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The Effect of Concept Mapping Instructional Strategy on the Biology Achievement of Senior Secondary School Slow Learners

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Abstract
The study investigated the comparative effectiveness of the expository and concept mapping instructional strategy of presenting secondary school biology concepts to slow learners. One hundred and twenty four biology slow learners were identified and randomly assigned to the expository group (n=62) and concept mapping group (n=62) and respectively taught the concept of photosynthesis. The groups were post-tested after two weeks of teaching for any significant differences in their biology achievement. Analysis of post-test scores indicated that the group taught by the concept mapping instructional strategy performed significantly (p<0.05) better than their expository group counterparts. Specifically, female slow learners taught with the concept mapping instructional strategy performed significantly (p<0.05) better than their male counterparts taught by the same method. These results have implications for biology teacher preparation, especially in the areas of teaching females and identifying slow learners and adopting effective methods of tackling their problems

Keywords: biology achievement; concept mapping; slow learners; gender differences

INTRODUCTION

The desire to improve science achievement through more effective instructional strategies and the increasing awareness in recent years of the teaching-learning situation has directed a lot of attention to understanding how learners learn and how to help them learn concepts. According to Novak (1987), research has shown that few students at the secondary school or college level have had any formal instruction in learning how to learn. The efforts in assisting the learner to learn have led to the development of metacognitive strategies to enhance meaningful learning (Novak, Gowin & Johansen, 1983; Cliburn,1987; Resnick,1983; Gibbs,1981; Flavel,1976; Biggs, 1988 Babkie & provost 2022; Thomas et al 2000).

Metacognitive strategies, as explained by Novak (1987) are strategies that empower the learner to take charge of his/her own learning in a highly meaningful fashion. Concept mapping as a metacognitive instructional strategy is based on Ausubel-Novak-Gowin theory of meaningful learning.(Ausubel, Novak& Hanesian, 1978; Gowin, 1981; Novak,1977; Novak& Gowin 1984) It relates directly to such theoretical principles as prior knowledge, subsumption, progressive differentiation, cognitive bridging and integrative reconciliation. Concept mapping is based upon a major psychological theory in science education and designed to help students 'learn how to learn' science. Making a concept map for a piece of scientific knowledge is the ability of the mapper to identify and relate its salient concepts to a general, super ordinate concept. Concepts may be defined as regularities in objects or events designated by some label, usually a term (Wandersee, 1990). Whether a process (e.g. precipitation), a procedure (e.g. titration), or a product (e.g. carbohydrate), concepts are what we think with in science.

Concept mapping serves as a tool to help learners organize their cognitive frameworks into more powerful integrated patterns. In this way, it serves as a metaknowledge and a metalearning tool. The heuristic of concept mapping - a kind a meta cognitive strategy assists learners in understanding concepts and relationships between them, and in seeing the hierarchical, conceptual, propositional nature of knowledge (Klausmeier, Ghatala & Frayer, 1974; Derbentseva et al 2004; Hibberd et al 2002 Novak, Gowin & Johanson 1983) The proponents of the concept mapping strategy posit that meaningful learning ensues when a learner is aware of, and can control, the cognitive processes associated with learning. Indeed, some research on concept mapping seems to demonstrate that meaningful learning results from its use in science classrooms (Stewart, Vankirk & Rowell, 1979; Novak & Gowin, 1984; Ault, 1985; Cliburn, 1987; Okebukola & Jegede, 1988; 1989; Jegede, Alaiyemola & Okebukola 1990 Kunchin 2000; Markow & Lonning 1998).

Despite the success of concept mapping in promoting meaningful learning of science concepts, its use in the classroom for teaching science to slow learners have not been explored. Science may prove challenging for slow learners. Because science concepts build on simpler ones, it is vital that students develop an understanding of the hierarchical nature of the concepts to aid further learning.

Kephart (1971) defined a slow learner as one who has reached his potential and yet achieves quite poorly in school subjects. The slow learners pattern of poor achievement is basic and consistent over time and across school subjects. The slow learner also processes information in a slightly different way from other learners (Nathan, 1972).

The slow learner therefore, requires different methods of presenting learning tasks such that the alterations in their processing of information will not interfere with the understanding of the tasks being presented (Clarke, 1980). The relative implication, therefore, is that the teacher of slow learners requires pedagogical competencies to cope with the attendant problems associated with slow learning. Two such competencies are as follows.

i. Developing a rationale which permits consistent interpretation of the slow learners' behavior and
ii. Generating a repertoire of techniques by which learning tasks can be presented in a variety of ways.

To successfully teach science concepts to slow learners there is the need to dedicate substantial time to instruction, use more hands-on-methods and incorporate extensive practical. There is therefore a need to find out if concept mapping could enhance learning for slow learners. The researcher is unaware of any evidence in Nigeria which shows that secondary biology teachers in the country make use of related methods of combating the problems associated with slow learning of biology. In fact, research (Balogun, 1985; Jegede, 1987) points to the fact that Nigerian secondary biology teachers lack the necessary skills in diagnosing and teaching slow learners of the subject. Most of these teachers continue to teach all biology learners with the same methods and instructional materials as if all these students study and understand at the same rate. Balogun (1985) in a review of research in biology education in Nigeria reported that 53% of secondary biology learners in Nigeria are slow learners.

There is also the issue concerning gender. Okebukola and Jegede (1987) reported after extensive review of literature on gender differences in science achievement that males perform better than females. Although over the past few decades, the wide gap in science performance between male and female students has been considerable reduced these gender gaps still persist. A lot of reasons have been assigned for this differences, high on the list is the instructional strategy. Udeani (2006) reported that concept mapping instructional strategy is an effective method of presenting science concepts to students to achieve meaningful learning. Premised on the foregoing the study examined if the concept mapping instructional strategy could improve the performance of female slow learners.

The major purpose of this study therefore, was to explore effective instructional technique of presenting learning tasks in order to increase the slow learners understanding of these tasks.
It was hypothesized that:

i. The concept mapping instructional technique could produce significant ($P<0.05$) gains over the expository instructional technique in the biology attainments of slow learners and
ii. Male slow learners taught by the concept mapping technique will not differ significantly ($P<0.05$) in their biology attainment from their female counterparts.

METHOD

From all the senior secondary class three biology students of Community Secondary School, Ede Oballa, Nsukka in Enugu State, 131 slow learners were selected based on past promotion and terminal examinations, teachers' observation ratings and comments and student inter-ratings. The researcher then observed this group of slow learners in their respective biology lessons for two weeks. This strategy helped to validate previous information concerning slow learners. The 131 slow learners were then stratified on gender difference and 124 of these were proportionally and randomly sampled (M=62, F=62) to ensure equal representation of the two gender groups. These 124 subjects were finally, randomly assigned to the expository and concept mapping treatment conditions as presented in Table 1.

The subjects ranged in age from 15years 2 months to 18years 5months with a mean of 17years 4months. All these subjects in the study must take Biology as one of their science subjects preparatory to obtaining the senior secondary school certificate.

Instrument

A 30-item multiple choice pre-test of internal consistency 0.74 measured through Crombach alpha was developed by the researcher and administered to the subjects prior to the experiment. The pre-test items were derived from senior secondary class two biology content such as osmosis, transpiration and movement in cells. The major aim was to establish the pre-experimental abilities of the subjects. As the results in Table 2 indicate there were no significant initial differences among the two treatment groups. Therefore, no covariate analysis was required for the post-experimental abilities of the subjects.

A 30 - item multiple choice post-test whose internal consistency through Crombach alpha 0.72 was also developed by the researcher. The post-test items were based on the concept of photosynthesis covered during the experimental period.

The Instructional Techniques

Two treatment conditions namely the concept mapping and the expository instructional technique were used to present the concept of photosynthesis for two weeks to slow learners. Brief descriptions of the techniques are given below.

Concept mapping is a systematic device for presenting a set of concept meanings embedded in a framework of propositions (Novak and Gowin, 1984). Concept maps are two dimensional hierarchical diagrams which illustrate the connectedness between and among individual concepts. It is based on the premise that concepts do not exist in isolation but depend upon others for meaning. The steps in concept-mapping as elucidated by Ault (1985) are:

i. Select an item for mapping. This could be an important text, passage, lecture notes for laboratory background material.
ii. Choose and underline key words or phrases; include objects and events in the list.
iii. Rank the list of concepts from the most abstract and inclusive to the most concrete and specific.
iv. Cluster the concepts according to two criteria: concepts that function at a similar level of abstraction and concepts that interrelate closely.
v. Arrange the concepts as a two-dimensional array analogous to a road map. Each concept is in effect, a potential destination for understanding. Its route is defined by other concepts in the neighbouring territory.
vi. Link related concepts with lines and label each line in propositional or prepositional form.

Figure 1 showed the concept map prepared by the teacher to aid the instructional process. At the end of the treatment period, the slow learners prepared their own maps which were used for diagnosing learning difficulties and clearing misconceptions.

A completed map represents an understanding of the relationship between important sets of concepts and efficiently communicates this understanding to others. It is the contention of the researcher that if biology slow learners are encouraged to prepare concept maps after a given period of instruction, meaningful learning will prevail and performance will be buttressed. This contention was put to test in this study. It is hoped that the findings will provide enlightenment as regards the quest for ways of discouraging rote learning and encouraging higher-level understanding of biological concepts by students particularly slow learners.

The expository technique is the popular method of teaching biology in most secondary schools. This technique consists of the presentation of biological facts and principles by the teacher and the students were mainly asked to listen to the lectures and take notes. Exposition is teacher centred, convergent teacher questions are emphasized and student participation is discouraged. Students are directed to verify teacher-designed experiments and use of textbooks is central (Selim and Shrigley, 1983).

RESULT

A t-test was applied to test the hypotheses stated for this study at the 0.05 level of significance.

Table 3 presents the results of the t-test analysis on the hypothesis associated with instructional technique. The group taught with the concept mapping instructional technique performed significantly ($P<0.05$) better than their expository counterparts in the biology post-test.

Table 4 presents the t-test results on the hypothesis associated with gender differences within the concept mapping group. Result of this analysis showed that the females in the concept mapping group performed significantly ($P<0.05$) better than their male counterparts, though this significant difference is weaker than that of the treatment conditions.

DISCUSSIONS

The data from this study provide support for the potency of the concept-mapping technique in bringing about meaningful learning of biological concepts in slow learners. The experimental group involved in concept mapping was found to achieve significantly better than their control group counterparts in the biology achievement post-test ($t=6.95$; $p<0.05$) as reported in Table 3. This is in accord with the findings of previous studies (Novak, Gowin and Johansen, 1983; Ault, 1985; Lehman, Carter and Kahle, 1985; Okebukola, 1986 and 1990 McClure, et al 1999; Safayeni et al 2005 Soyibo, 1995; Zantinget et al 2003), which provided evidence attesting to the efficacy of concept mapping in facilitating meaningful learning. This study has however, gone a step further to establish its efficacy in teaching slow learners.

The present results have implications for biology teacher preparation, especially in the area of identifying slow learners and adopting effective methods of tackling their problems. Biology educators would need to be aware of the utility value of the concept-mapping approach to teaching and learning. A schedule for learning about and using the concept-mapping strategy for instructional purposes should be built into the training programmes for pre-service biology teachers. Opportunities should also be given for the continuous review of the strategy with a view to improving on it and sharpening its potency.

It would appear that sex differences exist in the slow learner's biology achievement. Female slow learners who were taught with the concept-mapping approach performed significantly better ($t=2.79$; $p<0.05$) than their male counterparts. This significant effect support the findings of some of the previous research indicating that conventional methods of instruction seem particularly unsuitable for girls (Ruman, 1977; Grayhill, 1975; Kelly 2007; Lewis B.F 2006, Lynch and Peterson, 1989); Jegede, Alaiyemola and Okebukola 1990). It may well be that the metacognitive strategy of concept-mapping can be used to overcome differential gender-related performance, with respect to learning and achievement in science.

Table 1: Distribution of Subjects by Treatment and Sex

	Expository	Concept	Total
Male	31	31	62
Female	31	31	62
Total	62	62	124

Table 2: t-Test Results of Pre-test Scores

	N	X	SD	df	t
Expository	62	11.27	4.20		
Concept Mapping	62	10.85	3.70	61	0.16*

***Not significant at 0.05 (Table value for t = 2.00)**

Table 3: t-Test Results of Treatment Differences

	N	X	SD	df	t
Expository	62	16.25	2.08		
Concept Mapping	62	23.24	2.36	61	6.95*

*** Significant at 0.05 (Table value for t = 2.00)**

Table 4: t-Test Results for Sex Differences

	N	X	SD	df	t
Male Concept Mapping	31	17.9	2.14		
Female Concept Mapping	31	21.2	2.01	30	2.79

*** significant at 0.05 (Table value = 2.042)**

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APPENDIX