Journal of Science, Technology and Mathematics Education (JOSTMED)
Volume 7, Number 1

April., 2010
ISSN0748-4710

Efficacy of Consequence Mapping Instructional Strategy on Achievement and Knowledge Retention in Genetics Among Senior Secondary School Students in Niger State.

Babagana, M. and *Jibril, M.N.

Department of Science Education, Federal University of Technology, Minna
Army Day Secondary School, Bida, Niger State.

Abstract

The study investigated the effectiveness of consequence mapping instructional strategy (COMIS) in biology. The senior secondary school students offering biology in Edati local government area of Niger state constituted the population for the study. The sample consisted of one hundred and fifty four (154) senior secondary one biology students drawn from three randomly sampled schools in Edati Local Government Area of Niger State. They were sampled and assigned as experimental group (82) and control group (72). Three research questions and three hypotheses guided the study. A 24 – item, Genetically Difficult concepts Achievement Test (GEDCAT) four option, multiple choice tests was constructed and used by the researcher. The instrument was validated by three experts from Department of science Education, Federal university of technology, Minna. This was pilot tested with reliability coefficients of 0.69. The study revealed that the experimental group performed significantly better than the control group and COMIS is sex dependent not environment dependent. It was therefore recommended that each school should as a matter of fact organize workshops and seminars in order to provide biology teachers with necessary skills and competence in using COMIS for effective and efficient teaching and learning of science – biology. Students, especially the females, should be given favorable conditions such as incentives, motivation and science instructional materials in schools for learning sciences.

Introduction

Within the last two decades a great deal of research efforts in science education has been directed at strategies or techniques that will enhance the teaching and learning of science in general and biology in particular. Several research reports (Olarewaju, 1986; Aigbomian, 1987; Okoli, 1995; Nwagbo, 2002) converge to indicate that students achieve poorly in secondary school science subjects. Available statistics from the West African Examination council (WAEC) on senior secondary school student's performance in biology reveal that although biology has the highest enrolment relative to other science subjects, it records a very poor performance at senior secondary certificate examinations especially in the practical examination where students exhibit very poor science skills acquisition. This poor science skills acquisition by students is not in keeping with the aims and objectives of Education in Nigeria which states that:"education should aim at helping the child acquire appropriate skills, abilities and competencies, both mental and physical as equipment for the individual to live in and contribute to the development of his society"(FME 2004). It is worth mentioning here that scientific laws, theories and concepts formed the products of science. Concepts, according to Gagne (1970) are class of observable objects. Scientific concepts are made up of scientific truths which are in themselves not permanent truths. The scientific concepts provide meaningful and unique attributes of phenomena in nature. The mastery of science concepts depends upon learners' experience, constructive operation they are able to perform and examples they are able to cite as well as teachers understanding of such concepts (Busari, 1995).

According to Mukhejee (2002) concepts are learned and do not emerge simply with maturation. The teachers' Consideration and understanding of learners ability to assimilate, accommodate and adapt new concepts in order to attain intellectual equilibration at every stage of cognitive development as recommended by purgation psychologist is required

(Mukhejee, 2002)). To explore this depends on the teachers' understanding of such concepts. In other words the instructional strategies used by the teachers have profound influence on the cognitive development and ability of the learners. The teaching and learning of biology using ineffective and inefficient methods is largely responsible for the perception of such concepts as difficult to understand by both the teachers and students. Several research reports (Ali, 1996; Okebukola, 1998; Okoli, 1985; Nwasu, 1993; Nwagbo, 1999; Mukhejee, 2002) indicate that many science teachers prefer the expository method of teaching a situation where the teacher either gives explanation of a concept / topic and then jot some points on the board for the learners to copy and shy away from innovative activity oriented teaching methods (such as inquiry, discovery, concept mapping, investigative laboratory approach, cooperative learning , project, project methods, consequence mapping e.t.c.)

However, the problems of laboratory facilities and space, inadequate instructional materials, teacher preparation, students' preconceptions, students cognitive / communication ability and poor mathematical background are some of the problems influencing the teaching of scientific concepts. Consequently, the cardinal objectives of biology education at senior secondary level are that students at the end of their study should acquire: adequate laboratory and field skills in biology, meaningful and relevant knowledge in biology, ability to apply scientific knowledge to everyday life in matters of personal and community health and Agriculture, reasonable and functional scientific attitudes (Ramalingam, 1993). The teaching of biology is a challenging and task demanding as a result of the acts that major topics / concepts with wide coverage in the biology core curriculum are being perceived as difficult concepts. The concepts observed by Okebukola (1998) as perceived biology difficult concepts are enumerated as follows:

- Osmoregulation, excretion, Homeostasis.
- Central nervous system and peripheral nervous system.
- Ecology, Genetics.
-Evolution, Theories and evidence.

Duyilemi (1998) reported that the perceived difficult concepts vary in their degrees of difficulty and as such order of difficulty can vary from school to School, teacher to teacher and from student to student. The perceived difficult concepts are contained in Table 1 below:

Table 1: Genetics Concepts Perceived as Difficult by Students.

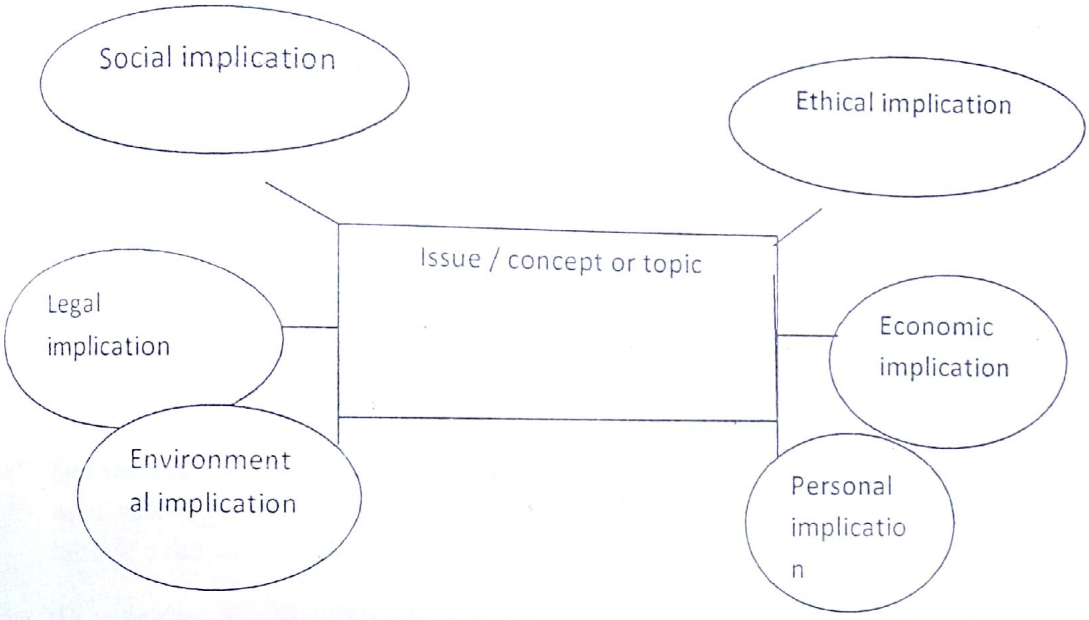
S/N	Items/concepts	Correct conceptions number and (%)		Misconceptions number and (%)	
1.	MUTATION	25	(20.8%)	80	(66.7%)
2.	PHENOTYPE	30	(25.0%)	78	(65.0%)
3.	GENOTYPE	30	(25.0%)	80	(66.7%)
4.	GENES	40	(33.3%)	71	(59.2%)
5.	CHROMOSOMES	33	(21.5%)	70	(58.3%)
6.	RECESSIVE CHARACTER	31	(25.8%)	66	(55.0%)
7.	DOMINANT CHARACTER	40	(33.3%)	67	(55.8%)
8.	HEREDITY	50	(41.7%)	58	(48.3%)
9.	FILIAL GENERATION	20	(16.7%)	52	(43.3%)
10.	ZYGOTE	40	(33.3%)	51	(42.5%)
Mean (x□)		28.2%		56.1%	

Source: Katto, O. D. (2004).

April., 2010
ISSN0748-4710

With evidence from sputnik 1 in 1957 there have been revolutionary trends in science teaching and learning all over the world. There has been a shift of emphasis from traditional method of teaching to problem solving approaches to teaching. The emphases are on those instructional strategies that enable students to be active participants in the lessons, thereby, learn by 'doing' science and less of reading science instead of being passive recipients (Usman, 2000: Katcha, 2009). This revolutionary trend is based on curricular reforms of 1950s and 1960s which were initiated by the American Association for the Advancement of science (AAS), National science foundation etc.

Consequence Mapping Instructional Strategy (COMIS) is a relatively new approach to science teaching that fits very well with teaching of concepts and principles of Science, Technology and Society discipline. It simply highlights the key factors and consequence of a topic or concept using a map. It is one of the theoretical models of instructional strategies developed and used by (Fullik and Ratcliffe, 1996). On a general note, diagram for consequence mapping is presented below.



A general structure of consequence map.

It is easiest to start by showing the class how a consequence map can be built up from considering an issue close to their experience.

The strategy is embedded in the constructivists theory of concepts teaching which Ausubel (1963) opined that it could result into meaningful learning of concepts. With Ausubel advance organizers, any teaching strategy which can subsume the new tasks or experiences into the existing cognitive structure will lead to meaningful learning. COMIS is one of such strategies that have been tried out by some earlier studies (Okebukola, 1990; Hassan, 1998; Aworonye, 2007; Orji, 2000; Katcha, 2009).

Statement of the problem

The persistent poor performance of students in biology coupled with poor science process skills acquisition exhibited by biology students in practical examinations in biology at senior school certificate examination (WAEC chief examiners report, 2007) leaves one in doubt about the effectiveness of the teaching methods widely employed by biology teachers for teaching the subject. The students' poor performance indicates that the students still

experience difficulty with some major topics or concepts in biology. Therefore the quest for alternative teaching methods that can lead to meaningful learning of biology at senior secondary (SS) is still on. This study is centered on investigation of the effectiveness of COMIS in improving students' achievement in selected difficult concepts in Genetics.

The expository method of teaching is very popular and is widely used by biology teachers to convey large volumes of scientific information to senior secondary school students in a bid to prepare them for the rigorous senior school certificate examination. There is need to find out how effective this teaching method is, relative to other teaching methods.

Purpose of the study

This study is aimed at investigating the effect of COMIS on:

- Student achievements in difficult concepts in genetics.
- Gender differences in students' achievement in difficult concepts in genetics.
- Students' cognitive style in achievement in difficult concepts in genetics

Hypotheses

The following null hypotheses were investigated:

HO1. There is no significant difference between the academic achievement of students taught by COMIS and those taught by expository method.

HO2. There is no significant difference between mean scores of posttest of male and female students taught by COMIS.

HO3. There is no significant difference between the mean scores of delayed-posttest of students taught by COMIS and those taught by expository method.

Methodology:

Study design

The design of the study was quasi-experimental specifically the pre-test-posttest and delayed-posttest matched group design was adopted for the study. This design was used because the subjects were of two groups (experimental and control groups) who have similar or comparable characteristics.

Population and sampling procedure

All the Senior Secondary School Classes I in Edati local government area of Niger state constituted the population for the study. The subjects for the study numbered one thousand one hundred and ninety eight (1198). The population included males and females students with the age range of 17.5 for boys and 15.5 for girls. They all offered biology as their school subjects at SSI and were equally ready to register the subject for SSCE at SSIII.

Instrument

The genetically difficult concepts achievement test (GEDCAT) constructed by the researcher was used for the study. The instrument is a multiple-choice, four options and a 24 item test, developed by the researcher based on the biology (Genetics) topics taught and which were from SSI biology curriculum namely: Mendelian theory, crossbreeding in organism and mutation. Four experts in test and measurements from the department of science education, Federal university of technology, Minna, and four biology teachers from Edati local government Area validated the instrument (GEDCAT). Validated items include the lesson notes, marking scheme and the model of COMIS used for the teaching. The GEDCAT was however, pilot-tested using schools outside the study area. The Richardson K-R20 internal consistence formula was used to analyze the instrument reliability to obtain the reliability estimate of 0.69. Therefore, GEDCAT was considered appropriate for the study. This was developed by the researcher based on the topics (Genetics) taught, which were from SSI biology curriculum namely: Mendelian theory, crossbreeding in organisms and mutation.

April., 2010
ISSN0748-4710

Treatment

The regular biology teachers in the sampled schools were employed for the research study. The teachers who participated in the experimental treatment were subjected to rigorous training for a period of two weeks. They underwent training on how to conduct instructions using the consequence mapping approach to ensure uniformity and mastery of the teaching method. Each teacher in the experimental group was given a copy of the validated plan and the copies of the instrument (COMIS) which was used for data collection. The teachers in the control group did not receive any training. They were required to teach the selected biology (Genetic) concepts using the conventional method of instruction which was popularly used by biology teachers. In addition, each teacher in the control group was given copies of the instrument which was used for data collection. The trained teachers in turn trained their students in consequence maps construction and application for learning.

The pre-test was administered and the results used to establish equivalence between the experimental and control groups. This was followed by the treatment period which lasted for four weeks during which the trained teachers engaged the experimental group in biology lessons based on the mode of treatment (COMIS). The experimental groups were then given treatment which was withheld from the control group. The posttest was then, administered on both experimental and control groups as was the case with the pre -test activities. This took place at the end of the treatment. The same test items (GEDCAT) served as pre-test and served as posttest. The delayed posttest was administered six weeks after the posttest. The same test items (GEDCAT) served as pretest and the posttest was administered as delayed-posttest.

Result of the findings

In the analysis of the data, mean and standard deviation scores of students on the test of effects of COMIS were used to answer the research questions. The null hypotheses were tested using t-test statistics. These hypotheses were either rejected or not rejected at 0.05 level of significance.

HO1: There is no significant difference between the academic achievement of students taught by COMIS and those taught by expository method.

Table 2: t- test Comparison between the Mean Scores of the Posttest for the Experimental and Control Groups.

Group	N	X	SD	Df	Std-error	t-cal	t-crit	Remarks
Experimental	64	31.2	15.4	98	2.45	9.30	1.98	*significant
Control	36	8.4	9.1					

*significant at 0.05

Table 2 shows that the experimental group performed better than the control group on the test of GEDCAT with the mean scores of 31.2 against 8.4 means scores of the control group. The t-value (calculated) of 9.3 is higher than the t-critical value of 1.98 with the result being significant at p=0.05 level of significance. The hypothesis (HO1) is thus rejected. This implies that there is a significant difference in academic achievement between the experimental and control groups.

HO2: There is no significant difference between the mean scores of posttest of male and female students taught by COMIS

Table 3: t-test Comparisons in the Mean Scores of Gender Taught by COMIS.

Group	N	X	SD	Df	Std-error	t-cal	T-crit	Remarks
Male	80	32.86	21.01	98	2.60	9.41	1.98	*Significant
Female	20	8.36	5.02					

*Significant at 0.05

From the table 3, it is shown that the male students with mean scores of 32.86 achieved significantly higher than the female students with the mean scores of 8.36 on the test of GEDCAT at the posttest. The critical t-value was 1.98 and the calculated t-value which was 9.41 is higher at df of 98. The hypothesis was thus rejected at ≤0.05 level of significance. This shows that there was significant difference between the male and the female students in their academic achievement when taught by COMIS.

HO3: There is no significant difference between the mean scores of delayed-posttest of students taught by COMIS and those taught by expository method.

Table 4: t-test Comparisons in the Mean Scores of Delayed-Posttest for the Experimental and Control Groups.

Group	N	X	SD	df	Std error	t-cal	t-crit	Remarks
Experimental	64	25.41	14.76	98	2.56	7.91	2.10	*Significant
Control	36	6.5	8.1					

*Significant at 0.05

Table 4 shows that the experimental group has mean score of 25.41 higher than the control group with mean scores of 6.5. The critical t-value was 2.10 while the t-calculated value (7.91) was far greater at df of 98. The result is significant at 0.05 level of significance. This implies that there was a significant difference between the academic achievement of experimental and control groups at delayed-posttest of GEDCAT in favor of the experimental group. This further explains that the retentive ability of learners in leaning difficult concepts in biology is higher when taught by COMIS than when taught by expository strategy.

Discussion

In table 2 the study revealed a significant difference between the two groups that the students in experimental group had the highest scores when compared with the control group in their academic achievement in posttest of GEDCAT. The mean differences in the mean posttest scores of the group may be as a result of COMIS treatment given to experimental group which was with-held from the control group that was taught with expository method. It implies that individuals taught concepts in biology using Consequence Mapping Instructional Strategy (COMIS) may be in a better position to participate actively in constructing their own knowledge and are likely to achieve higher than those taught by expository method. When students are afforded the opportunity to participate actively in biology instruction, they tend to ask more questions and take more initiatives. This is consistent with the findings of Ajewole and Balogun (1993) who assessed the effects of discovery and expository instructional methods on the achievement of low and high cognitive skills in biology. The findings indicated that the discovery group performed significantly better than the expository group.These results are also in agreement with findings from earlier studies such as (Usman, 2001; katcha, 2003; katcha, 2005 katcha, 2009; Pine and West, 1986; Adeleye, 1987; Gowin and Novak, 1984; and Okebukola, 1990).

Table 3 shows that there was significant difference between the male and female students academic achievement in test of GEDCAT when taught using COMIS as both performed unequally well on the posttest. Although COMIS is facilitative and effective in developing the higher cognitive abilities and increase students level of understanding and reflective thinking, it is interesting to note that COMIS appeared to be sex dependent in students' acquisition of difficult concepts in biology. This implies that most female students in schools in the study area were forced by circumstances to take up to sciences, as they seem to lack incentives, motivation, encouragement as well as materials and financial support from the government and school management. This is in consonance with Oduro-mensah's (1997) findings that students with more favorable science-related attitudes performed better than others with less favorable science related attitudes in both the processes/skills and cognitive area of biology. It is pertinent to note that the part of objectives for studying senior secondary school biology is to equip students with reasonable and functional scientific attitudes (Ramalingam, 1993). Some of the sampled female students for this study seem to lack interest and attitudes for learning sciences-biology. This finding also supports some studies which found that male students were better than female students (Bank, 1983; Novak and Mosunda, 1993; Soyibo, 1990).

Table 3 indicates that the students in the experimental group performed significantly better than the control group. This implies that the students taught difficult concepts in genetics using COMIS increases their retentive abilities. The students taught difficult concepts in biology with COMIS performed significantly better than those taught the same concepts using expository method.

Conclusion

The study examined the efficacy of Consequence Mapping Instructional Strategy (COMIS) as a technique in improving students' achievements in biology concepts and enhancing conceptual understanding. The results of the findings from the study suggested substantial and important changes in the understanding based on the achievement of students after treatment. The application of COMIS involves the use of instructional materials, practicals and above all the learner is carried along throughout the processes and procedures of knowledge construction. Consequence mapping has also been found to aid retention of concepts learnt. It appears that consequence mapping offered a valid and useful mechanism for enhancing meaningful concept of knowledge. The learner who is taught by the COMIS is able to subject the lesson to sensory experience as a result of 'doing' science more than 'reading' science

Recommendations

Based on the findings of the study, it is recommended that:

- The COMIS should be used in teaching in addition to other methods so as to enhance effective teaching and learning.
- There should be enough provision of literature on consequence mapping strategies which must be made available for teachers to use.
- Teachers should be encouraged to use consequence mapping instructional strategy in teaching biology, especially, the difficult concepts.
- The federal, state and other educational bodies should sensitize relevant agencies on the use of consequence mapping technique as an effective teaching strategy by organizing workshops/seminars for stakeholders in the education sector on its efficacy. Such workshops and seminars should be organized by experts.
- Teachers should encourage students to use consequence mapping to learn and or do assignments and homework.

References

Adeleye, F.B. (1987). The relationship between teacher questioning styles and students Classroom participation and achievement in biology. pp 45.

Ajewole, G.A. & Balogun, T.A. (1993). Effects of discovery and expository instructional methods on achievement of low and high cognitive skills in biology. Journal of science and technology education, 1 (2), 86-98

Ali, A. (1996). Fundamentals of research in education. Meks publisher Nig. Awka.

Ausubel, D.P. (1963). The psychology of meaningful verbal learning. New York: Grime and Stratton.

Babagana, M. (2009). Study of usage of research information on modern teaching techniques among secondary school biology teachers. Nigerian Journal of Technological Research. F.U.T. Minna (pp 120-128).

Banu, O.P (1992). Trends in the goals and objective of science education. Journal of Science Teachers Association of Nigeria, 27(2).

Busari, O.O. (1995). Teaching Secondary School Science. A guide for teachers Lagos: Ayo Adesina Nig. Ltd.

Duyilemi, B.O. (1998). Instructional Strategies for Effective Teaching of Biology in Secondary Schools. STAN. Natural biology panel workshop proceedings.

FME, (2004). Federal Ministry of Education, Modern Instructional Strategies. 12-19

Fullik, L.A. and Ratcliffe, D.S. (1996). Fundamentals of Science Technology Society. STAN(2001), 112-117.

Katcha M.A. (2009). Vee-diagrams as an instructional strategy for tackling difficult concepts in ecology.

Katto, O.D. (2004). Investigation into the conception of genetics and evolution held by secondary school biology students in Minna, Niger state, Nigeria. Unpublished M.TECH. Thesis.

Muklejee, A. (2002). Educational psychology (Rev. Edition) Samaru-Zaria: Asekome & co.

Novak, J.D. and Godwin, D.B. (1984). Learning how to learn. London Cambridge university press

Nwagbo, C. (1999). Effects of Guided Discovery and Expository Teaching Method on the Attitudes toward Biology of students of different levels of scientific literacy. Journal of STAN. Volume 34 (2) 66-73

Nwosu, A. A and Nzewi, U. M. (1997). Teachers Knowledge and Application Of Innovation Strategies in Biology Teaching. Proceedings of Ajumogobia Memorial Conference of the Science Teachers Association of Nigeria, 140 – 144

Oduro-mensah, D. (1987). Effects of science related attitude and teaching strategy on achievement in high school biology. In R.O. Oluche, U-Nzewi & V.C. Nwachukw (EDS) the future of unpublished postgraduate educational research in Nigeria (pp 57). Onitsha: summer educational publishers Ltd.

Okebukola, P.A. (1987). Remedying students' weakness in science. A test of efficiency of a psychological learning model. The STAN, 1(4), 311-338.

Okebukola, P.A. (1998). Concepts maps as instructional tools for promoting meaningful learning in biology STAN national biology panel workshop proceedings.

Olarewaju, A.O. (1996). Cause of students under achievement in science in O.O. Bello (ED) proceeding of the 27th Annual conference of STAN, 1995-1999.

Orji, A.B.C. (2000). The use of heuristics in teaching physics concepts. STAN bulletin 13 (2) 6-8.

Pine, A.L. & West, L.H.T. (1986). Concepts understanding of science learning: a interpretation of research within a source of knowledge. Science education, 70 (5) 585-604.

Ramalingam, S.T. (1993). Modern biology for senior secondary science series. Onitsha: Africana-fep publishers Ltd.

Soyibo, K. (1991). A Review of Empirical Research on Nigerian. Student . Achievement in Biology (1979 - 1988). Journal of Science Teachers Association of Nigeria, 27. 123 - 129.

Usman, A.I. (2000). The relationship between students' performance in practical activities and their academic achievement in integrated science using NISTEP models of teaching, unpublished, PhD thesis ABU Zaria.

WAEC (2008). West African Examination Council syllabus Lagos: WAEC press, 13-15.