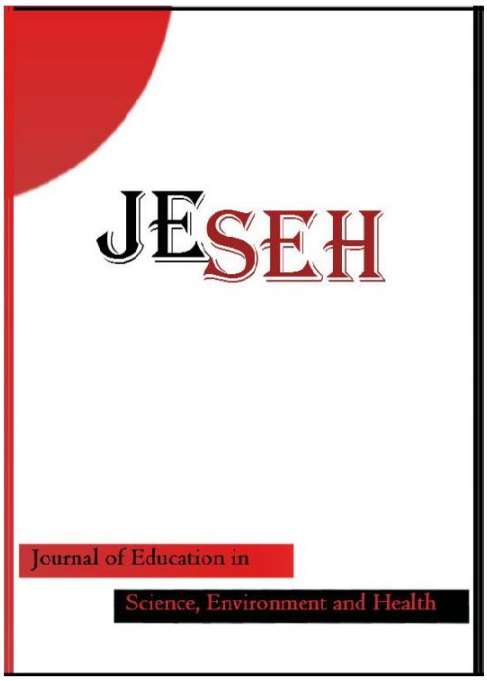

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Concept Mapping Strategy: An Effective Tool for Improving Students' Academic Achievement in Biology

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Abstract

The study investigated the use of concept mapping teaching method on secondary school students' academic achievement in biology. Two hypotheses tested at 0.05 level of significance guided the study. The design of the study was quasi-experimental design with 122 Senior Secondary students selected purposively from two senior secondary schools in Adamawa state. Instrument used for data collection was an achievement test tagged Biology Students' Achievement Test (BSAT) adapted from WAEC tests 2005 to 2010. The instrument was content validated by three experts and Cronbach alpha formula was used for testing its reliability. The reliability coefficient of 0.78 was obtained. The treatment lasted for six weeks and data were analyzed using one-way Analysis of Covariance (ANCOVA). The result revealed that, concept mapping method enhanced students' academic achievement in biology. Furthermore, there was no significant difference between male and female students in the experimental group. It was recommended that, concept mapping method should be incorporated in the teaching of biology for meaningful learning and that workshops should be organized for in-service and practicing teachers on how to use concept mapping strategy.

Key words: Concept Mapping, Gender, Achievement, Secondary School, Biology

Introduction

Over the years, researchers have been investigating why some learners acquire a deep, meaningful understanding of materials studied, whereas others have only a superficial grasp of the information presented. Often the latter kind of students may have high school grades and high standardized test scores. What appeared to underlie the differences in these two groups of students according to Novak (2010) was the differences in the way they approached learning of subject matter. Novak developed concept mapping strategy based on the theoretical foundation laid down by educational psychologists. The underlying basis of the theory is that meaningful (as opposed to rote) human learning occurs when new knowledge is consciously and purposively linked to an existing framework of prior knowledge (Novak, 2006). Furthermore, Novak mentioned that the mind organizes information in a hierarchical top-down fashion from higher level skills to the lower level skills. While, in rote (or memorised) learning, new concepts are added to the learner's framework in an arbitrary and verbatim way, producing a weak and unstable structure that quickly degenerates. The result of meaningful learning is a change in the way individuals experience the world. It is seen that the students who learn by rote according to Novak (2006) are able to recall the new information but they cannot apply the knowledge in other situations. To give an organized body of content in a meaningful way, keeping in mind the cognitive map of the learner simple ideas are presented first to the students followed by complex ideas joined in hierarchical manner so that proper learning can take place in sequential and integrated manner.

Concept mapping is a graphical tool for organizing and representing knowledge in networks of concepts and linking statements about a problem or subject (Novak & Canas, 2006). Concept mapping includes concepts, usually enclosed in circles or boxes of some type and relationships between concepts are indicated by a connecting line linking words. Concepts are graphical or pictorial arrangements that deal with a specific subject matter. They are useful tools in representing the structure of knowledge in a form that is psychologically compatible with the way in which human beings construct meaning. Mouton (1996) defines a concept as the most elementary symbolic construction by means of which people classify or categorise reality or make sense and attribute meaning to their world. Novak and Gowin (1994) demonstrated that, the label for most concepts is a single word, although sometimes symbols such as + or % are used. The core element of a concept mapping is a proposition, which consists of two or more concepts connected by a labeled link.

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Propositions according to Novak (2010) are meaningful statements about some object or event. In a concept mapping, propositions are connected to each other to form a hierarchical and branching structure, with the most inclusive, most general concepts at the top of the mapping and the more specific, less general concepts arranged below, that represents the organization of knowledge in long-term memory.

One of the important characteristic of Concept Mapping is the inclusion of "crosslink." Cross-links show how a concept in one domain of knowledge represented on the mapping is related to a concept in another domain shown on the mapping. In the creation of new knowledge, cross-links often represent creative leaps on the part of the knowledge producer (Novak, 2000). A final aspect of the structure of Concept Mapping is the inclusion of specific examples of events or objects. These can help to clarify the meaning of a given concept. Normally these are not included in ovals or boxes, since they are specific events or objects and do not represent concepts. Summarily, Novak (2004: 154) identified six procedures to follow in constructing concept mapping.

i. Identify the key concepts in a paragraph, research report, and chapter; or simply think of the concepts of a subject area and list them. Some people find it helpful to write the concept labels on separate cards or small pieces of paper, so that they can be moved around
ii. Rank the concepts by placing the broadest and most inclusive idea at the top of the map. It is sometimes difficult to identify the broadest, most inclusive concept. It is helpful to be aware of the context of the concepts we are dealing with or to have some idea of the situation for which these concepts are arranged.
iii. Work down the paper and add more specific concepts.
iv. Connect the concepts by lines. Label the lines with action or linking words. The linking words should define the relationship between the two concepts so that it reads as a true statement, or proposition. The connection creates meaning. When you can hold together a large number of related ideas, you can see the structure of meaning for a given subject area.
v. Specific examples of concepts can be added below the concept labels. (e.g., golden retriever is a specific example of a dog breed.
vi. Perhaps you can already see ways that the concept map could be made differently.

Remember there is no one way to draw a concept map. As one's understanding of relationships between concepts changes, so will the mapping. This is what gives the concept mapping power and flexibility. For example, using the topic plant cell. The major concepts may include:

i. Cell Wall
ii. Protoplasm
iii. Cytoplasm
iv. Nucleus
v. Vacuole

After listing these major concepts they are then arranged hierarchically from lowest to highest. The most general concepts are on the top in the hierarchy while the specific concepts are placed below. The concepts are then connected with lines or arrows to indicate relationships.

The idea of concept mapping is to determine how meaningful learning increases students' achievement. Concept mapping as a strategy in education is parallel with the movement from teacher to learner and as a result has the power to improve academic achievement (Peterson & Snyder, 2008). Today, educators and researchers are convinced that, most students learn best through personal experience and by connecting new information to what they already believe or know. For this reason students need to personally construct their own knowledge. Sakiyo and Jebson (2008) suggested learner-centred teaching methods provide adequate learning outcomes rather than teacher-centred approaches which are dominated by the teacher. Sakiyo and Jebson also pointed out that, student activities are better than teacher activities in promoting authentic students learning in secondary school. Therefore, the recommendations of researchers to involve students in the construction of their knowledge, paved the way to look at concept mapping teaching method as it relates to students' meaningful learning and achievement.

Concept mapping increases recall of information in instructions in biology subject (Hall, 2002). Kinechin (2000) recommended the use of concept mapping on instruction and learning in secondary school biology education. The important point is that the beginning stage of drawing concept maps not only needs active participation of the learner in the learning process but also paves the way on their understanding of a specific learning area. As a result, such information about learners' understanding empowers facilitators to determine learners' cognitive deficiencies and provide corrective feedback (Nowruzi, Khiabani & Nafissi, 2010). Lambiotte and Dancereau (2001) stated that the students that made concept maps have a broader knowledge base and therefore more able to solve problems compared to those students that learned by rote memorization. Lambiotte and Dancereau also found out that, the students with low prior knowledge learned better with concept mapping than those taught

with lecture method. Concept mapping has also been shown to increase the learners' writing ability (Gorjian, Pazhakh, & Parang, 2002). This improvement has been demonstrated in terms of the quantity and quality of producing, arranging and relating ideas (Pishghadam & Ghanizadeh, 2006). In science education, concept mapping has been widely recommended and used in a variety of ways. It has been used to help teachers and students build an organized knowledge based on a given discipline or on a given topic (Blackwell & Pepper, 2008). It has also, been used to facilitate middle level students' learning of science content (Novak & Gowin, 1994; Adlaon, 2002; Dhaaka, 2012). Findings from these studies indicate that concept mapping is an effective tool for aiding students' comprehension of science materials.

Moreover, giving students more chance to get involved in the learning process through the use of concept mapping skills makes them perform significantly better than their counterparts who have been exposed to the teaching using the usual traditional lecture method (Nnamdi & Okechukwu, 2006). It has also become clear that for students who have some concept mapping experience, there exists a correlation between their concept mapping ability and performance in achievement test (Chee & Wong, 1996). Concept mapping has also proved to be a useful vehicle to fill the usual gap between theories and practice (Sutherlang & Katz, 2005). Access of representation at a given situation in learning is also helped through concept mapping (Bruillard, 2000). Concept mapping has also proved as useful tools in lesson design, and can determine the key concepts and their relationship, and build the whole curriculum as a content analysis tool in itself (Kaszas & Turcsanyi-Szabo, 2003).

Significant researches have indicated that gender plays a role in students' academic achievement particularly in biology and science in general. Okeke (2007) observed that the consequences of gender disparity cut across social, economic, political and educational development, especially in the areas of science and technology. Offor (2007) identified some reasons for gender disparity in science education to include; opportunity cost of education, early marriage among girls, lack of female role models, poor self concept, inherent sex differences, teaching methods and gender stereotyping among students and teachers. However, limited studies have been conducted on the effect of concept mapping teaching methods on secondary school students' achievement in biology in Nigeria.

Statement of the Problem

Educational researchers have sought to find out why some learners acquire a deep, meaningful understanding of materials studied, whereas others have only a superficial grasp of the information presented. Generally, pupils memorize the content and reproduce the same to pass the examination (Dhaaka, 2012). In such an environment students' academic achievement, cannot be attained. Often this kind of learning leads to students' poor academic achievement. Students' poor academic achievement has been a focus of many studies examining the effects of interaction pattern on learning outcomes (Orji & Ebele, 2006). Many factors were reported to contribute for the students' poor academic achievement in biology, but Orji and Ebele attributed students' poor performance to ineffective methods of biology instruction adopted by Nigerian secondary school teachers. Concept mapping could be a strategy to motivate students to promote their academic achievement in biology.

Purpose of the Study

This study determined the effect of concept mapping teaching strategy on secondary school students' academic achievement in biology in Adamawa state. Specifically the study sought to establish the following specific purposes:

1. To determine the effect of concept mapping teaching method on secondary school students' academic achievement in biology
2. To determine the influence of gender on secondary school students' academic achievement when taught biology using concept mapping method of teaching in biology.

Hypotheses

Two hypotheses test at 0.05level of significance, guided the study.

HO_1. There is no significant mean difference on secondary school students' academic achievement in biology when biology is taught using concept mapping and lecture methods.

HO_2. There is no significant influence of gender on secondary school students' academic achievement in biology when biology is taught using concept mapping method of teaching.

Method

The study adopted the quasi-experimental pre-test, post-test non-equivalent control group design. The study was conducted in Adamawa State, Nigeria. The target population of the study was all Senior Secondary two (SSII) students in senior secondary schools in Adamawa state offering biology. The reason for using SSII students was because the class is stable. It is neither facing the problem of being freshly introduced to senior secondary biology (as is the case with SS1) nor preparing for any end of course or terminal examination (as is the case with SSIII). The sample for the study consisted of 52 male and 70 female SSII biology students from two public co-educational senior secondary schools in Girei local government area of Adamawa State. Purposive sampling technique was used to select the co-educational schools for the study. Two intact classes were chosen randomly from each of the schools. The intact classes in each of the schools were then assigned randomly to one experimental and control group. The experimental group was concept mapping group while the control group was the lecture method group.

The instrument for data collection was an achievement test tagged the "Biology Students' Achievement Test" (BSAT). The BSAT is a 60-itemed multiple-choice objective test items with four options. The instrument was adapted from West African Examination Council (WAEC) biology tests from 2005 to 2010. The items covered six cognitive domains of educational objectives (Knowledge contains 25% of the items, comprehension 25%, application 15%, analysis 15%, synthesis 10%, while evaluation takes 10%). The instrument was pilot tested on 30 students from a non-participating school. The BSAT yielded a Cronbach alpha reliability index of 0.78 which was a good reliability index.

The pre-test was administered in the first week of the research to both experimental and control groups before the treatment. The treatment was done strictly on selected topics drawn from senior secondary school II syllabus which included: Nutrition, Habitat and Nutrient cycle. The experimental group was subjected to treatment of concept mapping method, while the control group was taught using the lecture method. The class teaching was done by one of the researchers. Posttest was administered to both the experimental and control groups after six weeks of instruction. The hypotheses were tested at 0.05 level of significance using one-way Analysis of Covariance (ANCOVA).

Results and Discussion

HO_1. There is no significant mean difference on secondary school students' academic achievement in biology when biology is taught using concept mapping and lecture methods.

Table 1. ANCOVA of the Experimental and Control Groups

Source	Type III sum of square	Df	MS	F	P-value	Partial eta
Corrected Model	2966.1	2	1483.088	40.982	0.00	0.408
Pretest	5461.1	1	5461.164	0.093	0.12	0.031
Teaching Methods	431.7	1	431.794	2.567	0.00	0.398
Error	4306.4	119	2843.233			
Corected Total	7272.5	121	36.188			

From the Table 1, there is significant mean difference between the experimental and control group. Since the computed p-value (0.00) is less than the f-value (2.567) at 0.05 level of significant, the null hypothesis of no significant effect is rejected. This means there is significant difference of students' academic achievement between experimental and control group in favour of concept mapping group.

HO_2. There is no significant influence of gender on secondary school students' academic achievement in biology when biology is taught using concept mapping method of teaching.

Table 2. Male and Female ANCOVA in the Experimental Group

Source	Type III sum of square	Df	MS	F	P-value	Partial eta
Corrected model	244.7	2	122.3	7.546	0.001	0.212
Pretest	241.2	1	214.2	1.087	0.00	0.210
Gender	1.5	1	1.50.09	0.766	0.002	
Error	907.9	56	16.2			
Corrected total	1152.6	58				

From the Table 2, there is no significant mean difference between male and female students in the experimental group. Since the computed p-value (0.766) is greater than the f-value (0.09) at 0.05 level of significant, the null hypothesis of no significant effect is accepted. This means there is no significant difference of students' academic achievement between male and female in the concept mapping group.

Discussion and Conclusion

The study found out that, Students taught biology concepts using concept mapping method performed better than those taught with lecture method. This means students' performance significantly differed based on the teaching methods used in the study. This finding agrees with findings of Akeju, Simpson, Rotimi and Kenni (2011) that found significant difference between experimental and control groups in favour of concept mapping group. Dhaaka (2012) recommended the use of concept mapping as an effective tool for biology teaching. Along the same vein Yezka and Nasrabadi (2004) maintained that, concept mapping strategy promotes meaningful learning as well as students' academic achievement.

The study also found no gender difference in students' achievement in biology. This finding agrees with the findings of Sakiyo (2008) who reported no gender difference in the acquisition of science process skills when students are taught using student-centred teaching methods. Sakiyo (2007) suggested that, gender differences can be eliminated when teachers used certain teaching strategies that can bring about gender equity in science education.

This study shows that, Concept mapping strategy promotes students' academic achievement in biology. Students' academic achievement cannot be translated in terms of acquiring knowledge to pass examinations, but to acquire dip meaningful understanding of the materials presented to the students. There was no gender difference in students' academic achievement in biology, the increase in students' academic achievement does not depend on gender, and this means concept mapping is an effective to tool for both male and female students.

Recommendations

From the result of this study, the following recommendations are made:

1. It is evident that, concept mapping teaching is effective in promoting meaningful learning and improving students' academic achievement in biology. Therefore, teachers should use this teaching method to teach biology teaching lessons.
2. Workshops should be organized and made compulsory for practicing teachers so that they can embrace the skills of concept mapping teaching method.
3. Pre-service teachers should be exposed to the concept mapping teaching method
4. Concept mapping teaching method should be suggested for some biology content areas in the curriculum.

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