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EFFECT OF SELF-GENERATED CONCEPT-MAPPING INSTRUCTIONAL STRATEGY ON THE ACHIEVEMENT OF STUDENTS IN EVOLUTIONARY CONCEPT

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Abstract
This paper is a report of the outcome of a study that was carried out in Manicaland, Mashonaland and Matebeleland provinces in Zimbabwe, to assess the impact of self-generated Concept-mapping instructional strategies on the achievement of senior secondary school students in Biology instruction. The research design was quantitative and was of a quasi-experimental nature that included a pre-test, post-test and non-equivalent control group design. The respondents were one hundred and twenty senior secondary school Form 5 students selected randomly from six schools. Instructional material and Evolution Test Items (ETI) were the research instruments used to gather the data. The data obtained were analysed using t-test and chi-square statistical techniques. The results showed that the Self-generated Concept-Mapping instructional strategy (SGCMIS), significantly improves students' achievements than the Expository Instructional Strategy, EIS (Control group).

Introduction

One major problem facing science education in Zimbabwean secondary schools is that of student's partial understanding of basic scientific concept and theories. In the view of Novak (1991), "students only learn to memorise definitions of concept and algorithms to solve problems." The consequence of this problem is students' poor performance in science subjects as reported in several studies (Abimbola, 1986; Aworanti, 1994; Brumby, 1979; Mahadeva, 1983; NERDC, 1992; STAN, 1992; WAEC, 1985).

This study is an attempted contribution to finding the solution to this problem that is facing meaningful learning of scientific concepts and theories through the introduction of self-generated concept-mapping as an instructional method.

The influence of students' gender and ability levels on learning has been studied by many educators. Among these studies are those of Bajah (1979), Inomiesa (1989), Kelly (1978), Magret (1981), Okebukola (1984), Roach (1979), and Wonsencreaft (1983). Magret (1981) reported the series of studies conducted by the International Association for the Evaluation of Educational Achievements in which the difference in sex and performance in science subjects was observed. The results of the studies showed that males had a higher level of achievement than their female counterparts and also had more favourable attitudes to science.

Bajah (1979) carried out a study in Nigeria on the influence of gender and environment among college chemistry students. He observed that males were superior to females in school achievements. Roach (1979) studied the effect of conceptual style, performance, related cognitive variables and sex on achievement in Mathematics. The result of the study revealed that females had higher mathematical achievement than males. This result is contrary to that of Bajah (1979), but in agreement with that of Wonzencreaft (1983), which showed, that females' achievement is higher than male's achievement in science subjects.

In the U.S.A., Kelly (1978) also observed that female students performed better than males in science subjects when they had male teachers. This observation indicates that the teacher or instructional strategy used can affect the differential performance of male and female students. One such instructional strategy is concept-mapping.

Meaning of Concept-Mapping

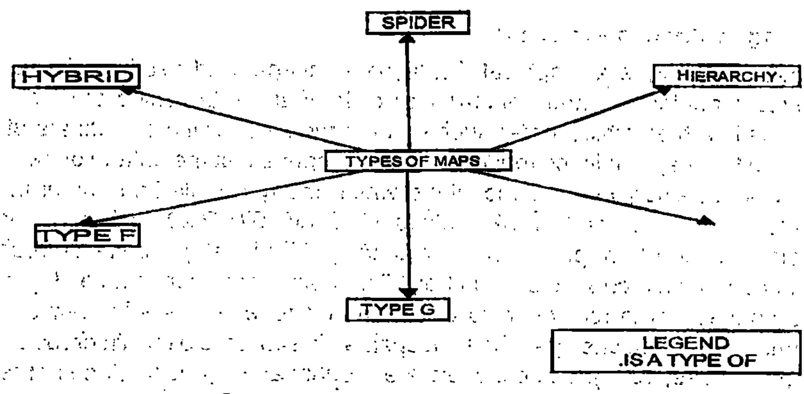
Concept-mapping is a graphical display of concepts and relationships. It involves mapping out and construction of logical relationships among concepts in a hierarchical order such that the most general concepts are at the top of the map, while the most specific concepts are at the bottom of the map. Concept-mapping is a technique which many people find useful in organising their ideas and showing relationships (MASTEP, 2001). In concept-mapping, concepts are placed in a visual array. Relationships are re-ordered in spaces between connected concepts. The completed map is a display of those concepts with relationships plotted and it reveals a single view of patterns of interrelationships. The concept map is similar to a terrain or road map (McAleese, 1986). The concepts are roughly analogous to place names while relationships are like roads or streets; that is, relationships (named "links" in some of the literature) between connected concepts are like routes of travel between places. The total concept map is a guide for comprehension as a road map for a travel guide. McAleese (1988) also used the metaphor of "a wadded net" for concept maps. This is a very interesting and apt metaphor especially if one thinks of the knots (concepts) and the connecting cordage (relationships) as representing not just concept maps but knowledge in general. Knowledge can be thought of as connected ultimately with all other knowledge through concepts and relationships. Concept- mapping was developed by Novak's research team (1977 and 1991).

Ausubel, Novak and Hanesian (1978) viewed concept-mapping as compatible to meaningful Learning theories, and this is because map construction involves (i) organising of concepts, (ii) linking existing concepts to other relevant concepts, (iii) arranging the concepts hierarchically and (iv) labelling the linkage between the concepts,

Types of Concept Maps

There are three common types of concept maps as identified by Jones, Palinear, Ogle and Carr (1987). These are Spider maps [or Cluster], Chain maps and Hierarchy maps. Each of these represents a different type of structure of content. In concept maps, typically, relationships are named and the relationship name is written between concepts or included in a legend as presented with symbols for relationships (as in Figure 1).

Figure 1: Spider Map: Types of Concept maps



Thus, for the spider map in Figure 1, the relationship name "is a type," is included in a legend. For the chain map in figure 2, the relationship "leads to" or "enables" is also included in a legend. For the hierarchy maps in Figure 3, "subsumes" is the relationship name. Having the concepts mapped and the relationships shown enables a third typical emphasis in mapping: that of stating propositions. For example, the user of the map in Figure 2 could generate several propositions, one of which is, "chain is a type of map." The proposition becomes repetitions unless numerous relationships are contained on the map.

Figure 2: Chain Map: Stages in Concept Mapping

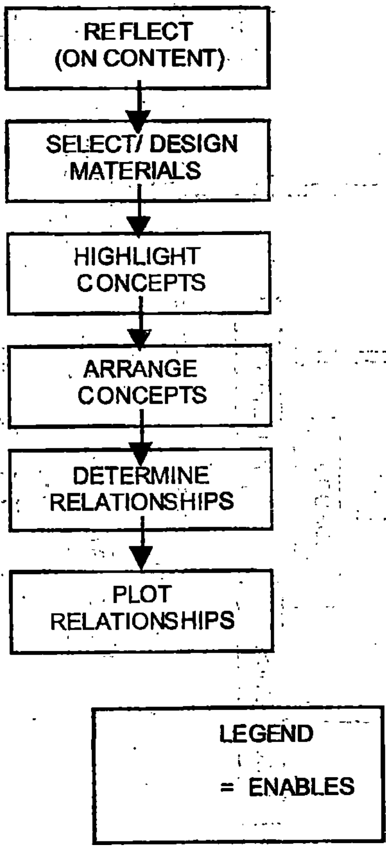
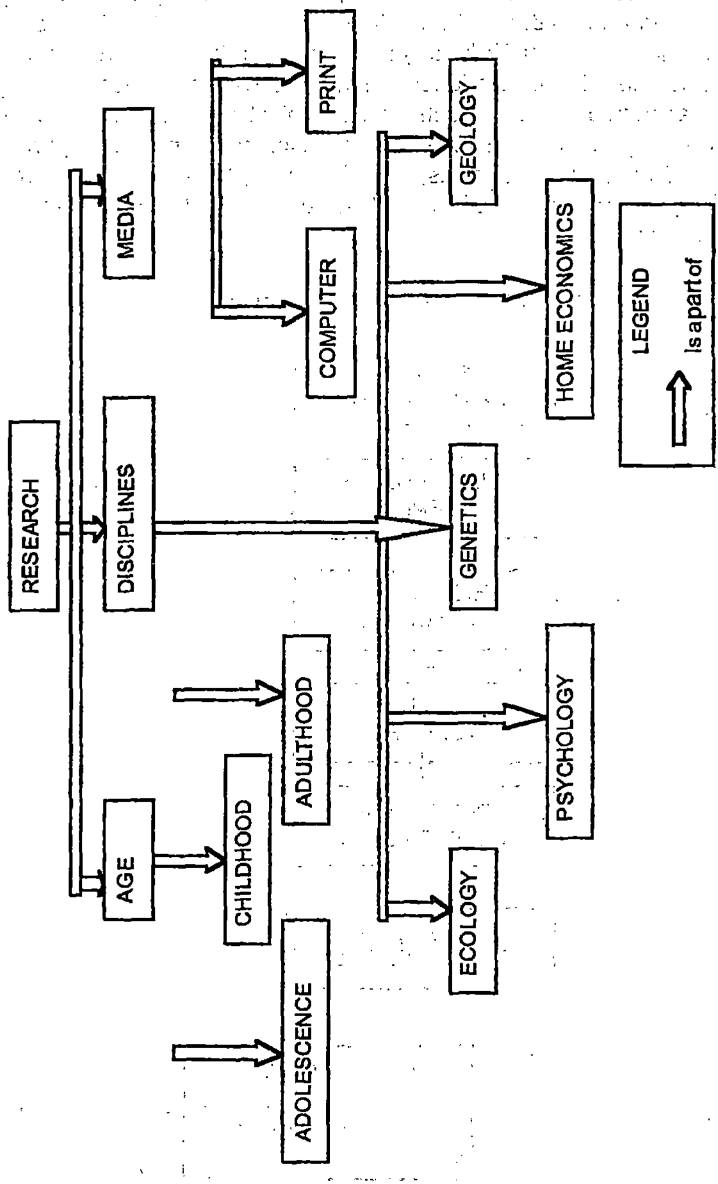
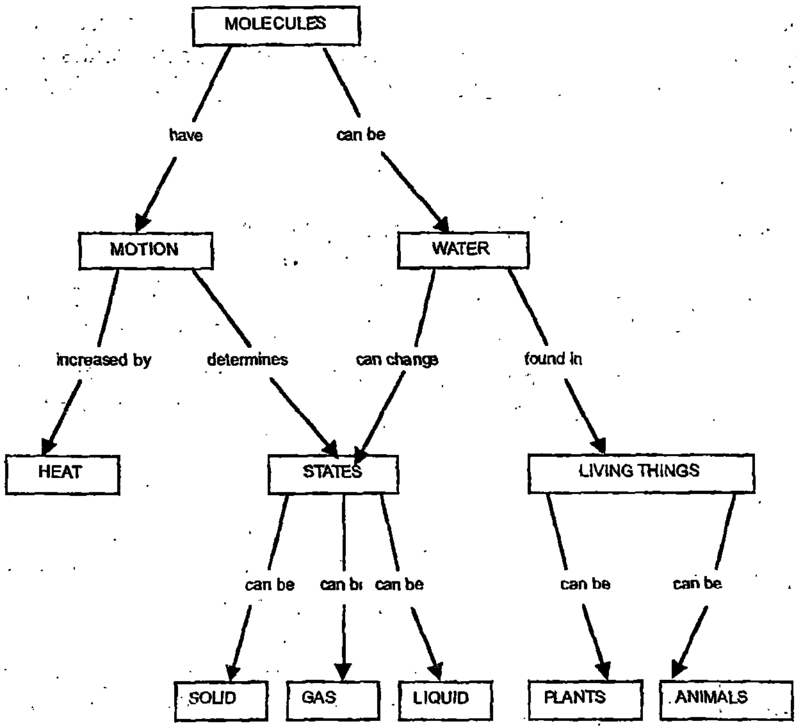


Figure 3: Hierarchy Map: Research on Concept Mapping



Finally, meaning increases for students as they recognise new links between sets of concepts or propositions at the same level in the hierarchy. These cross-links between one segment of the concept hierarchy and another segment represent the integrative connection among different sub-domain of the structure. Figure 4 presents a hierarchical concept map (Novak and Gowin, 1984).

Figure 4: Hierarchical concept map (Novak and Gowin, 1984).



The type of concept map used in this study was the Hierarchical type that was based on Ausubel's theory. Novak and colleagues (e.g. Novak and Gowin, 1984) coined the term concept map. Concept maps were intended to 'tap into a learner's cognitive structure and to externalise, for both the learner and the teacher to see, what the learner already knows' (Novak and Gowin, 1984). Reliance on Ausubel's theory, which posited a hierarchical memory (cognitive) structure, and on his principles of progressive differentiation and integrative inevitably led to a specific view of concept maps. Ausubel's theory thus provided guidance as to what constitutes a legitimate concept map.

Novak and Gowin (1984) argued that concept maps should be: (a) hierarchical with super-ordinate concepts at the apex; (b) labeled with appropriate linking words; and (c) cross linked such that relations between sub-branches of the hierarchy are identified. The hierarchical structure arises because "new information often is related to and is subsumable under more general, inclusive concepts." Moreover, the hierarchy expands according to the principle of progressive differentiation: new concepts and new links are added to the hierarchy, either by creating new branches or by differentiating existing ones even further.

Types of Instructional Strategy

There are two forms of instructional strategies. These are:

(i) Self-generated Concept-mapping Instructional Strategy (SGCMIS). Here, students' prepared concept maps were used for instruction.

(ii) Expository Instructional Strategy (EIS). This is the control group. Concept maps were constructed by neither the teacher nor the students.

Hypotheses

Three hypotheses were generated to test the impact of Self-generated Concept-mapping instructional strategy on the achievement of senior secondary school students in Evolution. These are:

H_o 1: There is no significant difference in the previous knowledge of students in Evolution Concepts in both experimental and control groups.

H_o 2 There is no significant difference between the achievement of students exposed to SGCMIS (Experimental group) and those exposed to EIS (Control group).

H_o 3 There is no significant difference between the achievement of Male and Female students exposed to SGCMIS (Experimental group).

Methods

Subjects

A total of One hundred and eighty Form 5 students selected randomly from six senior secondary schools in Manicaland, Mashonaland and Matebeleland provinces in Zimbabwe were the respondents for this study. The six schools (St. Augustine, Hartzel, Marondera, Waddilove, Umzingware and St. Dominics) were randomly assigned into the experimental and the Control groups.

Instrumentation

A pre-test and post-test on Evolution (ETI), i.e. Evolution Test Item, at an interval of four weeks were given to the students in order to test their knowledge before and after receiving instruction on evolution. ETI consisted of 50 multiple objective questions on evolution.

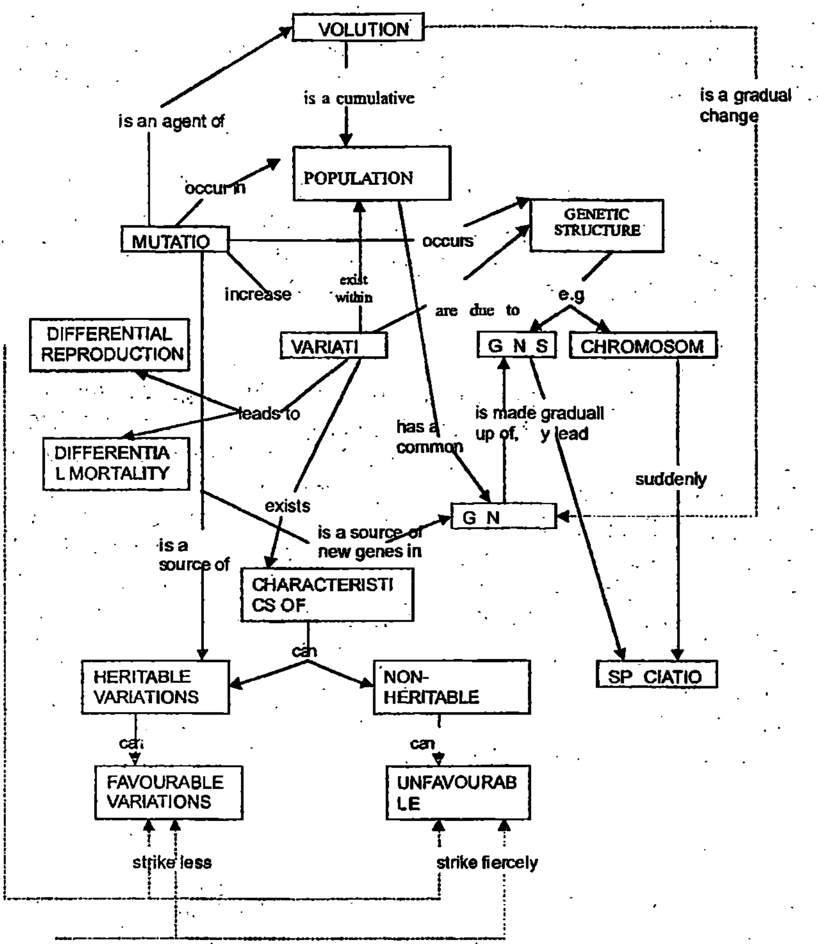
Training and practice

The Biology teacher and the students who were in the group where concept maps were to be constructed were given proper training and practice by the researcher on the concept-mapping technique and the learning theory behind it. The operational definitions of key terms such as (i) concepts, (ii) propositions, (iii) cross-links, (iv) linking words, (v) hierarchy and examples, were also learned. Evolution was the Biology theory chosen for the study. It is a topic that the students usually perceive to be too difficult to learn and teachers regard as too difficult to teach (Brumby, 1979; Demastes and Good, 1993). Some specific concepts were identified, such as natural selection, population, isolation, speciation, extinction, adaptation, variation, survival of the fittest, mutation, heredity, environment etc., their relationships, link-words and crosswords were also formed to make different concept maps (see sample in Figure 5: Hierarchical concept map on Theory of Evolution).

Results

Hypothesis 1: There is no significant difference in the previous knowledge of students in Evolution concepts in both experimental and control groups. The t-test statistical technique was used to test this hypothesis. The t-value ($t_{(118, 0.05)} = 1.19$) calculated was not significant at 0.05 alpha level (see Table 2), therefore, hypotheses 1 was accepted. The pre-test mean scores (x = 13.85) of students in the experimental group were just a little bit lower than the pre-test mean scores (x = 14.65) of the control group students. The result shows that there is no significant difference between the achievement

Figure 5: Hierarchical concept map on Theory of Evolution



of students in the experimental group and students in the control group. The result also suggests that the students in both experimental and control groups have more or less the same background level of the knowledge of the Biology instruction (Evolutionary Concepts).

Table 1: Summary of Pre-test and Post-test scores of Experimental Group A, and Control Group Students

		Pre-Test		Post-Test		
Group	N	x	SD	x	SD	t-value
Experimental Group	60	13.85	3.01	63.32	9.72	37.48
Control Group	60	14.14	4.21	25.11	8.63	8.44

Significant at 0.05

Table 2: t-test of difference between the pre-test mean scores of experimental group and control group students

Group	N	x	SD	t-value
Experimental Group	60	13.85	3.01	1.19
Control Group	60	14.65	4.21	

Not Significant at 0.05

Hypothesis 2: stated that there is no significant difference between the achievement of students exposed to Self-generated concept-mapping instructional strategy (SGCMIS), (Experimental group), and those exposed to Expository instructional strategy (control group). The t-test statistical technique was used to test this hypothesis. The t-value ($t_{(118, 0.05)} = 22.76$) calculated is significant at 0.05 alpha level (see Table 3), therefore, hypothesis 2 was rejected. The post-test mean scores (x = 63.32) of students in the experimental group were higher than the post-test mean scores (x = 25.11) of the control group students. This result shows that there is a significant difference between the achievements of the students that were taught evolution using, SGCMIS and those taught Evolution using the EIS as a result of instructional modes used in teaching the students.

Table 3: t-test of difference between the post-test mean scores of experimental group and control group students.

Group	N	x	SD	t-value
Experimental Group	60	63.32	9.72	22.76
Control Group	60	25.11	8.63	

Significant at 0.05

Hypothesis 3: stated that there is no significant difference between the achievement of male and female students that were taught evolution using SGCMIS. The chi-square statistical technique was used to test this hypothesis. The ? -value ($?_{(1, 0.05)}$= 0.12) calculated was not significant at alpha level (See Table 4). Therefore hypothesis 3 was accepted. The result therefore confirms that there is no significant difference between the achievement of male and female students using SGCMIS as a mode of instruction.

Table 4: Summary of Chi-square of Post-test scores of Experimental and Control Groups (Male and Female).

Study Group	Sex	Observed Scores (O)	Expected Scores	O - E	$(O - E)^2$	$(O - E)^2/E$
Experimental	M	31.64	32.71	-1.07	1.14	0.03
	F	34.81	33.26	1.55	2.40	0.07
Control	M	25.38	24.77	0.61	0.37	0.01
	F	24.57	25.18	-0.61	0.37	0.01
Total						**0.12**

Not Significant at P = 0.05

Discussion and Conclusion

The degree to which each of these forms of instruction enhances students' construction of appropriate conceptions of evolution can be linked up with the observed significant difference among the students achievement that were exposed to SGCMIS and EIS. According to the findings students perform better when SGCMIS was used to teach them than the other form of instruction, thus, showing that students show higher achievement when they are actively involved in the construction of knowledge individually and collectively through concept-mapping in the class under the guidance of the teacher. In addition, the active joint construction of concept maps by students and teacher during class instruction in this study, gives the teacher the opportunity to quickly identify and correct conceptual confusion immediately it occurs among the students before it becomes absorbed in the students for higher achievement on the part of students that were exposed to SGCMIS.

Greater opportunities for the teacher to help students make meaningful connection between their previous knowledge and understanding that are compatible with those accepted to biologists are provided when SGCMIS was used than EIS. Enough challenges and practical opportunities for students to collectively and individually construct meaningful connection between new concepts and their previous conceptions are provided through using SGCMIS. The construction of concept map involves constructing logical relationships among concepts in hierarchical order, such that the most general concept is at the top and most specific concept at the bottom of the map, therefore, it requires logical and analytical thinking skills. SGCMIS seems to facilitate the developments of logical and analytical thinking skills, and this is partially likely to account for better achievement of students that were exposed to SGCMIS than EIS.

Recommendations

The following recommendations are suggested based on the major findings and conclusions drawn in this study:

SGCMIS is a mode of instruction that improves instruction and students' achievement. Hence, the Biology teachers are advised to learn and adopt its use for teaching evolution and other similar complex Biology theories and concepts. Through this, there would be a quick identification and eradication of conceptual confusion, which is encountered by the students during instruction before it becomes established in the students' cognitive structure by the teacher.

Concept-mapping instructional strategies can lead to improvement in the quality of teaching because it would enable the teacher to focus attention on the inter-relationship between the central concept to be taught and other related concepts. Concept-mapping would provide the teachers with useful insight on the best logical and hierarchical presentation of the concepts to the students. More comprehensive tables of specification and assigning of appropriate weights to marks during class tests and examinations are enhanced when the teachers are using concept-mapping. As a result, for planning class instructions, students' evaluation, and self-evaluation and as assessment tools, Biology teachers should endeavour to employ concept-mapping instructional strategies.

References

Abimbola, I.O. (1989). The Role of Philosophy of Science in Biology Education in Nigeria. *Nigeria Educational Forum*, 72 (2), 175-184.

Ausubel, D.P., Novak, J.D. & Hanesian, H. (1978.*Educational Psychology: A Cognitive View* (2nd Edition). New York: Holt, Rinehart & Winston.

Aworanti, A.O. (1994). Effect of the Conceptual Change Instructional Programme on Senior Secondary Students' Performance in Biology Concepts Unpublished Ph.D. Thesis Department of Curriculum Studies and Educational Technology, University of Ilorin, Nigeria.

Bajah, T.S. (1979). Correlates of Students' Extrinsic School Environment Factors with level of Attainment in a Standardized Test in Chemistry. *Journal of the Science Teachers' Association of Nigeria,* 18 (1), 49-63.

Brumby, M. (1979). Problems in Learning the Concept of Natural Selection. *Journal of Biological Education,* 13 (2), 119-122.

Demastes, S. & Good, R. (1993). A Description of University Students' Conceptual Change in Evolution. A paper Presented at the 66th Annual Meeting of the National Association for Research in Science Teaching. Atlanta, Georgia, U.S.A. April, 15-19.

Inomiesa, A. (1989). Sex and School Location as Factors in Primary Science Achievement. *Journal of the Science Teachers' association of Nigeria, 26* (1), 82-88.

Kelly, A. (1978). Girls and Science. *International Association for Evaluation of Educational Achievement Monograph Studies No.9* .Stockholm: Almguist and Wikseil.

.Magret, B.S. (1981).*Sex Bias in Education* London: Basil Blackwell Publishers.

Mahadeva, N.M. (1983). Misconceptions and Myths Masquerading as Biological Facts: In H. Helm & J.D. Novak (Eds.)*Proceedings of the International Seminal, Misconceptions in Science and Mathematics.*Department of Education, Cornell University, Ithaca, New York, June 20-24, 266-271.

Mathematics and Science Teachers' Extension Programme (MASTEP). (2001). *Teaching Methods for Biology: A distance Education Course* . Windhoek: MASTEP.

McAleese, R. (1986). Some Problems of Knowledge Representation in an Authoring Environment: Exteriorization, Anomalous State Meta-Cognition and Self Confrontation.*Programmed Learning and Education Technology* , 22, 299-306.

McAleese, R. (1988. From Concept Maps to Computer-Aided Instruction. Is it Possible Using Notecard? Paper Presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA.

Nigerian Educational Research and Development Council (NERDC) (1992). *Performance of Nigerian Students in Public Examinations: (Final Repoi Part A. GCE/SSCE 1987-1991).*Being Part of Final Report Presented to the Joint Consultative Committee (J.C.C.) at the J.C.C. Plenary Meeting held in Katsina State, July 27-31.

Novak, J.D. (1977)*A Theory of Education,* Ithaca, New York: Cornell University Press.

Novak, J.D. (1991). Clarify with Concept Maps *The Science Teacher,* 58 (7), 45-49.

Okebukola, P.A.O. (1984). Tackling the Problem of Large Classes in Biology: An Investigation into the Effects of a Cooperative Learning Technique*Journal of Science Teachers' Association of Nigeria,*22 (2), 2-5.

Roach, D.A. (1979). Effect of Conceptual Style, Performance, Related Cognitive variables and

Sex on Achievement in Mathematics. *British Journal of Educational Psychology* 49, 79-82.

Science Teacher Association of Nigeria (STAN) (1992). Raising the Standard of Performance in Public Examinations in Science, Technology and Mathematics, WAEC Symposium, April, University of Ibadan.

West African Examinations Council, (WAEC) (1985).Factors Affecting Candidates Performance in WAEC May/June G.C.E. o/l Biology Examination (Research Report). Lagos.

Wonsecreaft, M. (1983): Sex Comparisons of certain Abilities*Journal of Educational Research* 57, 21-27.