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EFFECT OF COLLABORATIVE CONCEPT MAPPING TEACHING STRATEGY ON STUDENTS' ATTITUDES TOWARDS CHEMISTRY IN SELECTED SECONDARY SCHOOLS IN KENYA

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ABSTRACT

In Kenya, the fundamental challenge facing teaching of chemistry as a science subject in secondary schools is how to enhance students' conceptual understanding as well as affective characteristics associated with teaching/learning process. The challenge has impeded students' attainment of meaningful learning. Based on this challenge, the present study was designed to determine the effect of Collaborative Concept Mapping (CCM) teaching strategy on secondary school students' attitude towards Chemistry learning. A Solomon-Four Group quasi-experimental research design was used in the study. Four co-educational secondary schools were randomly selected for the study from secondary schools in Bomet District. Students in the experimental groups were taught using CCM teaching strategy for 8 weeks while the rest were taught using conventional teaching methods. Students' Attitude Towards Chemistry Questionnaire (ATCQ) was used for data collection. The research instrument was pilot-tested for validity and reliability before being used in the study. Descriptive as well as inferential statistics were used in data analyses. These statistics included frequencies, mean, t- Test and ANOVA. All the statistical tests were subjected to a test of significance at alpha (α) level of 0.05. Results of the study showed that CCM as a teaching strategy had no significant effect on students' ATC.

Keywords: Collaborative Learning, Concept Maps and Attitude towards Chemistry

INTRODUCTION

Each country needs sufficient supply of high school graduates with an adequate knowledge of science to sustain its scientific and technological development as well as its economic well being (Keeve, 1999). Theories in economics and sociology link the level of scientific and technological development in a country with its national development (Opare, 1996). Generally, Science and Technology Education (STE) are regarded as a vehicle for economic and social development in a country (Shumba, 2003). However, scientific and technological development cannot be achieved unless the necessary scientific infrastructure is put in place, which in itself presupposes an adequate system of education.

In Kenya, education is expected to impart on the students the necessary knowledge and skills required for national development as well as inculcate the right attitude to work and administrative skills necessary for a smooth transitional process of a developing country (Republic of Kenya, 1981; KIE, 1992). Based on this premise, the government of Kenya policies on education is geared towards achieving quality education and training for its citizens to ensure overall success in its development strategies (Republic of Kenya, 2005). The Government of Kenya recently unveiled its grand plan (Vision 2030) for changing the country into a newly industrializing, middle-income country providing high quality life for its citizens by the year 2030 (Republic of Kenya, 2007). There is need therefore for Kenya,

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much more than before, to improve on the quality of science and technology education if the projected goal is to be realized.

The persistently low enrollment in science particularly in secondary schools and tertiary levels of education have aroused concern of science educators, researchers and policy makers the world over (Hardin & Hilderbrand,1988). As a result, most countries are seeking to improve their education standards by promoting programs that not only enhance effective acquisition of rapidly growing bodies of knowledge in a well organized framework, but also promote the learners' capability to learn meaningfully (Novak, 1998). In Kenya it has been noted that many students shun sciences especially when given an option; this especially applies to girls (Aduda, 2003). Students in Kenya have also been noted to perform poorly generally in sciences (Changeiywo, 2000). Perhaps the poor performance is the one that prompted the Government of Kenya through the Ministry of Education Science and Technology (MOEST), with the assistance of the Government of Japan through Japan International Co-operation Agency (JICA), to initiate a program on Strengthening of Mathematics and Sciences in Secondary School Education (SMASSE). Chemistry as a science subject is introduced to the learners in Kenya for the first time at secondary school level on splitting of primary school science into three branches; that is, biology, physics and chemistry. The knowledge of chemistry is necessary for understanding composition, properties and behaviour changes of matter that form the environment. The teaching of chemistry also aims at developing scientific concepts, principles and skills in the learners (KIE, 2002).

The importance of good teaching cannot be overemphasized; however, it is worth noting that good teaching encourages high quality students learning (Ramsden, 1995). Chemistry learning too often occurs by rote learning of factual knowledge (Gabel, 1999). Chemistry teaching has also often focused more on transmission of information than on knowledge construction in small groups (Zohar, 2004). Also, students often do not want to think for themselves, they just want to know the right answer (Lawson, 2002). Students have also been reported to often lack interest in studying chemistry (Asunta, 2003; Gräber, 1994; Lavonen, Juuti, Byman, Uitto & Meisalo, 2004; Osborne, 2003).

According to Novak and Gowin, meaningful learning occurs when individuals "choose to relate new knowledge to relevant concepts and propositions they already know" (Novak & Gowin, 1984:7). This calls for commitment on the part of the learner to link new concepts with higher order and more inclusive concepts that are already understood by the learner that can serve to anchor new learning and assimilate new ideas (Novak, 1993). The commitment aspect calls for interest and general positive attitudes toward learning process as well as the subject being studied by the student. Perhaps this is why research in science education stresses the need of fostering affective relationships in science instructions (Haladyna & Shaughnessy, 1982; Lederman, 1992). Affective characteristics thus form a base upon which meaningful learning can be promoted. Efforts made to translate the new conceptions of learning into classroom practices include development of instructional methods that engage learners actively in the process of knowledge acquisition; Collaborative Concept Mapping (CCM) teaching strategy proposed in the present study is perhaps one of the ways towards this end.

Despite the apparent importance of both the affective and cognitive aspects of the learners in development of meaningful learning, research on the two aspects in relation to teaching and learning strategies among the learners in Kenya is limited. Much of the research that has been carried out in Kenya as relates to teaching/learning process centered on the cognitive aspects of the learners in terms of achievement; instructional methods used by teachers; attitudes

towards science and mathematics as well as factors that affect science performance (Barchok, 2006; Changeiywo, 2000; Eshiwani, 1974; Kyalo, 1984; Wanjala, 1984; Mondoh, 1986; Maundu, 1986; Wachanga, 2002). None of these studies sought to find out how a teaching strategy affects students' affective characteristics with an aim of promoting meaningful learning. In an attempt to fill this gap, this study investigated the effect of Collaborative Concept Mapping (CCM) teaching strategy on students' attitudes towards chemistry learning.

HYPOTHESIS OF THE STUDY

The following null hypothesis was postulated and tested at 0.05 α level of significance:

$H_0$1**:** There is no significant difference in Attitudes Towards Chemistry as a subject between students exposed to CCM teaching strategy and those not exposed to it.

METHODOLOGY

Research Design

The study adopted a Solomon Four Group quasi-experimental research design. The research design is represented as follows:-

Group 1 (E_1) O_1 X O_2

Group 2 (C_1) O_3 __ O_4

Group 3 (E_2) __ X O_5

Group 4 (C_2) __ __ O_6

Where: O_1 and O_3 are pre-tests

O_2; O_4, O_5, & O_6 are post-test

X is the treatment where students will be taught by use of CCM

-------- indicates non-equivalent groups

Group 1 is the experimental group which received the pretest (O_1), the treatment (X) and the post-test (O_2). Group 2 is the true control group which received a pre-tests (O_3) followed by the control condition and finally a post-test (O_4). Group 3 received the treatment (X) and post-test (O_5) only, but did not receive pretest while Group IV received post-tests (O_6) only. Groups 2 and 4 were taught through the conventional teaching methods.

Participants

The target population of the study was Form Three chemistry students in secondary schools in Kenya. The accessible population however was the 4,231 chemistry students in co-educational secondary schools in Bomet District. Based on the research design adopted, four (4) Co-educational secondary schools were selected for the study using cluster sampling technique. Preliminary assessment of all the schools was done before sampling to ensure that all the schools selected meet the minimum standards required for the study. Preliminary information sought included experience and qualification of chemistry teachers as well as extent of syllabus coverage in form three chemistry classes. The 4 schools selected were randomly assigned into treatment and control conditions to form 4 groups. A total of 166 students participated in the study.

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Research Instrument

Mole Concept Achievement Test (MCAT) was administered to the students to determine the students' achievement level 1 (MCA1) on the topic "mole concept". To enhance reliability and validity, the instrument was piloted in schools from the neighboring Narok District. The test was also given to two expert in science education and two experienced chemistry teachers to assess the content as well as the appropriateness of the test to Form Three chemistry students.

Data Collection Procedures

Chemistry teachers from participating schools were trained by the researcher on construction of concept maps as well as the expectations and procedures on CCM teaching strategy. Ethical issues in the study were also addressed during the training of these teachers. This was done to ensure that all the teachers involved in the research adhered to the standard conduct of research. To ensure that there was as much uniformity in the presentation of content on the chosen topic; the researcher met with all the four teachers involved in the study on weekly basis. In these meetings discussions on the content, problems as well instructional approaches applied was done. Emphasis on certain aspects of teaching was also addressed in these meetings; this was particularly important to ensure that teachers in experimental group adhered to all the set instructional conditions of the treatment. Teachers in the experimental group were also issued with instructional manuals specifically designed for the topic of "mole concept" to enhance their adherence to treatment conditions. All the teachers involved in the study adopted a common schemes of work developed jointly with the researcher for the topic of mole concept; this ensured that the intended content was covered uniformly for all the groups involved in the study.

Before the treatment started, students in experimental groups were trained by the respective teachers on concept mapping skills for a period of two weeks. After this period pretest was administered to group 1 and group 2. The treatment was then administered for a period of 8 weeks. The control groups were taught using regular teaching methods. Soon after the treatment period, a posttest was administered. The research instruments were administered by the researcher with help of subject teachers in both the pretest and posttest.

RESULTS AND DISCUSSION

Effect of Collaborative Concept Mapping on Students' ATC

In this study, ATC was taken to mean a moderately intense emotion that predisposes a student to respond consistently in favourable or unfavourable manner towards chemistry as a subject. ATC was conceived in a model having four dimensions, namely: Liking of chemistry; Relevance of chemistry; Usefulness of chemistry and Career interest in the field of chemistry. Operationally, ATC was defined as a composite variable derived from mean score of non-missing students' response on 32 items measuring the constract on a 5-point Likert Scale, that is: Strongly Disagree (SD)=1; Disagree (D)=2; Undecided (U)=3; Agree (A)=4 and Strongly Agree (SA)=5. Negative statements were scored in a reverse order. The mean scores on pretest measurement on ATC in group 1 and group 2 are as shown in Table 1.

Table 1. Pre-test Mean Scores on ATC

Group	*Mean*	*SD*
1 (Experimental 1)	125.8478	25.56036
2 (Control 1)	130.3171	14.28363

The means were 125.8478 and 130.3171 for group 1 and group 2 respectively out of a maximum score of 160 points. The results showed that the students in the two groups had moderately favourable ATC (mean>80). To find out whether there was any significant difference in the two means, an independent t-Test was performed.

Table 2. t-Test on ATC Pre-test Scores

		Levene's Test for Equality of Variances				
		F	*Sig.*	*T*	*df*	*Sig. (2-tailed)*
PRE ATC	Equal variances assumed	6.479	.013	-.990	85	.325
	Equal variances not assumed			-1.021	72.100	.311

Results of the analysis presented in Table 2 showed that there were no significant difference in the two means ($t_{(85)} = -0.990$, $p>0.05$). The results meant that the two groups of students were predisposed to the same level on their ATC prior to exposure to CCM intervention. The Sum, Mean and Standard Deviation (SD) for the 4 dimensions on ATC; that is Liking of Chemistry, Relevance of Chemistry, Utility of Chemistry and Career interest in Chemistry field are summarized in Table 3.

Table 3. Summary of Students Response on the four Dimensions of ATC

Dimension	*Group*	*N*	*Sum*	*Mean*	*SD*
Liking of Chemistry	1	41	1976.00	48.1951	9.24992
	2	41	1999.00	48.7561	8.16327
	3	43	2037.00	47.3721	12.39052
	4	41	1845.00	45.0000	11.20491
Relevance of Chemistry	1	41	909.00	22.1707	4.12857
	2	41	891.00	21.7317	3.60572
	3	43	937.00	21.7907	5.47965
	4	41	846.00	20.6341	4.84126
Utility of Chemistry	1	41	1077.00	26.2683	6.02920
	2	41	1071.00	26.1220	5.96739
	3	43	1106.00	25.7209	6.35957
	4	41	1003.00	24.4634	6.91772
Career interest in Chemistry field	1	41	1075.00	26.2195	5.79013
	2	41	1064.00	25.9512	6.10308
	3	43	1145.00	26.6279	7.49928
	4	41	913.00	22.2683	7.30761
Overall ATC	*1*	*41*	*5037.00*	*122.8537*	*22.45948*
	2	*41*	*5025.00*	*122.5610*	*21.03455*
	3	*43*	*5225.00*	*121.5116*	*30.17202*
	4	*41*	*4607.00*	*112.3659*	*27.41601*

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From Table 3 the overall means for ATC are 122.8537, 122.5610, 121.5116 and 112.3659 out of the possible maximum score of 160 points respectively for group1, group 2, group 3 and group 4. This showed that generally, the students in all the four groups have moderately favourable ATC (mean>80).

Tests on homogeneity of variance on students' means on ATC in the four groups showed that the Levene's statistic on equality of variance was not significant (p>0.05); this meant assumption on homogeneity of variance was tenable (a requirement to run ANOVA). The results of this analysis are presented in Table 4.

Table 4. Test on Homogeneity of Variance on ATC

	Levene Statistic	*df1*	*df2*	*Sig.*
Relevance	2.034	3	162	.111
Likechemi	2.289	3	162	.080
Utility	.425	3	162	.736
Career Interest	2.358	3	162	.074
Atc	2.348	3	162	.075

Since assumption on homogeneity of variance was met, ANOVA was run to find out whether there were any significant differences in means of the four groups. The results of this analysis are presented in Table 5.

Table 5. ANOVA Results on ATC

		Sum of Squares	*Df*	*Mean Square*	*F*	*Sig.*
Relevance	Between Groups	53.837	3	17.946	.855	.466
	Within Groups	3400.482	162	20.991		
	Total	3454.319	165			
Liking	Between Groups	336.731	3	112.244	1.036	.378
	Within Groups	17558.047	162	108.383		
	Total	17894.777	165			
Utility	Between Groups	82.745	3	27.582	.688	.560
	Within Groups	6491.285	162	40.070		
	Total	6574.030	165			
Career Interest	Between Groups	504.671	3	168.224	3.718	.013
	Within Groups	7329.022	162	45.241		
	Total	7833.693	165			
ATC	Between Groups	3086.452	3	1028.817	1.570	.199
	Within Groups	106175.476	162	655.404		
	Total	109261.928	165			

The results in Table 5 showed that there was no significant difference in the means in the 4 dimensions of ATC except in career interest. Overall there were no significant differences in the means of students in the 4 groups. The result suggests that CCM teaching strategy as an intervention had no effect on ATC of students in the experimental groups (group1 and group 3). The finding let to the acceptance of the null hypothesis that stated that there is no significant difference in Attitudes towards Chemistry (ATC) between students exposed to CCM teaching strategy and those not exposed to it.

DISCUSSION OF THE RESULTS

A positive attitude among students is an important goal of science education in many jurisdictions (Mayer, Mullen & Moore, 2000). The use of Collaborative Concept Mapping teaching strategy (CCM) as proposed in this study was expected to enhance development of favourable Attitudes towards Chemistry (ATC) among secondary school chemistry students. The assumption was based on the anecdotal evidence from teachers as well as research findings suggesting that students' attitudes toward a subject is influenced by the instructional methods used. Tinto (2003) highlighted five conditions necessary to promote persistence within a course as expectations, support, feedback, involvement and learning. CCM teaching strategy is expected to offer students opportunity to integrate these five conditions into a chemistry classroom developing their knowledge as well as improving on their attitudes towards chemistry.

Results on analyses of means on ATC showed that students in the experimental groups as well as those in the control groups all had favourable ATC. ANOVA results also showed no significant difference on experimental groups (group 1 and 3) and control groups (group 2 and 4) means on ATC at 0.05 α levels. The results suggest that CCM as a teaching strategy had no significant effect on development of ATC among students in experimental groups. This led to acceptance of the null hypothesis which stated there is no significant difference in Attitudes towards Chemistry (ATC) between students exposed to CCM teaching strategy and those not exposed to it.

The findings of this study are consistent with results obtained by Wasanga (1997) who also reported general moderately positive attitudes towards science among students in Kenya. The findings are also in agreement with research findings in other countries; for example in Hungary, Duncan (1989) reported that both boys and girls generally have positive attitudes towards science. An international assessment of science students in 20 countries by the International Assessment of Educational Progress (IAEP, 1992) also reported similar trends. The IAEP study showed that a significant majority of the 20 countries assessed had positive attitudes towards science for both male and female students despite a general performance gap that was prevalent in nearly all of the countries.

Science and Technology Education (STE) is attached a lot of value in the society among developing countries (Harding, Hilderbrand & Klainin, 1989). Kenya being a developing nation has laid a lot of emphasis in science education; this need being more urgent if the envisaged goals in Vision 2030 are to be realized. As a result of this need, STE has received a lot of support from all the determinants of education system in the recent past; which includes curriculum planners, school community, textbooks and material publishers. Perhaps it is as a result of these multi-directional campaigns that all the students irrespective of their socio-background history do have favourable ATC as reflected by the findings of the present study.

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However, the short intervention period of 8 weeks is probably one of the reasons that can account for the negative results. Research has demonstrated that concept mapping is a skill that requires time for mastery before one appreciates its usefulness (Beyerebach & Smith, 1990; Brandt *et al*., 2001). A meta-analysis conducted by Horton *et al.,* (1993) showed that positive effects of concept mapping were achieved in studies that ranged in length from 12 to 22 weeks. Novak, Gowin & Johansen (1983) found that 7th and 8th grade science students who used concept mapping demonstrated superior problem-solving performance after six months of use. Thus the short period of intervention in this study was unlikely to have had any meaningful effect on development of ATC.

Moreover, the results of this study echoed findings of Chee and Wong (1996) on effect of incorporating concept mapping into Computer Assisted Instruction (CAI) in Singapore. In the study, students generally showed favourable attitudes towards chemistry and towards CAI but no significant difference in attitudes towards chemistry and towards CAI were found among the three groups of students involved in the study. It is worth noting that the intervention period in the study was short just as was the case in the present study. The short period of intervention was pointed out as one of the reasons why CAI had little effect on the attitudes of the students.

Even though this study showed that CCM as a teaching strategy had no significant effect on attitudes toward chemistry as a subject, it cannot be ruled out that CCM would have an effect, if other measures of attitudes were employed or if a different topics was used. Although attempts were made to ensure that the learning environment of all the students involved in the study was similar as possible; it is important to appreciate the possibility that attitudes toward chemistry can be shaped by non-school influences (e.g., media, peers, parents). This possibility is plausible especially with respect to topics perceived to be abstract and difficult such as “mole concept” dealt with in the present study. Studies investigating effect of various instructional methods have suggested use of mixed methods approach for concurrent triangulation and corroboration of findings within a single investigation (Cresswell, Clark, Gutmann, & Hanson, 2003; Clary & Wandersee (2007). The use of quantitative methods of data collection alone in this study might have been limiting, bearing in mind the multi-dimensional aspect of attitude, a psychological construct, which has implication for cognitive, affective as well as behavioral characteristics of the learner.

IMPLICATIONS OF THE STUDY

The present study showed no evidence that CCM teaching strategy has any significant influence on the development of ATC among the students studied. Generally however, all the students who participated in this study irrespective of the group showed moderately favourable ATC in both in the pretest and posttest analyses. This suggests that chemistry as a subject in the curriculum does not appear to be a disliked subject. This means that the students’ perception of chemistry as a science in the curriculum has changed for the better. Chemistry teachers and educators in Kenya should not blame the poor achievements of students in chemistry examinations entirely on unfavourable attitudes towards the subject. This notwithstanding, research has shown that achievement and attitudes towards a subject influence each other positively (Zekele, 2000); but neither attitudes nor achievement is dependent on the other, rather they interact with each other in a complex and unpredictable ways (Dossey *et al*., 1987). It is imperative that chemistry teachers and all education stakeholders in Kenya play their role in maintaining and strengthening the favourable trends in chemistry education. They can achieve this by upholding and advocating for positive attitudes towards chemistry as a subject. Negative disposition towards subjects, especially by

teachers, affects students adversely since teacher/student relationship and interaction is crucial for the students in their attitude formation (Kaplan, 1990).

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