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Concept Mapping As a Study Skill: Effects on Students Achievement in Biology

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ABSTRACT The purpose of this study was to determine if the use of concept mapping as study skill can influence students' achievement in biology. The design of the study was quasi experimental Pretest Posttest control group design. The population consisted of 280 SSII students from where 120 students were selected. 100 students were used for analysis while 20 students dropped out of the study. To guide this study five research questions were raised and three hypotheses stated and tested at 0.05 level of significance. The major instrument used for data collection was biology achievement test. Another instrument used for data collection was an interview schedule to determine the students' perception of the usefulness of concept mapping in their studies. The major findings of this study include: a non significant difference in immediate Post achievement test scores between students who used concept mapping as a study skill and those who reviewed and summarized in their studies; a steady, consistent and significant increase in test scores of students who used concept mapping as study skill across achievement tests 1-6; a significant difference in estimated retention between students who used concept mapping as study skill and those who summarized after review, and all the students interviewed agreed that concept maps helped them to determine relationships among concepts, sharpened their understandings and increased their critical thinking. It was concluded that concept mapping could serve as an appropriate alternative for studying biology since what is learned through it can be retained for a long time.

INTRODUCTION

Background of the Problem

To remember information longer and to be able to use it more effectively, you need to move that information into your long-term memory (Johnson and Raven 1998, p.1018). Concept mapping can help you do this. Concept mapping is a means of organizing ideas (Trowbridge and Bybee 1996, p.264). Concept mapping is a learning strategy that students find useful in understanding complex ideas and clarifying ambiguous relationships. It is a two-dimensional representation of the relationship between key ideas in a topic (Ajaja 2009, p.73). Concept mapping has been defined as a "metalearning" (Wandersee 1990, p.927), the development of which can be traced to the well-known work of Ausubel, Novak and Gowin.

Meta cognition which is a strategy used in self-directed learning are mental processes that assist learners to reflect on their thinking by internalizing, understanding, and recalling the content to be learned (Borich 2004, p.297). They include invisible thinking skills such as self-interrogation, self-checking, self-monitoring, and analyzing, as well as memory aids (called mnemonics) for classifying and recalling content. Metacognitive strategies are most easily conveyed to learners through a process called mental modeling (Duffy et al. 1988; Rekrut 1999). Mental modeling helps students internalize, recall, and then generalize problem solutions to different content at a later time.

Based on educational psychology theories of how we organize information, concept maps are hierarchical with broader, more general items at the top and more specific topics arranged in a cascade below them. Concept mapping helps you understand ideas by showing you their connections to other ideas. It not only identifies the major ideas of interest from a chapter or year class notes but also shows the relationships among the ideas.

The development of concept mapping is traced to the well-known work of Ausubel et al. in the early 1970s (Rice et al. 1998). Since its introduction, the concept map has become a very useful tool in teaching and learning and particularly in science education research. The prominent role of concept mapping in science education was reflected in the publication in 1990 of a special issue of the Journal of Research in Science Teaching on the topic of concept mapping, which included an article listing 100 references related to the use of concept mapping (Al-Kunifed and Wandersee 1990).

A review of literature on concept map indicates that it is used in instruction and assessment (Novak and Gowin 1984; Jegede et al. 1990; Willerman and Mac Harg 1991; Novak and Mu-

sonda 1991; Baron et al. 1992; Power and Wright 1992; Roth and Roychoudhury 1993; Trowbridge and Bybee 1996; Lomask et al. 1996; and Rice et al. 1998). Some other researchers have demonstrated its use in learning (MeCagg 1991; ChmeilesKI and Danseeau 1998; Johnson and Raven 1998).

This research was motivated in part by the growing incidence of failure in biology at the senior school certificate examination as a clear manifestation of poor learning strategy. Most researchers on concept mapping ascribe it to having the potential of making learners to remember information longer and to be able to use it more effectively because the information was moved into the long-term memory. In a situation like ours where the dominant method of teaching science in general and biology in particular is lecture method because of lack of equipped laboratories, it becomes necessary to look for alternative methods of instruction and study which will guarantee effective learning. Concept mapping look like one based on research findings on its usefulness.

Concept mapping is based on Ausubel's (1968) theory of learning which emphasized the difference between meaningful and rote learning. Ausubel argued that meaningful learning builds one's cognitive structure by assimilating new concepts into one's existing conceptual structure. Novak (1998) confirmed Ausubel's stand when he stated that concept mapping is a major methodological tool of Ausubel's assimilation theory of meaningful learning.

The literature on concept mapping provides a mixed bag of findings. Whereas in some situations significant differences were found, in others differences were not found in terms of its effectiveness. For example, Lambiotte, and Dansereau (1992) compared the effectiveness of different forms of lecture on recall of information. In one of the classes, concept maps outlines constructed by an expert was used as lecture aids. In the other class, the concept map aid was not provided. On comparison of the two groups on recall of material presented, the concept mapping condition did not show any significant difference over the other group. This however did not agree with the findings of Hall et al. (1992) who found a significant difference favoring concept mapping on recall of information in instructions using concept mapping in one subject domain.

Kinechin (2000a, b) discussed the positive impact of using concept maps on instruction and learning in secondary biology education. Building on the researches earlier conducted, Kinechin (2000b) demonstrated the relevance of concept mapping for teacher planning and preparing a lesson and creating an opportunity for meaningful learning on behalf of students. Kinechin (2000b) found a positive effect on students who used concept maps to revise and summarize the material.

Markow and Lonning (1998) tested the effect of concept map construction on concept understanding in college chemistry laboratories. They found that students had a strong positive attitude towards using concept maps for better understanding of chemistry laboratory concepts, although multiple choice achievement tests did not reveal any difference in students conceptual understanding between the experimental and control groups.

From the foregoing, attempt has been made to explain the meaning of concept mapping, trace its origin, discussed the areas where it is used and gave a highlight of research findings on its use under different situations and conditions. Literature on the use of concept mapping as a study skill has been very scanty. This has therefore created an imbalance in research efforts on the extent it can go in influencing learning of school subjects. The purpose of this study therefore was to find out the influence of concept mapping on learning outcome of biology students when used as study skill.

Statement of the Problem

This study is a direct response to the deteriorating performance of students in biology in both senior school certificate examinations (WAEC 2004, 2005, 2006, 2007, 2008) and university matriculation examinations (JAMB 2004, 2005, 2006, 2007, 2008). The poor performances were occasioned by the very poor state of resources for teaching and learning biology and the unchallenging environment under which the business of teaching biology takes place. The state of the biology laboratories in schools ranged from total absence of laboratories to ill-equipped ones. The situation therefore calls for a search for alternative methods that will shunt the use of laboratories but yet guarantee effective learning by students. The notion that concept mapping ma-

kes students to remember information longer and be able to use it more effectively, because the information is moved into the long-term memory, makes it the possible alternative.

The statement of the problem therefore is, will the use of concept mapping as a study skill by biology students influence their learning and retention of biology knowledge?

Research Questions

To guide this study, the following research questions were raised and answered:

1. Is there any difference in biology achievement test scores between students who used concept mapping as a study skill and those who did not?
2. Is there any difference in biology achievement test scores among students who used concept mapping as a study skill between Post test 1 and other Post tests (2-6)?
3. Is there any difference in retention of biology knowledge between students who used concept mapping as study skill and those who summarized content materials through mere review?
4. Did the use of concept mapping as a study skill help you learn concepts in biology?
5. Is the technique of concept mapping useful to you?

Research Hypotheses

The following hypotheses were tested at 0.05 level of significance.

H_{o1}. There is no significant difference in mean biology achievement test score between students who used concept mapping as a study skill and those who did not.

H_{o2}. There is no significant difference in biology achievement test scores among students who used concept mapping between Posttest 1 and other Post tests (2-6).

H_{o3}. There is no significant difference in retention of biology knowledge between students who used concept mapping as a study skill and those who did not.

METHODOLOGY

Design of the Study

The quasi-experimental, non-equivalent pretest, post-test, follow-up test, control group design was employed using only the SSII biology students. The design was most appropriate since two intact classes were used and no randomization was done in the selection of subjects. As a rule, when any of the research procedures required in true experimental condition is absent, the design is best described as quasi – experimental design.

Population and Sample of the Study

This study was conducted using 280 students enrolled in Senior Secondary School Class II (SSII biology) during the 2008/2009 Academic Session at St. Charles College Abavo, Delta State, Nigeria. From this population, 120 students participated in the study. The students drawn were largely from middle class homes in two classes taught by their two class teachers. The two intact classes consisted of 60 male students each. One class served as the experimental group where students used concept mapping as a study skill while the second class was used as the control group were students summarized after review of the contents they were exposed to.

Before this study, the students had all previously studied first and second terms biology units of SSII as contained in the National curriculum for Senior Secondary Schools. The biology teachers were asked to indicate on their class rosters each students' biology achievement level as high, middle or low based on students past results and their observations in biology classes. The two teachers who used to instruct the students were graduates in biology and had seven years of teaching experience. The two teachers were males and thus removed the effects of teacher sex influences on teaching effectiveness.

Instruments

The instruments used for the study consisted of a six-week instructional unit, an achievement test in biology called Biology Achievement Test (BAI) and an interview schedule.

The six-week instructional units covered contents in the following topics: Ecological succession, overcrowding, food shortage, balance in nature, regulation of internal environment and nervous coordination.

The biology achievement test consisted of 50 items multiple choice questions drawn from the contents covered in the six-week instructional unit.

Qualitative methodologies were used to assess students' perceptions regarding the usefulness of concept mapping in the study of biology concepts. Twelve students from the experimental group were interviewed and audio recorded with permission. Four students each from the high, middle and low achievers based on their past results were interviewed. The samples of interviewed questions asked included the following:

1) Do you understand how to construct concept maps?
2) Did the use of concept mapping help you to learn biology concepts better?
3) Is concept-mapping technique useful to you?
4) Do you think you scored more marks when you used concept mapping as study skill?

The validity of the achievement test was done by a panel of judges, made of one experienced biology teacher, one biology science educator and one measurement and evaluation expert. All of them had the contents of the six-week instructional unit. They mainly determined the content validity by comparing the items in test with contents in the instructional unit. Also, the validity of interview schedule was determined by a jury. This was achieved by playing back the recorded audio tape and patiently listening to the conversation between the interviewer and students interviewed. The credibility and, hence trustworthiness of students' perceptions concerning the usefulness of concept mapping as a study skill was enhanced by the provision of the interview transcripts.

The reliability of the achievement test was determined by administering the test instrument to fifty (50) students of Abavo Girls Grammar School, Abavo. These students were not part of the study. Using Cronbach's alpha, the reliability of the instrument was put at 0.72. This confirmed the reliability of the instrument (Johnson and Christensen 2000; Borich 2004; Wiseman 1999).

Treatment Procedure

The two groups used in this study consisted of:

(a) experimental group (students here used concept mapping as study skill) and
(b) control group (students here summarized content covered after review).

Students in both control and experimental groups received extracts from Biology: Principles and Explorations by Johnson and Raven (1998) covering contents in the six-week instructional unit. They also received a list of concepts sheet for each week instruction a week prior to instruction. All the concepts on the list were copied directly from the contents of the six-week instructional unit.

Subjects in the experimental group were introduced to and trained on how to construct concept maps following the procedures of Novak and Gowin (1984). For example, to create a concept map, start with what you already know. Build from what is familiar. What are the key components or ideas in the topic you are trying to understand? Place each concept in its own individual circle, box or other geometrical shapes. Connect concept boxes with arrows to show relationships. Label each arrow with descriptive terms so that your diagram can be read as a statement or proposition by following interconnections from the top down. With these steps learned and internalized, the students practiced constructing several small concept maps prior to the six weeks instruction and learning.

A week before the commencement of instruction, both the experimental and control groups were pretested to determine the equivalence of the groups before treatment. This was done with the 50 items multiple choice biology test instrument. On treatment, for each instructional unit, the control group was asked to read the extract and construct a list of objectives, which include the concepts to be learned as a pre-instruction assignment. While the experimental group was asked to read extract and constructed a pre-instruction concept map. This was followed with both groups between 40-50 minutes pre-study instruction on concepts in the various week's instruction. After this, they did the study, and turned in assignments at the end of every week's instruction. The control group used the concepts on the list of concept sheet and wrote a summary to show their understanding of the topics after review of learning extracts provided. The experimental group restructured their concept maps briefly during the class instruction and extensively as homework after each week instruction. This post instruction concept map constituted the experimental group's understanding of the concepts learned in the unit of instruction.

A week after completing each week's instru-

ctional study and at the beginning of another week's study, a 25 items biology achievement test was given to both groups. The 25 items biology tests were derived from the 50 items biology achievement test administered in the pre-test. The test scores of students were averaged at the end of the 6 weeks treatment. Six separate 25 items achievement tests were constructed by the researcher. Each test covered concepts contained in each week instructional unit. Two equivalent forms (identical questions and different response order) of each test were constructed to avoid the possibility that students in the experimental group would benefit from talking with students in the control group. This agreed with the recommendation of Markow and Lonning (1998). The intent of alternate test forms was to discourage intentional cheating by sharing answer keys. At the end of four weeks after treatment, a delayed post-test was given to determine retention of biology knowledge with the 50 items biology achievement test.

Analyses of covariance (ANCOVA) was used to test for significant differences between achievement test score means for the control group (students who summarized their understanding of the concepts they were exposed to through revision) and the experimental group (students who constructed concept maps on the topics they were exposed to). Paired sample t-test was used to test for significant differences between students' pre-instruction/study and post-instruction/study scores in the experimental group.

The perception of students on the usefulness of concept mapping when used as study skill were collected through interviewing of sampled students in the experimental group. Their perceptions were drawn from interview transcripts.

RESULTS

Table 1 shows that the mean pre-test scores of students in the concept mapping group (25.48) and review group (25.10) fall within a close range. This demonstrated the equivalence of the groups before treatment.

The equivalence of the groups was confirmed with finding of a non-significant difference in pre-test scores between the concept mapping and summarizing groups as shown in Table 2, $F = 0.046$, $P > 0.05$.

Table 1 also shows that the post-test scores of the concept mapping (46.75) and review (47.34) groups were slightly different with (0.59) marks. The follow-up test scores of concept mapping and summarizing groups (35.68 and 40.44) respectively, indicated a decrease in test scores of subjects. Again shown in Table 1, the estimated retention of 88.55 found among students in concept mapping group is higher than that of the summarizing group of 81.62.

Table 1: Comparison of the experimental and control groups on pre and post and follow-up achievement test scores, and estimated retention (in %) using the differences between Post and follow-up test

Type of study skill	*N*	*Mean*	*SD*
(a) Pre-test achievement:			
• Concept mapping	50	25.48	7.45
• Review	50	25.10	7.30
(b) Post-test achievement:			
• Concept mapping	50	46.75	10.81
• Review	50	47.34	12.01
(c) Follow-up achievement:			
• Concept mapping	40	40.44	7.34
• Review	40	35.68	6.94
(d) Estimated retention:			
• Concept mapping	40	88.55	6.48
• Review	40	81.62	6.27

Table 2: ANOVA Summary Table comparing pre-achievement test scores of concept mapping and reviewed groups

Source	*Sum of squares*	*df*	*Mean square*	*F*
Between groups	2.560	1	2.56	.046
Within groups	5483.200	98	55.747	
Total	5485.760	99		

A non-significant difference was found between the mean achievement test scores of students in concept mapping and those in review group, $F = 0.578$ $P > 0.05$ (Table 3). With this finding, H_{o1} was therefore retained, since there was no significant difference.

Table 4 shows that the test scores of subjects in concept mapping group increased across the tests. The mean test scores of the various tests include; test 1 = 42.48, test 2 = 44.16, test 3 = 46.04, test 4 = 47.52, test 5 = 49.60, and test 6 = 50.72.

Table 5 shows that the t-test analyses of paired post tests scores were significant for 1 and 2, 1 and 3, 1 and 4, 1 and 5 and 1 and 6. With this finding, H_{o2} was rejected because a significant difference was established. The result confirmed a steady and consistent improvement in test scores over time due to experience.

Table 3: ANOVA summary table comparing post-achievement test scores of concept mapping and review groups with pre-test scores

Source	*Type II sum of squares*	*df*	*Mean square*	*F*
Corrected model	4093.479[a]	2	2046.739	22.698
Intercept	5111.736	1	5111.736	56.689
Groups	52.092	1	52.092	.578
Pre-test	4059.373	1	4059.373	45.018
Error	8746.661	97	90.172	
Total	236947.700	100		
Corrected total	12840.140	99		

A R squared = 319 (Adjusted R squared = 305).

Table 4: Comparison of mean post achievement posttest scores of concept mapping group in tests 1, 2, 3, 4, 5, and 6

Test No.	*N*	*Mean*	*SD*
Test 1	50	42.48	9.74
Test 2	50	44.16	10.78
Test 3	50	46.04	11.60
Test 4	50	47.52	11.77
Test 5	50	49.60	11.77
Test 6	50	50.72	12.51

Table 5: t-test analysis comparing means of tests 1 VS 2, 1 VS 3, 1 VS 4, 1 VS 5, and 1 VS 6 of students in concept mapping group

Test combinations	*N*	*Mean*	*SD*	*t-cal*	*P*
Test 1	50	42.48	9.74	1.866	0.05
Test 2	50	44.16	10.78		
Test 1	50	42.48	9.74	3.548	0.05
Test 3	50	46.04	11.60		
Test 1	50	42.48	9.74	4.505	0.05
Test 4	50	47.52	11.77		
Test 1	50	42.48	9.74	6.433	0.05
Test 5	50	49.60	11.77		
Test 1	50	42.48	9.74	6.59	0.05
Test 6	50	50.72	12.51		

A significant difference was found in estimated retention test scores between groups who used concept mapping as study skill and those who used review, $t = 5.507$ $P < 0.05$ (Table 6). With this result, H_{o3}, was therefore rejected.

Table 6: t-test summary table comparing estimated retention of students in concept mapping and review groups

Group	*N*	*Mean*	*SD*	*t-cal*	*P*
Retention of concept mapping group	40	88.58	6.27	5.507	0.05
Retention of review group	40	81.62	6.48		

Based on the analysis of interview as shown in Table 7, the following conclusions were drawn:

(i) That the construction of pre-lesson concept maps helped students to understand concepts during teaching;
(ii) That the construction of pre-lesson concept maps helped students to understand the most import concepts in the topic; and
(iii) That the construction of concept maps helped students to think critically, follow teachers' teaching logically and made corrections in their map where necessary.

DISCUSSION

This study is significant in the sense that it has affirmed the relevance of concept mapping in improving learning when used as a study skill. Although the literature on concept mapping is wide, it must be stressed that most of the studies centered on its use as an instructional strategy rather than as a study skill.

The results of this study indicated that learning did occur as shown in Table 1 and that there was no significant difference in learning outcome shown in Table 3 as measured with immediate post-test between students who studied content materials with concept maps and those who summarized the materials after reading. This is consistent with the findings of Markow and Lonning (1998); and Kinechine (2000b). This finding of learning occurring tend to suggest that the construction of pre-instruction concept maps and their use in studying have influenced the students' in the experimental group understanding of concepts in the biology topics.

The non-significant difference in immediate post achievement test scores between those who used concept maps as study skill and those who summarized after review can be explained with lack of enough experience on construction and use of concept maps in studying. This was why the immediate post achievement test scores of students who summarized after review was higher

Table 7: Interview transcript on relevance of concept maps.

Conclusions from Interview	*No.*	*No. in favour*	*No. not in favour*
The mixed-up list of concepts used in producing concept maps forces you to look for relationships.	12	9	3
The concepts brought out certain important things; one would not have taken note of throw mere review.	12	8	4
If you did a pre-lesson concept map, as the teacher is teaching the topic, you will think critically, go through it and make appropriate corrections.	12	10	2

than those who used concept maps. This initial performance by concept mapping group was really due to the fact that students within this groups did not have much experience with the method, while the review and summarize group had several years of experience with the method of study. This agreed with Ajaja (1998) position while discussing (Egelston and Lahnston 1973) findings on effects of experience and task difficulty on achievement. He noted that task difficulty resulting in lack of enough experience will result in a familiar method being superior on an immediate test of retention, however, unless the rule is over learned at the time of initial learning and/or adequately revised at some subsequent time, this advantage of the familiar method will have disappeared by some few weeks of practice and consistent use of the unfamiliar method. This has been demonstrated and shown in Table 5, where there is a steady, consistent and significant improvement in test scores of students in concept mapping group across tests 1–6. The initial advantage of the review and summarize method disappearing over time is confirmed with the significant differences between test scoes 1 and tests scores 2-6. This means that the longer the period of experience with a study method, the more marks the subjects who use it will earn in an achievement test. It is projected that at maturation of experiences with concept mapping, students studying with it will earn more marks in achievement tests than those studying with review and summarize method.

Another finding of this study was the retention of biology knowledge as measured on the differences between immediate Posttest and follow-up tests scores. There is a significant difference in estimated retention of biology knowledge between students who used concept mapping for study and those who used review and summarize method as shown in Table 6. A comparison of test scores of subjects who used review and summarize method in post and follow-up tests as indicated in Table 1, showed a reasonable decline in mean scores from the post-test to the follow-up test. The mean scores of those who used concept mapping for study, declined only slightly between the tests. This may have accounted for the significant high retention of biology knowledge found among students who used concept mapping as a study skill.

The major factor that may have been responsible for this result (high retention) is the high level of critical thinking applied in concept mapping construction. This is affirmed by one of the conclusions drawn from the interview transcript that pre-lesson concept maps make students think critically. This stand is justified by Johnson and Raven, (1998) conclusion that to remember information longer and to be able to use it more effectively, you need to move that information into your long-term memory and that concept mapping can help do this. The lower retention of biology knowledge as found among students who used review and summarize method for study, was due to the fact that the method has its strongest positive effect on measure of comprehension rather than on measure of retention.

CONCLUSION

The findings of this study tend to suggest that concept mapping when efficiently used as a study skill could enhance immediate post achievement test scores and retention of biology knowledge well over other study skills used by students. This will however, only be possible when the major limitations of this study like lack of appropriate knowledge on how to construct concept maps and insufficient experience on the use of concept maps are eliminated. This will eliminate the frustration expressed by lower ability students in constructing concept maps.

Conclusively, the method seems the best alternative to experimental studies since it has the potential for the retention of knowledge for a long

time. Concept mapping is therefore recommended to schools in developing nations as a reliable method for study since most of their schools lack equipped laboratories and instructional materials for hands-on activities.

RECOMMENDATIONS

The findings of this study indicated a significant retention of biology knowledge when students study with concept mapping as a study skill. All the students who used concept mapping as a study skill agreed that the strategy helped to determine relationships among concepts, sharpened their understandings and increased their critical thinking. Based on these, it is recommended that biology teachers should resort to using concept mapping as a teaching strategy as an alternative to laboratory experience in situations where laboratory facilities are not available-since it guarantee the retention of biology knowledge.

ABBREVIATIONS

(a) *JAMB:* Joint Admission and Matriculation Board.
(b) *WAEC:* West African Examination Council.
(c) *SSII:* Senior Secondary class II.

NOTES

(i) *Pre-test:* Test administered before treatment.
(ii) *Immediate Post-test:* This is the test administered immediately after treatment.
(iii) *Follow-up test:* This is the Posttest administered long after the Posttest was administered.

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