REDUCING GENDER DIFFERENCES IN ACHIEVEMENT IN BIOLOGY THROUGH CONCEPT MAPPING TEACHING STRATEGY

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Abstract

This study investigated the existence of gender differences in achievement in biology when concept mapping teaching strategy (CMTS) is used among coeducational secondary school students. The study employed a non-equivalent, one group pretest-posttest control group design as a quasi-experimental research design. A sample of four co-educational secondary school classes in four schools, were purposively selected and participated in the study. The four form two classes were all subjected to treatment. The study sample comprised of 189 form two students in Siaya District, Kenya. All the students from co-educational secondary schools were taught the same biology content. After a four-week intervention period, all the students in the four classes were post-tested using the Biology Achievement Test (BAT). Student data were analyzed using t-test. The results show that after the intervention, students exposed to CMTS had a significantly higher achievement than they had earlier on and there were no gender differences in achievement. The study concludes that CMTS is an effective teaching strategy, which provides equal learning experiences, enhances learners' achievement in biology and reduces gender differences in biology achievement. It is recommended that curriculum developers and biology teachers incorporate concept mapping as one of their major teaching strategies to enhance active and meaningful learning in biology lessons.

Keywords: *Concept mapping teaching strategy, achievement in biology, Gender.*

Introduction

Gender related differences in achievement continue to generate much debate and attention annually (Elwood & Carlisle, 2003). According to Kahle and Meece (2004), gender studies in the last 25 years have sought to identify what role gender has on the learning of, involvement in, and success in science and science related fields especially in females. Different explanations have been advanced to explain this differential performance and these can be grouped into biological factors and school classroom factors. Gray (1981) has suggested that gender differences in science achievement are as result of genetically based gender differences in spatial ability. Bryden (1979) has attempted an explanation of differences in spatial ability by using cerebral organization of men and women. He argued that there exists a dichotomy between linguistic ability and spatial skills in the hemispheres of the brain. The left hemisphere of the brain controls linguistic skills while the right controls the spatial skills. He holds that these differences explain why boys perform better than girls in sciences that require spatial skills.

This biological explanation has been challenged by Rose (1979), Fennema and Sherman (1978), Methen and Wilkinson (1988), and Dimitrov(1999). In the recent past, the gender differences in achievement in the United Kingdom have been in the favour of girls (Elwood & Carlisle, 2003). This has been attributed to affirmative action policies that have been aggressively implemented.

Another assessment was carried out under the Programme for International Student Assessment (PISA) in mathematics and sciences in 2006 in 30 countries that revealed the existence of gender differences in performance in favor of boys. In the same study, students were assessed separately for analytical reasoning and problem solving skills (some of the essential ingredients of science performance), and the females tended to perform significantly better and in many countries outperformed male 15 year olds in problem solving (Tembon& Fort,2008). This finding suggests that the lower performance of females in mathematics and sciences cannot be attributed to weaknesses in cognitive competencies that underlie these subjects. More likely, it reflects the way in which these cognitive competencies are

contextualized in science instruction at school.

According to Eshiwani (1993) the school is the main place for the teaching and learning of science. He observes that the school classroom practices is in many ways responsible for differential treatment of girls and boys and hence gender differences in performance.

The Kenyan context is different with regard to gender differences. The performance of students in the Kenya Certificate of Secondary Education (KCSE) biology has shown the existence of gender disparities in favor of boys. It has been observed that boys perform better than girls in mathematics and sciences in the national examinations (KNEC, 2004; KNEC, 2006; KNEC, 2011). For instance in the year 2010, the boys had a mean score of 31.24 and girls had a mean of 26.99 out of 200 respectively. Even though the performance of both genders is below par, the gender differences are significant. In a research study aimed at improving the participation of girls in science and mathematics in primary and secondary schools, it was reported that girls' achievement in sciences in Kenya was much lower that of boys partly due to poor attitude towards sciences. It was also reported that teachers in normal classes use discouraging remarks on girls' participation (FAWE, 1998). These discriminatory teaching techniques in the learning environment could be resulting in the gender differences.

Concept Mapping

According to Angelo and Howard (1997) concept mapping is an active, creative, visual and spatial learning activity in which concepts are organized according to their hierarchical relationships. Novak (1990) defines concept mapping as a process in which a systematic representation of knowledge is created. In a study, Jegede and Okebukola (1989) explored the possibility that the concept mapping teaching strategy could be a fruitful way of helping to change students' attitude towards biology concepts traditionally perceived to be difficult-ecology and genetics. They found out that students' perceptions of the difficulty towards ecology and genetics changed for the better as a result of engagement in concept mapping. Jegede, Alaiyemola and Okebukola (1990) found out in a study of nutrition that concept maps can be effective for affective as well as cognitive instructional objectives. They found out that there was a tendency for concept mapping strategy to significantly reduce anxiety towards biology achievement in males more than in females. Gakuyo (2004) carried out a study to investigate the effects of concept mapping strategy on students' conceptualization of some mathematical concepts and found a significant difference in conceptualization in favor of concept mapping teaching strategy. The study also focused on the students' ability to draw good concept maps. This study has yielded similar results in favor of concept mapping.

Asan (2007) carried out a study to determine the effects of incorporating concept mapping on the achievement of 5th grade students in a science class among Turkey students. The students from both experimental and control classes were exposed to the same teaching techniques covering the course on heat and temperature. After this, the experimental group was exposed to review by used of computer –based concept mapping whereas the control group was given review through traditional methods. The results of post-test indicated statistically significant differences in favor of the experimental group. In another study, Boujaoude and Attieh (2008) investigated whether or not the construction of concept maps by students improves their achievement and ability to higher order questions in chemistry. The participants were Grade 10 chemistry students in a high school in Lebanon. Findings indicate that there significant differences in scores in favor of the experimental group. Karukuyu (2010) investigated the effects of concept mapping on attitude and achievement in a physics course. The participants were 9th grade students in a high school in Turkey. Findings conclude that using concept mapping was more effective than traditional instruction in improving students' achievement in physics.

The use of concept mapping introduces constructivist teaching in a classroom. Constructivist teaching

moves students and teachers away from learning by rote to active and meaningful learning. Constructivist teaching places emphasis on active learner participation in authentic learning activities. Many researchers in science education recognize that learning is an active process in which learners have to actively construct meanings and knowledge either individually or through an interactive process in groups (Driver, 1989; Driver & Bell, 1986; Driver & Oldham, 1986). This implies that in constructivist epistemology, the learners are autonomous and inquisitive thinkers; the learning process is democratic and involves inventing ideas rather than accumulating facts. Although a number of factors have been investigated with regard to concept mapping, there are other factors that have not been sufficiently investigated for example the influence of gender on the use of concept mapping.

Purpose of the study and objective of the study

The purpose of the study was to investigate the effect of concept mapping teaching strategy on achievement and specifically to determine whether there are gender differences in achievement when concept mapping teaching strategy is used in the teaching of biology from an experimental perspective.

Hypothesis of the Study

The following null hypothesis was tested.

There is no statistically significant gender difference in achievement of students exposed to Concept Mapping Teaching Strategy.

Theoretical Framework

The study was based on Ausubel's theory of meaningful learning (Ausubel, 1978). According to Ausubel, learning takes place by assimilation of new concepts and propositions into existing conceptual and prepositional framework held by the learner. According to him meaningful learning results when learners consciously and explicitly tie new knowledge to relevant concepts they already possess. He further asserts that when meaningful learning takes place it produces a series of changes within our entire cognitive structure, modifying existing concepts and forming new linkages between concepts. Ausubel further asserts that that the fundamental process involved in meaningful learning is the incorporation of new concepts and propositions into a hierarchical cognitive structure. This incorporation involves more specific, less inclusive ideas being subsumed under more inclusive concepts and propositions into the cognitive structure.

Methodology

The study employed a non-equivalent, one group pretest-posttest control group design as a quasi-experimental research design. This study adopted the design because of ethical reasons of treatment of one group and denying the other. Again, once classes are constituted they exist as intact groups and school authorities do not normally allow such classes to be broken up and re-constituted for research purposes (Gall, Borg & Gall, 1996; Fraenkel & Wallen, 2008). The table below shows the diagrammatic representation of the research design.

Table 1 Diagrammatic representation of the research design

Pre -test Observations	Treatment	Post -test Observations
O_1	X	O_2

During the study, all the students were taught using the concept mapping teaching strategy.

Sampling Procedures and Sample Size

The study used district coeducational secondary schools to ensure that students involved had comparable abilities. A list of 24 district coeducational secondary schools in Siaya district was used as the sampling frame. Purposive sampling technique was used to select four schools that formed the study sample. For a school to be selected it had to meet the following criteria: 1)The students must have done the topic of gaseous exchange and were to the next topic of respiration to control for the variable of student exposure. 2) The teachers in the four schools must have had a teaching experience of at least 3 years to control for the teacher-experience variable. 3) The sampled schools had to have the number of boys and girls that were more or less the same for purposes of comparability. All the four classes were placed experimental treatment this produced a sample of 98 boys and 91 girls, giving a total sample of 189 students.

Instrumentation

This study used Biology Achievement Test (BAT) for data collection. The BAT was developed by the researcher and was based on the topic gaseous exchange that is a pre-requisite to respiration. The posttest was also developed by the researcher and was based on the topic respiration. Both tests had 14 items each and a maximum score of 40 marks. These items carried different marks ranging from 1-5. The tests had two sections A and B. Section A contained 9 items which focused on knowledge, comprehension and application of the basic concepts of gaseous exchange and respiration. Section B tested the students' ability to interpret and apply the concepts of gaseous exchange and respiration respectively. The items of BAT were derived from the specific objectives taken from KIE's approved biology education syllabus (KIE, 2002), Teachers guides, and student books.

To achieve curricular and content validity the instrument was presented to five experts in science education and three practicing secondary school teachers who had taught Form Two biology and had a teaching experience of at least three years. After piloting, each of the items was analyzed and the difficulty and discrimination indices computed. The difficulty indices of BAT pre-test items ranged from 0.1 to 0.8 where as its discrimination indices ranged from 0. 02 to 0.4. 0n the other hand the difficulty indices of BAT post-test ranged from 0.1 to 0.9 and discrimination indices ranged from 0.01 to 0.5. Gronlund and Linn (1988) recommend difficulty and discrimination indices within the range of 0.3- 0.7 and 0.2-0.5 respectively. However, Anastasi (1982) argues that the appropriate difficulty level depends on the purpose of the test. She further argues that for a test testing mastery of skills or knowledge, even very easy items or difficult items may be included. In this study, the items whose difficulty and discrimination indices were out of range were improved in consultation with the experts in science education and retained in the test.

The BAT pilot results were used to estimate its reliability. The Cronbach's Correlation Coefficient alpha (α) formula was used because it is considered appropriate for both essay and structured items, especially where the items are of varying difficulty and have a range of scores (Ary et al., 1972; Ebel, 1972; Anastasi, 1982). BAT pretest and posttest were found to have reliabilities of 0.82 and 0.80 respectively and, therefore, met the standards required for this study.

The construction and use of instructional materials

The researcher developed an instructional manual for the teachers to use during the treatment period. The manual was based on the revised Kenya secondary school biology syllabus. The teachers of the various classes were trained by the researcher on the skills of concept mapping teaching strategy for three days. Before treatment, a pre-test of BAT was administered to all the classes. After the pre-test, the teachers taught their students using concept mapping teaching strategy. The treatment period was four

weeks and the biology topic was respiration. During the study equal treatment was given to both boys in the course of the teaching and learning process. The participation of girls and boys in the learning process was monitored to ensure that all the students were actively involved. At the end of the treatment period, a post-test was administered to all the classes.

Data Collection

In this study, BAT was used to collect data. The researchers administered the instrument with the assistance of the biology teachers in the respective schools. All the classes were given pre-tests before the start of the experiment. This was followed by treatment to all the classes, which took four weeks. After the treatment, the researcher, with the assistance of biology teachers administered post-tests to the all the classes. The researchers then scored the tests. This generated quantitative data.

Data Analysis

The effect of the experimental treatment was determined by comparing the pretest and post test scores. Data were analyzed using independent sample t-tests. In detecting the differences between two means, t-test has superior quality (Gall et al, 1996).

Results

The pre-test BAT was administered to boys and girls. The students' mean scores were subjected to a t-test to compare whether there was a difference them. The results are presented in table 1.

Table 2 Independent sample t-test of the Pre-test scores on BAT

Gender	N	Mean	Std.Dev	t- value	df	p- value
Boys	98	19.631	3.284	12.443	187	0.000
Girls	91	13.819	3.134			

An examination of table 1 shows that the mean scores for boys and girls on BAT pre-test were statistically significant, since $t(187) = 12.443$, $p < 0.05$. This shows that there existed gender differences in achievement before the study. This can be attributed to the gender discriminative practices that existed in the classrooms before.

Effects of CMTS on students' achievement by gender

The BAT posttest was administered to all groups at the end of the treatment. The mean scores obtained were 24.063 for boys and 23.319 for girls respectively. These results show that both boys and girls had higher mean scores after the treatment period. Though the mean score of boys was higher than that of girls, it was necessary to carry out an independent t-test to detect the quality of the differences. The results are presented in table 2.

Table 3 Independent sample t-test of the Post-test scores on BAT

Gender	N	Mean	Std.Dèvt	- value	df	p–value
Boys	98	24.063	2.716	1.865	187	0.064
Girls	91	23.319	2.767			

The results show that there is no statistically significant difference between the means of boys and girls since $t(187) = 1.865$, $p > 0.05$. The null hypothesis that there is no statistically significant gender difference in achievement of students exposed to concept mapping teaching strategy was therefore upheld. This shows that gender disparities in achievement had been minimized after the experimental intervention.

Discussion

The results of this study show there is no statistically significant gender difference in achievement in biology between students taught using concept mapping teaching strategy. There is an indication that CMTS is a superior teaching strategy compared to the other methods that were prevailing before the intervention.

These findings are in agreement to previous findings made by studies that examined whether there is gender difference in achievement when students are exposed to concept mapping teaching strategy. For example in a study by Esiobu and Soyibo (1995) to determine the effects of concept Vee mappings on students cognitive achievement in ecology and genetics they found out that the post-test mean scores of boys was slightly higher than those of girls in all the groups under the study, however these differences were not statistically significant. Bello and Abimbola (1997) sought to examine gender influence on students' concept mapping ability and achievement in evolution. The findings from the study revealed that there is no gender influence on students' concept mapping ability and their achievement in evolution.

Orora, Wachanga & Keraro (2005) carried out a study to determine the effects of cooperative concept mapping teaching strategy on achievement which is a combination of concept mapping cooperative modes of learning they found out that there was no significant difference in achievement between boys and girls. In this study boys and girls were given equal opportunities to participate in the learning process through concept mapping. This enabled girls to perform as well as boys. Therefore, the gender differences in performance can be reduced by the adoption of concept mapping teaching strategy.

Conclusion

Based on the results of this study, the following conclusion has been reached:
Gender does not affect the students' achievement in biology when they are taught using concept mapping teaching strategy.

Implication of the study

The findings of this study have indicated that the use of concept mapping teaching strategy in the teaching of biology in secondary schools results in higher students' achievement and reduces gender differences in achievement. The strategy should therefore be used in biology teaching at secondary school level. The findings of this study indicate that if adopted, the concept mapping teaching strategy could minimize the gender disparities experienced in the performance of science subjects in school. Girls have been achieving lower scores in science at national examinations compared to boys. The implication is that this strategy could make students perform better in the examinations and reduce gender differences in achievement.

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