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

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Abstract:
Achievement level in Mathematics in Secondary Schools in Kenya is still low despite numerous interventions. Conceptual understanding and attitudes have emerged in recent discoveries as the critical factors contributing to the continued inertia in performance in the subject. This study sought to establish the effect of Collaborative Concept Mapping (CCM) teaching strategy on secondary school students' development of cognitive and affective domain. Specifically, the study sought to find out if there was any difference in Students' achievement in mathematics, as a group and gender wise, and students' attitude toward Mathematics subject when taught using the Collaborative Concept Mapping Teaching Strategy and the Conventional Methods of Instruction. The theoretical framework is based on constructivist theory which views learners as active constructors of meaning from input by processing it through existing cognitive structures and retaining it in the long-term memory. This study used a Quasi-experimental Solomon Four-Fold research design. The sample for the study comprised 161 form three students and 4 teachers of mathematics from 4 randomly selected sub-county co-educational secondary schools in the 4 sub-counties of Bomet County. The four co-educational schools were randomly assigned into two experimental (E_1 & E_2) and two control (C_1 & C_2) groups. Students in the experimental group were taught using Collaborative Concept Mapping (CCM) Teaching Strategy for three weeks while the control group was taught using Conventional Methods of Instruction. Students' Attitude Towards Mathematics Questionnaire (SATMQ) was used to collect data. Circles Concept Achievement Test (CCAT) was administered to determine students'

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conceptual understanding and achievement on the topic of 'circles concept' in Mathematics. Descriptive and inferential statistics were used in data analysis which 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. The results revealed that there was statistically significant difference in mathematics achievement and attitudes towards mathematics in favour of CCM between students exposed to Collaborative Concept Mapping teaching strategy (CCM) and those taught using Conventional Method of Instruction. The findings further revealed that there was no statistically significant gender difference among students exposed to CCM teaching strategy. From the findings it can be concluded that the level of achievement in the learning of mathematical concepts and the attitude towards mathematics is marked higher when the students are taught using the Collaborative Concept Mapping Teaching Strategy (CCM) than when the conventional method is employed. Based on the findings, recommendations were made on the need for teachers to integrate Collaborative Concept Mapping Teaching Strategy (CCM) teaching strategy in the mathematics instruction to enhance conceptual understanding, improve achievement and foster positive attitude in the subject. There is also need for teacher training institutions to incorporate CCM as one of the strategies in mathematics instruction and that the serving teachers can be retooled to enable them to integrate CCM teaching strategy effectively in Mathematics learning. Mathematics curriculum developers need to restructure and integrate CCM among learner-centred strategies in Mathematics education.

Keywords: collaborative concept mapping, attitude, achievement, mathematics

1. Introduction

In the current highly competitive knowledge-based economy of the 21st century, education is the most vital strategy for socio-economic development across the world (Aikman & Unterhalter, 2005). For individuals and states it is key to creating, applying, and spreading knowledge and thus to the development of dynamic, globally competitive economies (World Bank report, 2011). It also helps the individual to realize their highest potential by preparing them for the future challenges in life (Sharma, 2012). Kenya Vision 2030 aims at making Kenya an industrialized, middle income country providing high quality life for all its citizens by the year 2030. Kenya's economy like other countries' economies requires a steady supply of scientifically and technologically knowledgeable human resource (Mutahi, 2009). This underscores the immense role science and technology play in the development of a country. Hence, students should be well-equipped with the necessary knowledge and skills in science and technology to perform in the modern economy. Mathematics is the cradle of all innovations, without which the world cannot move forward. Mathematics makes our life orderly and prevents chaos. Certain qualities that are nurtured by mathematics are power of reasoning, creativity, abstract or spatial thinking, critical thinking, problem-solving ability and even effective communication skills. Be it a cook or a farmer, a carpenter or a mechanic, a shopkeeper or a doctor, an engineer or a scientist, a musician or a magician, everyone needs mathematics in their day-to-day life (Guwahati, 2015*)*.

Mathematics is also a very important subject in the school curriculum and a strategic subject in the learning of other subjects and development of science and technology. Hence any citizen of any country should attain a reasonable level of mathematical literacy if adequate levels of scientific and technological development are to be achieved. Mathematics has not only found its usefulness in academic areas such as Science, Medicine, and Engineering but also in the day to day operations of businessmen, sportsmen, and even farmers (Thomaskutty, 2010). The Kenya Government recognizes the importance of Mathematics and the subject was made compulsory both at primary and secondary school levels soon after independence in 1963 (K.I.E, 1979). Secondary mathematics aims at producing a person who is numerate, orderly, logical, accurate and precise in thought. The person should also be competent in appraising and utilising mathematical skills in playing a positive role in the development of a modern society (K.I.E: 2002). Thomaskutty (2010) gives examples of the Egyptian, Mesopotamian, and Greek civilizations, which were advanced alongside Mathematics. Mathematics is not only important for its practical use but also for its aesthetic appeal just like the study of poetry, music, painting, and literature. Simply put, people study mathematics because it is one of the loveliest disciplines known to humankind (Phillips, 2008).

Although mathematics is an important subject in the school curriculum, the performance of students in the subject at KCSE level has been dismal over the years. Low achievement in mathematics is attributed to poor interpretation of questions, poor grasping of concepts and failure to relate Mathematics knowledge to real life situation (KNEC, 2014, 2013, 2012, 2011, 2010). Research findings have also cited the following factors as responsible for the dismal performance of students at this level: students' negative attitudes towards the learning of Mathematics (Eshiwani, 1986; Ogoma, 1987; Badmus, 2002 & Obodo, 2004), parents/guardians educational level (Kipkemoi, 2006), insufficient learning materials (Kiragu, 1988; Muraya and Kimamo, 2011), gender difference (Agwagah, 2000) and teachers' use of inappropriate teaching methods which make students become passive and have less interaction with each other in doing task (Zakaria, Solfitri, Daud & Abidin, 2012, Muraya and Kimamo, 2011; Harbour-Peters, 2001; Gambari, 2010). Poor teaching method is cited as one of the major factor influencing poor achievement and retention (Osemwinyen, 2009; Tolu, 2009).

Research has demonstrated that additional affective factors, such as beliefs, attitudes, predispositions based on prior learning experiences, personal experience, goals, subjective perceptions, confidence, and motivation, also greatly affect students' abilities to learn and apply statistical reasoning skills (Gal & Ginsburg, 1994; Gal, Ginsburg, & Schau, 1997; Gordon, 1995). For example, Perepiczka, Chandler, and Becerra (2011) found that attitudes toward statistics along with statistics anxiety significantly relate to self-efficacy to learn statistics, which Finney and Schraw (2003) linked to course performance measures. Attitudes towards subjects are the important determinants of academic success and achievement. To succeed in a subject, positive attitude towards a subject is a prerequisite. Other studies have shown that classroom strategies used to teach a subject are influenced by teacher attitudes that, in turn, influence pupil attitudes (Carpenter & Lubinski, 1990). Of interest is how mathematics teachers produce positive attitudes in their students by use of collaborative concept mapping instructional strategy.

Gender differences in mathematics performance have also been identified as an area of concern and have also focused on attitude that students have towards mathematics. Several studies have reported that there are gender differences in attitude towards mathematics with girls showing more negative attitudes than boys. In general, most of the studies reported that, compared with boys, girls lacked confidence, had debilitating causal attribution patterns, perceived mathematics as a male domain, and were anxious about mathematics (Vermeer et al, 2000). Studies that compared gender differences in mathematics' self-confidence have mostly reported that girls had lower self-confidence in mathematics than boys (Case et al., 1997; Norton and Rennie, 1998). In some cases, boys were more confident than girls even when their mathematics achievement was like that of girls (Casey et al., 1997).

Reports emanating from international studies have highlighted implications for improving instruction in mathematics and science teaching with a call for professional competence for practicing teachers (Gonzales, et al., 2009). The use of teacher-centered Traditional Teaching Methods (TTM) is pre-dominant in the teaching of Mathematics. The most widely used TTM is the Lecture Method (Taylor & Francis, 2011). UNESCO (1986) suggested adoption of teaching approaches that have the potential to motivate learners and involve them in active knowledge construction. Collaborative Learning (CL) is one such approach that engages learners in active learning where they work and learn together in small groups to accomplish shared goals (Panitz, 1996). The need for improved achievement in Mathematics has made teachers and researchers seek appropriate Learner-centered instructional strategies which allow students to control their learning process as well as develop the required interest in mathematics. Learner-centered teaching approaches promote imaginative, critical and creativity skills resulting in better achievement (Ministry of Education, 2001)

Several efforts have been made globally, regionally and nationally to improve the performance of mathematics. In another research by Keitany (2014) in Marakwet West Sub-County to assess the impact of SMASSE in-service training, found that despite the launching of the SMASSE INSET to cover the whole country in the year 2003, it was found that the performance of secondary school students in mathematics at KCSE level has been very low. These points to the need to improve mathematics instruction by use of innovative methods that are student centred. Mathematics instruction should provide students with opportunities to engage in mathematical inquiry and meaning making through discourse. Teachers should encourage this process by creating a conducive classroom environment and remaining flexible and responsive to students' response and feedback (NCTM, 2000).

Learner-centered teaching approaches promote imaginative, critical and creativity skills resulting in better achievement (Ministry of Education, 2001). Collaborative Learning is one such approach that engages learners in active learning where they work and learn together in small groups to accomplish shared goals (Panitz, 1996). This approach is characterized by group discussions which allow learners' expression and revision of their beliefs in the context of discourse (Sharan & Sharan, 1992; Bereiter & Scardamalia, 1993; Olson & Bruner, 1996). More specifically, collaborative learning is based on the model that knowledge can be created within a population where members actively interact by sharing experiences and take asymmetric roles. Collaborative Learning has positive effects on students' discussions in which they elaborate on the subject, challenge and amend one another's ideas, and thus remember these ideas more easily (Cohen, 1984).

Concept mapping is a visual representation of an individual's knowledge structure on a topic (Novak & Gowin, 1984; Novak, 1990). Concept map was developed by Joseph Novak based on the cognitive theories of David Ausubel (Assimilation Theory) who stressed the importance of prior knowledge to gain deep learning on new concepts, thus by understanding what you already knew, and relating new concepts to what you knew, meaningful deep learning can easily occur. Concept maps are used to evaluate how students organize their knowledge and give an observable record of their understanding. Several researchers like Ausubel (1968), Novak & Gowin (1984), Malone & Deckers (1984), Markham and Mintzes (1994), McClure et al (1999) have recognized the advantages of this form of information presentation and have used concept mapping strategies in order to see how the individuals structure their knowledge as the subject matter. It organizes knowledge in an understandable visual way and connects prior knowledge with new concepts by utilizing a visual structure for planning and thinking (Christodoulou, 2010).

In learning mathematics, it is important for students to use the correct mathematical terminology, learn how to translate mathematical expressions into verbal problems and how to translate verbal problems into mathematical expressions that can be worked with (Askey, 1999). In addition, noting the importance of communication in the mathematical process, Kotsopoulos (2007) points out that students experience interference when they borrow language from their everyday lives to use in their mathematics world, such that their inability to minimize this interference could potentially undermine their ability to learn. Based on this point, Adler (1999) suggests that it is important for teachers to set up learning opportunities that encourages students to use mathematical language themselves, to better grasp the underlying mathematical meaning of concepts (as cited in Kotsopoulos, 2007). To achieve these benefits as outlined by Adler, teachers must create environments free of hierarchies and encourage collaborations amongst students. In the same breath; they must remain mindful of their use of vocabulary because they directly contribute to students' understanding of concepts (Gay, 2008). By encouraging students to verbalize what they mean and reiterate what their peers have said, teachers can make it easier for reluctant students to contribute (Manouchehri & St. John, 2006). This is based on the premise that explicitly referencing and building on the ideas of others, is a feature of academic and professional discourse (Choppin, 2007). The study reported in this paper sought to illustrate how a teacher can effectively orchestrate classroom discourse so that students better grasp the underlying meaning of mathematical concepts by use of Collaborative Concept Mapping Approach.

Collaborative Concept Mapping Teaching Approach (CCMTA) is a hybrid teaching/learning strategy involving an interaction between two or more individuals during concept mapping to create a shared understanding of a concept, discipline or area of practice that none had previously possessed or could have come to on their own (Johnson, Johnson & Smith, 1991). Collaboration is achieved among the group through evaluation, questioning, discussion and debate with others. Collaborative concept mapping is a great tool to use during a learning session for students to check their understanding together and build on what they already know and is likely to be an effective summative assessment technique that enhances rich discussions amongst students.

Research has revealed that use of effective student-centered instructional approaches has a significant impact on the learning outcome, especially in abstract topics (Sola and Ojo, 2007). Collaborative Concept Mapping is such strategies which Mathematics teachers should employ to enhance achievement in the subject. Research findings show that a teaching method is a crucial factor affecting students' learning and achievement (Kiboss, 2004; Ndirangu, 2000; Wachanga, 2002, Waihenya, 2000). In almost all Kenyan schools, conventional/traditional methods of teaching which cannot prepare learners appropriately dominate the classroom. Poor teaching methods, limited classroom interactions and poorly motivated students have been cited as major contributing factors. The conventional methods of instruction currently in use for teaching mathematics in most secondary schools in Kenya are strongly thought to contribute to learners' inability to achieve meaningful mathematics learning. This study reported in this paper sought to investigate the effect of Collaborative Concept Mapping Teaching Strategy (CCMTS) on Secondary Schools students' achievement and attitude toward Mathematics.

2. Purpose and Objectives of the Study

This study sought to establish the effect of Collaborative Concept Mapping (CCM) teaching strategy on students' development of cognitive and affective domain. Specifically, it sought to:

1) Find out if there was any difference in Students' achievement in mathematics when taught using the Collaborative Concept Mapping Teaching Strategy and the Conventional Methods of Instruction.
2) Find out if there was a gender difference in students' achievement in mathematics when exposed to Collaborative Concept Mapping teaching strategy and Conventional Methods of Instruction.

3) Find out if there was any difference in students' attitudes toward mathematics when taught using the Collaborative Concept Mapping teaching strategy and Conventional Methods of Instruction.

3. Hypotheses of the Study

The following three null hypotheses were tested at an alpha (α=0.05) level of significances.

Ho1: There is no statistically significant difference in the achievement in mathematics between students exposed to Collaborative Concept Mapping (CCM) teaching strategy and those taught using Conventional Methods of Instruction.

Ho2: There is no statistically significant gender difference in students' achievement in mathematics when students are exposed to Collaborative Concept Mapping teaching strategy

Ho3: There is no statistically significant difference in the attitudes towards mathematics subject between students taught using Collaborative Concept Mapping teaching strategy and those taught using Conventional Methods of Instruction.

4. Theoretical and Conceptual Framework of the Study

This study was conducted within an interpretive paradigm with a constructivist view of learning. In constructivist teaching and learning, learners are expected to actively construct meanings of concepts. They are expected to construct meanings from input by processing it through existing cognitive structures and then retaining it in long term memory (Okere, 1996). The social constructivist view of learning is based on the notion that knowledge is first constructed in a social context and is then taken up by individuals (Guba & Lincoln, 1994; Eggan & Kauchak, 2004). According to social constructivists, the process of sharing each person's point of view, called collaborative elaboration (Meter & Stevens, 2000), results in learners building understanding together that wouldn't be possible if they worked individually (Greeno, Collins & Resnick, 1996). The internal construction of knowledge is viewed as being driven primarily by social interaction (Wertsch, 1985). Collaborative Concept Mapping Teaching Strategy was found to be consistent with social constructivism in its dimension of learning as learners engaged in active knowledge construction through social negotiation rather than competition. The dependent variable in this study was learners' attitude towards mathematics and achievement in mathematics. In an ideal situation, the teaching influences learners' achievement. However, various intervening variables such as teacher and learner characteristics including teacher's gender, training and experience, the class room environment, type of school and learners' age, academic ability may affect the expected outcome. Gender differences in academic achievement were built into the study as a dependent variable. To control for classroom environment, the study involved co-educational schools where boys and girls learn together in the same classroom. Type of school was controlled by involving one category of schools, the Sub-county secondary schools which enroll most learners at the secondary school level in the County and generally in Kenya. Learners in each category of schools are of comparable academic ability because the Kenya Certificate of Primary (KCPE) examination scores is used for placement in secondary schools.

The researcher believes that CCM will enable the learners draw associations among the concepts.

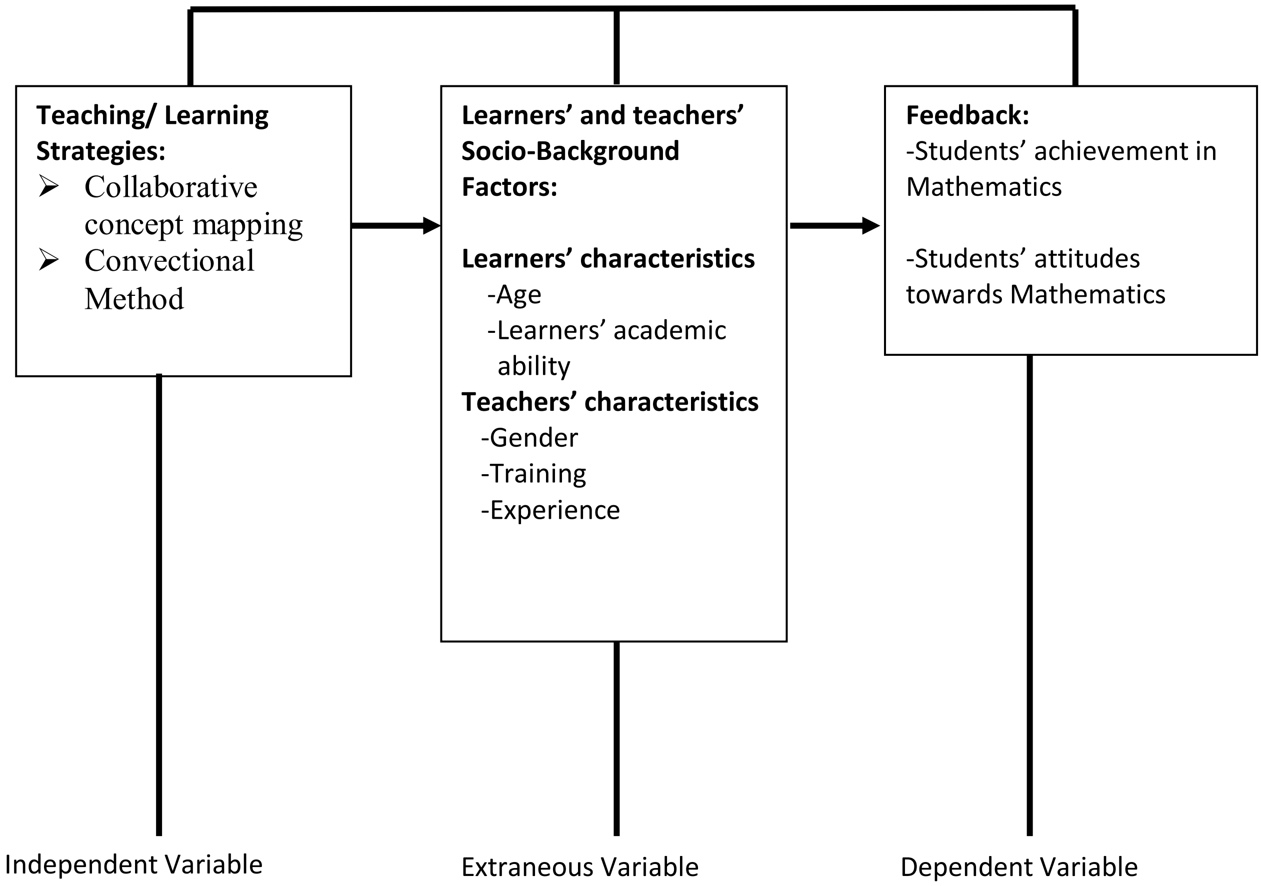

Figure 1: Conceptual Framework of the Study
(Source: The author)

Hypothetically, CCM teaching strategy influence achievement and attitudes towards Mathematics directly or indirectly through complex interaction with learners' and teachers' socio-background factors as shown by the direction of the arrows in in Figure 1. Learners' age and academic ability was controlled by selecting form three class and involving one category of schools, sub-county co-educational schools, respectively. Sub-county schools enroll most learners at the secondary school level in the county. Learners in each of the category of schools are of similar academic ability since the Kenya Certificate of Primary (KCPE) examination marks are used for placement in secondary schools. Teachers' characteristics including gender, training and experience was controlled by purposely selecting male trained teachers with teaching experience of at least three years in the service.

5. Methodology

This study employed the Quasi Experimental design in which the researcher used the Solomon Four Non-Equivalent Control Group Design approach using both quantitative and qualitative analysis frameworks. The design is considered rigorous enough and appropriate for quasi-experimental studies (Fraenkel & Wallen, 2000). Non-equivalent group is deemed appropriate because classes in secondary school once constituted exist as intact groups and school authorities do not normally allow such classes to be broken up and reconstituted for research purposes (Borg & Gall, 1989; Fraenkel & Wallen, 2000; Trochim, 2006). Hence it was not possible to break classes into research groups and randomly assign treatment as required in true experimental designs. The schools were randomly selected and assigned treatment and conditions as intact groups. The research design is represented as shown figure 2 below:

Figure 2: The Solomon Four-Fold Design

Group 1(E_1)	O_1	X	O_2
Group 2(C_1)	O_3	C	O_4
Group 3(E_2)	_	X	O_5
Group 4(C_2)	_	C	O_6

Where:
O_1 and O_3 are pre-tests
O_2, O_4, O_5 and O_6 are the post-tests
X is the treatment in which the students were taught using CCM
C is control condition.
_ indicates no pre-test
…. indicates non-equivalent groups

Group 1 represents the experimental group which received the pre-test (O_1), the treatment (X) and the post-test (O_2). Group 2 is the true control group which received a pre-test (O_3), the control condition and a post-test (O_4). Group 3 received treatment and post-test (O_5) only while Group 4 received post-test (O_6) only. Groups 1(E1) and 3(E2) were taught using CCMTS while groups 2(C1) and 4(C2) were taught using conventional method of instruction.

This design helps the researcher to assess the effects of the experimental treatment relative to the control condition, the interaction between pre-test and experimental conditions, the effects of the pre-test relative to no pre-test and the homogeneity of the groups before administration of the treatment (Gall and Gall, 2007). To control for interaction between selection and maturation the schools were randomly assigned to control and treatment groups. The duration for the research study was three weeks. To control for selection and history both pre-test and post-test were administered simultaneously to the control and experimental groups whereas interaction between selection and instrumentation was controlled by ensuring that the conditions under which the instruments were administered were kept as similar as possible in all the sampled schools (Gall, Borg & Gall, 1996). An instructional manual for teachers was developed based on the approved Kenya Institute of Education (KIE) Mathematics syllabus (2002) and Secondary School Mathematics Teacher's Handbook (2006) was used by teachers in experimental groups to ensure that there was uniformity in exposure of students to intervention.

The study involved Form three students in co-educational secondary schools in Bomet County, Kenya, participated in the study. The accessible population was 10368 (Data, CDE's office, Bomet 2017) form three students in co-educational secondary schools in the 5 sub-counties of Bomet County. The County was selected for the study because it is among the Counties in Kenya which usually post dismal performance of students in Mathematics at Kenya Certificate of Secondary Education (K.C.S.E). Form three students were selected because they are deemed to have covered adequate content and materials in mathematics in secondary school curriculum and have shaped up their attitudes towards the subject. Secondary schools in Bomet County were stratified into Boys, Girls and Co-educational secondary schools. Co-educational schools constitute 79.1% of all the schools in Bomet County formed sampling frame for this study. Fraenkel and Wallen (2000) observed that the success of experimental and quasi-experimental designs normally relies on stringent control of extraneous variables. Selecting one type of school and one category of school minimized the variation in the characteristics of the groups. Simple random sampling technique was used to select one school from each of the four (4) sub-counties selected. The four schools were then randomly assigned treatment and control conditions. In schools with more than one stream, only one stream was selected randomly. The total number of students in each of the Groups E1, C1, E2 and C2 were 39, 40, 42 and 40 respectively.

Data was collected using questionnaires, interview schedule and achievement test. The selection of these tools was guided by the nature of data that was to be collected, time available for the study as well as objectives of the study. These were administered to the students to determine their conceptual achievement on Circle concept test and their attitude towards mathematics and the teachers' perceptions and feelings about the effectiveness of the Collaborative Concept Mapping teaching strategy. The researcher used structured questionnaires that were aimed at eliciting specific information on student's Bio-data and Attitudes Towards Mathematics. The ATM questionnaire was adopted and modified from the scales developed by Fennema, E. & Sherman, J. (1976) on Instruments designed to measure attitudes towards the learning of mathematics by females and males. ATM was measured along four dimensions: Utility of mathematics as a subject in daily life, liking of mathematics, career interest in mathematics and the relevance of mathematics in the world. There were 12 items on utility of mathematics, 26 on liking of mathematics, 10 on career interest of mathematics and 8 on relevance of mathematics in the world, totaling 56 question items. Information on students' attitudes was solicited using the 56 (fifty-six) question items (28 positives and 28 negatives) on 5-point Likert scale containing alternatives response ranging from Strongly Agree (SA), Agree, Undecided, Disagree to Strongly Disagree (SD).

The Circle Concept Achievement Test (CCAT) contained questions items that assessed students' achievement in circle concept in two (2) levels. Level 1(CCAT1) required the student to choose the correct statement/answer among the four alternatives given. Level 2 (CCAT2) required the student to show the working to the final answer. The problems in the test were set in an increasing degree of complexities, to test the student's deeper conceptual understanding. Test items were developed by the researcher based on the K.I.E syllabus and the Kenya National Examinations Council (KNEC) past examination papers on the topic circle. The test items measured concepts and principles: Area of Circles, sectors and segments, Length of Chords and arcs, Construction of Tangents and Construction of circumscribed, inscribed and escribed circles.

The researcher used an interview schedule containing structured questions for mathematics teachers. The interview questions were similar in intent with the questionnaire. Each interview schedule was designed with the research questions in mind. The subjects were interviewed on site, generally after the lesson and whenever possible, during the lesson. Throughout the interview sessions, the investigator was able to collect sufficient descriptive details from the teachers about students' feelings towards lessons taught conventionally and how the collaborative concept mapping strategy was perceived by the subjects.

Piloting was done to establish whether the instruments could be used to collect relevant data, identify any problems likely to occur at the time of actual data collection process and to also check whether the instructions in the questionnaires are understandable to the respondents. This exercise was conducted in selected secondary schools, in the neighbouring County of Kericho, which were not included in the actual study. The results were used to test the validity and reliability of the research tools. To ensure that the research tools were valid item analysis was done. This ensured each question answered a specific objective of the study. Face validity and content validity are the validity issues most frequently reported in the literature (Parahoo, 2006). Face validity basically checks that the questionnaire seems to measure the concept being tested (LoBiondo-Wood & Haber, 2010) and this was assessed by getting mathematics education experts to test-run the instrument to see if the questions appear to be relevant, clear and unambiguous as outlined by Jones & Rattray (2010). A panel of experts is used to evaluate the content validity of the questionnaires (Polit & Beck, 2010). The questionnaire was submitted to departmental specialists to check and examine whether the questions reflect the concepts being studied and that the scope of the questions is adequate, in the manner proposed by LoBiondo-Wood & Haber (2010). The instruments were amended according to the experts' comments and recommendations before being administered. The reliability estimate using Cronbach's Alpha method, for the four domains of ATC utility, liking, career interest and relevance were 0.82, 0.78, 0.85, and 0.87 respectively. The reliability coefficient of CCAT was estimated using the Cronbach's alpha (α) coefficient. It yielded a reliability coefficient of

0.86. This was above the recommended threshold of 0.7 hence the instrument was considered ideal for the study. The collected data was analyzed using both descriptive and inferential statistics. Descriptive statistics involved frequencies and percentages and means, while inferential statistics entailed the use of Analysis of Variance (ANOVA). There was need to supplement the empirical data with qualitative data from out-group and individual interviews to unravel meanings that the students attach to classroom interactions and/or experiences with the instructional material particularly the CCM strategy. Information on interview responses from the interview guide were analyzed and presented in form of descriptive data.

6. Findings

Findings are presented according to the objectives of the study.

6.1 Effect of Collaborative Concept Mapping on Students' Achievement in Mathematics

The objective was to find out if there is any difference in students' achievement in mathematics when taught using the Collaborative Concept Mapping teaching strategy (CCM) and those taught using conventional method of instruction. Achievement in the study was perceived at two levels. The two levels of achievement were measured by use of Circle Concept Achievement Test (CCAT). Achievement level 1 and 2 were coded as CCAT1 (Pre-test) and CCAT2 (Post-test) respectively. In the pretest, only one level of achievement was measured; that is students choosing the correct answers out of the alternatives given in each of the questions. The Sum, Mean, Standard deviation (SD), Kurtosis and Skewness on students' achievement in pretest (CCAT1) are presented in Table 5 for experimental 1(E1) and control 1(C1) group.

The students were subjected to an achievement test before the treatment and the findings are as presented in Table 1.

Table 1: Summary on Students' Pre-test Scores in CCAT1

Group	Sum	Mean	N	Std. Deviation	Skewness	Kurtosis
1. Experimental 1(E1)	204.00	5.2308	39	.87243	.522	-.161
2. Control 1 (C1)	207.00	5.1750	40	1.00989	.260	-.407
Total	**411.00**	**5.2025**	**79**	**.93890**	**.343**	**-.313**

As indicated in Table 1, it was observed that the mean values in Pre-test Scores for experimental and control group was 5.2308 and 5.1750 respectively out of a maximum score of 10 points. These results reflected an almost normal distribution of scores in both the experimental and control group despite the slight Skewness to the right and slight Kurtosis to the left compared to the standard normal distribution. To test whether there was any significant difference in the two means, an independent t-Test was done, and the results presented in Table 2.

Table 2: Independent Samples t-test on Students' Pre-test Scores in CCAT1

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	T	Df	Sig.(2-tailed)	Mean Difference
Pre-test Scores in CCAT1	Equal variances assumed	.679	.413	.262	77	.794	.05577
	Equal variances not assumed			.263	75.909	.793	.05577

The results as shown in Table 2 showed that there is no significant difference in the two means ($t_{(77)} = .262$, $p > 0.05$). This implied that the two groups were similar in terms of achievement before administration of treatment.

All the four groups were given post-test after the treatment and control condition. Their means and standard deviations are presented in Table 3.

Table 3: Mean Scores on Post-Test in CCAT2

Group	Mean	N	Std. Deviation
E1	63.1538	39	9.15521
E2	62.2381	42	10.67664
C1	56.4000	40	8.44833
C2	54.7500	40	8.82232
Total	**59.1491**	**161**	**9.93114**

From the results as shown in Table 3, it was noted that the highest mean score was attained by students from the Experimental 1(63.1538) followed by Experimental 2 (62.2381), Control 1 (56.4000) and finally Control 2 (54.7500).

Generally, the mean scores of the subjects in the experimental groups (E1&E2) are higher than the means of the control groups (C1& C2). This indicates that the subjects in the experimental groups scored higher on the students' achievement test than those in the control groups. The results show that the experimental group students exhibited higher scores as compared to the control group students. There was need to find out whether there is any significant difference in the achievement of the students in mathematics. To test whether there was any significant difference in the four means, an analysis of variance was performed on the Post-Test scores in CCAT2 and the results are as presented in Table 4.

Table 4: Analysis of Variance on Post-Test in CCAT2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2102.626	3	700.875	8.045	.000
Within Groups	13677.796	157	87.120		
Total	**15780.422**	**160**			

The results as indicated in Table 4 displayed significant difference in the four means as indicated by higher F value ($F(3,157) = 8.045$, $p < 0.05$). An examination of the results indicates that the F-ratio is statistically significant because the F-value (F=8.045) exceeds the critical value of (3.157) needed to reject the hypothesis in question. This is a clear indication that the posttest scores obtained by the subjects are statistically different.

Post-hoc tests of multiple comparisons using Bonferroni test was performed to point out the source of the observed significant differences among the group means. The results are as presented in Table 5. Bonferroni test is considered ideal for making multiple comparisons since it is flexible for use with any set of statistical tests (Howel, 2002). The use of Bonferroni procedure with alpha (α) at 5 % guarantees that the probability of any false rejection among all the comparisons made is no greater than 0.05. This is a much stronger protection than controlling the probability of a false rejection at 0.05 for each separate comparison (Orora et al., 2013).

Table 5: Bonferroni Post-Hoc pair wise Multiple Comparisons Test Results of the Post-test

(I) Group	(J) Group	Mean Difference (I-J)	Sig.
	E2	.91575	1.000
E1	C1	6.75385	.009*
	C2	8.40385	.001*
	E1	-.91575	1.000
E2	C1	5.83810	.031*
	C2	7.48810	.002*
	E1	-6.75385	.009*
C1	E2	-5.83810	.031*
	C2	1.65000	1.000
	E1	-8.40385	.001*
C2	E2	-7.48810	.002*
	C1	-1.65000	1.000

*The mean difference is significant at $p< 0.05$

Results in Table 5 show that the difference between the mean scores of experimental and control groups is statistically significant. Significant differences were noted between group pairs E1 & C1 (p= .009), E1 & C2 (p= .001), E2 & C1 (p= .031) and E2 & C2 (p= .002). However, there was no statistically significant difference between the mean scores of E1 & E2 (p= 1.000) and C1 & C2 (p= 1.000) at the 0.05 level. This difference in achievement can be attributed to the intervention where CCM was used. These results indicate that; a) There was no significant interaction between CCAT1 pre-test and the treatment conditions, otherwise the pre-tested groups would have attained significantly different results from those who did not take the pre-test. b) Application of CCM resulted in higher student achievement than the conventional method that was used to teach the control groups. It is considered so since groups E1 and E2 obtained scores that were significantly higher than those of groups C1 and C2.

There was therefore need for the rejection of the null hypothesis (Ho_1) which stated that there is no statistically significant difference in the Achievement in Mathematics Test (AMT) between students exposed to Collaborative Concept Mapping teaching strategy (CCM) and those taught using conventional method of instruction.

6.2 Effect of CCM on student's gender and achievement in Mathematics Test

The objective was to find out if there is any difference in students' achievement in mathematics according to gender. The students were subjected to an achievement test before the treatment and the findings of the mean achievement of boys and girls in pre-test (CCAT1) are as presented in Table 6.

Table 6: Mean Scores on Pre-Test scores in CCAT1 between boys and girls

Gender	N	Mean	Std. Deviation
Boys	44	5.2273	.98509
Girls	35	5.1714	.89066

An inspection of the results in Table 6 shows that the mean scores for boys and girls in pre-test were 5.2273 and 5.1714 respectively. To check whether their means were significant, an independent samples t-test was performed, and the results are as shown in Table 7.

Table 7: Independent Samples t-test on Students' Pre-test Scores in CCAT1

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	t	df
Equal variances assumed	1.034	.312	.261	77
Equal variances not assumed			.264	75.692

From Table 7, the pre-test results showed no significant gender difference in achievement before the intervention ($t_{(77)} = .261$, $p>0.05$). To find out whether there was gender difference in achievement after students were exposed to CCMTS, the CCAT2 post-test mean scores of boys and girls in experimental groups were analyzed and compared as shown in Table 8.

Table 8: Mean Scores on Post-Test in CCAT2 between boys and girls

	Gender	Mean	N	Std. Deviation
Posttest	**Boys**	59.9773	44	9.24974
	Girls	59.4286	35	9.67801

The results show that boys had slightly higher mean score (M=59.9773, SD=9.24974) than girls (M=59.4286, SD=9.67801). To test whether there was any statistically significant difference in their means, an independent Samples t-Test was performed on CCAT2 and results are as presented in Table 9.

Table 9: Independent Samples t-Test in Post-Test on CCAT2 between boys and girls

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	t	df
Equal variances assumed	.334	.565	.257	77
Equal variances not assumed			.255	71.508

The results in Table 9 show that there was no significant difference in the means of boys and girls exposed to CCM ($t_{(77)} = .565$, $p>0.05$). This implied that gender had no influence on the students' achievement since both boys and girls benefited equally when CCM was used. This led to the acceptance of the null hypothesis which stated that there is no statistically significant gender difference in AMT when students are exposed to CCM.

6.3 Effect of Collaborative Concept Mapping on Students' Attitudes Towards Mathematics

The objective was to find out whether there is any difference in students' attitudes toward mathematics when taught using the CCM teaching strategy and Conventional Method of Instruction. Attitude towards mathematics is envisaged in a model with four dimensions of 56 items, namely career interest in the field of mathematics, liking of mathematics, relevance of mathematics and utility of mathematics. Half of the 56 items are negative, and the remaining half are positives statements and the four dimensions were enlisted for career interest in the field of mathematics, liking of mathematics, relevance of mathematics and utility of mathematics respectively. The overall score on the four dimensions was derived from the mean scores of students' responses on 56 items measuring the construct on a 5-point Likert Scale ranging from Strongly Agree, Agree, Undecided, Disagree to Strongly Disagree. The results are as presented in Table 10.

Table 10: Pre-test Mean Score on ATM

	Group	N	Mean	Maximum Mean Score	Std. Deviation
Career	Experimental	81	38.8148	50	5.67255
	Control	80	37.7750	50	6.42774
Liking	Experimental	81	89.5432	130	12.32584
	Control	80	90.9875	130	15.21533
Relevance	Experimental	81	29.2222	40	4.17732
	Control	80	29.4125	40	6.11430
Utility	Experimental	81	45.4815	60	6.18690
	Control	80	45.3875	60	7.29747
Overall Pre-ATM	**Experimental**	**81**	**203.0617**	280	**22.55900**
	Control	**80**	**203.5625**	280	**30.76446**

As shown in Table 10, the overall Pre-ATM means were 203.0617 and 203.5625 for Experimental and Control groups respectively. To check whether there was any significant difference in their means an analysis of variance was performed as shown in Table 11.

Table 11: An analysis of variance on Pre-ATM

		Sum of Squares	df	Mean Square	F	Sig.
Career	Between Groups	43.517	1	43.517	1.185	.278
	Within Groups	5838.172	159	36.718		
	Total	5881.689	160			
Liking	Between Groups	83.957	1	83.957	.438	.509
	Within Groups	30443.086	159	191.466		
	Total	30527.043	160			
Relevance	Between Groups	1.457	1	1.457	.053	.818
	Within Groups	4349.388	159	27.355		
	Total	4350.845	160			
Utility	Between Groups	.355	1	.355	.008	.930
	Within Groups	7269.210	159	45.718		
	Total	7269.565	160			
Overall Pre-ATM	Between Groups	10.093	1	10.093	.014	.906
	Within Groups	115482.379	159	726.304		
	Total	**115492.472**	**160**			

The overall results presented displayed no significant difference in the means of Experimental and Control groups in pre-ATM ($F_{(1,159)}$ =.014, p>0.05). The results implied that the two group of students had similar ATM prior to exposure to CCMTS intervention. The post-ATM mean and standard deviation after the intervention for the Experimental and Control groups on the four dimensions of; Career interest in the field of Mathematics, Liking of Mathematics, Relevance of Mathematics and Utility of Mathematics are summarized in Table 12.

Table 12: Summary of Students' Responses on the four Dimensions of Post-ATM

	Group	N	Mean	Maximum Mean Score	Std. Deviation
Career	Experimental	81	40.7531	50	5.78474
	Control	80	37.8875	50	5.90429
Liking	Experimental	81	95.1358	130	9.56785
	Control	80	91.9250	130	15.09445
Relevance	Experimental	81	31.0000	40	4.13824
	Control	80	29.8125	40	5.70608
Utility	Experimental	81	48.0864	60	5.02792
	Control	80	45.7875	60	6.76307
Overall Post ATM	**Experimental**	**81**	**211.8765**	**280**	**19.48101**
	Control	**80**	**203.9000**	**280**	**29.77791**

In Table 12 the overall means on post-ATM are 211.8765, and 203.9000 out of the maximum score of 280 points for the Experimental and Control groups respectively. This reflected a higher mean for the Experimental group than the Control group. Diagrammatically the means on Post-ATM are shown in Figure 3.

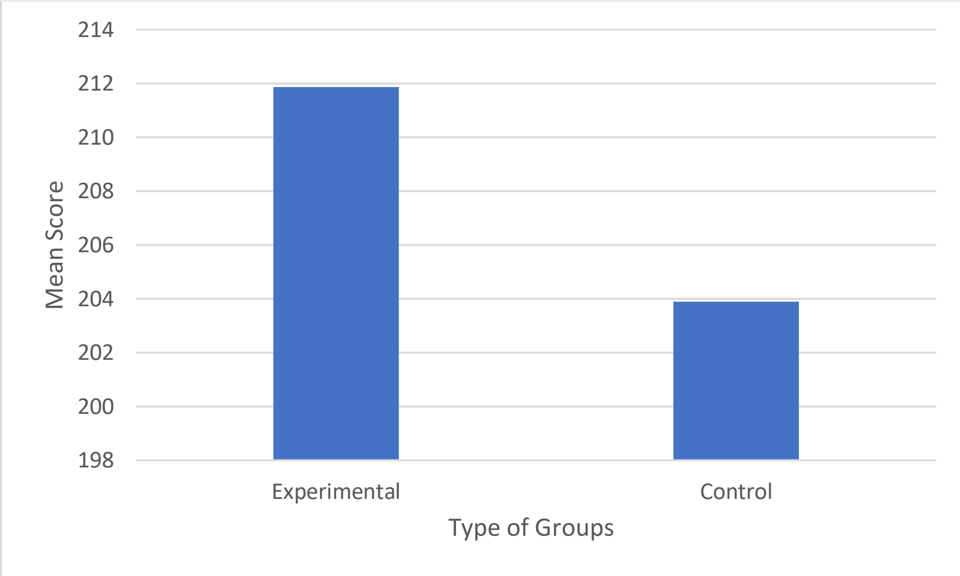

Figure 3: Means of Post-ATM

An analysis of variance on post-ATM was run to check whether there were any significant differences in the two means on the four dimensions of post-ATM as indicated in Table 4.13.

Table 4.13: An analysis of variance on post-ATM

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	330.504	1	330.504	9.676	.002
Career	Within Groups	5431.049	159	34.158		
	Total	5761.553	160			
	Between Groups	414.931	1	414.931	2.605	.108
Liking	Within Groups	25323.056	159	159.265		
	Total	25737.988	160			
	Between Groups	56.757	1	56.757	2.289	.132
Relevance	Within Groups	3942.188	159	24.794		
	Total	3998.944	160			
	Between Groups	212.714	1	212.714	6.001	.015
Utility	Within Groups	5635.783	159	35.445		
	Total	5848.497	160			
	Between Groups	**2560.817**	**1**	**2560.817**	**4.055**	**.046**
Overall Post-ATM	**Within Groups**	**100411.965**	**159**	**631.522**		
	Total	**102972.783**	**160**			

The results presented in Table 4.13 showed that there were statistically significant differences in the means of students in the four dimensions of post-ATM except in liking of mathematics and Relevance of Mathematics. In overall there were significant differences in the means in the four dimensions of post-ATM in the four groups of students ($F_{(1, 159)} = 4.055$, $p<0.05$). The result suggests that the intervention of CCMTS had significant effect on students' ATM in the experimental group (E1and E2). This finding let to the rejection of the null hypothesis which stated that there is no significant mean difference in Attitudes Towards Mathematics (ATM) subject between students taught using CCM teaching strategy and those taught using Conventional Method Instruction.

7. Discussion of the Results

7.1 Effect of Collaborative Concept Mapping on Students' Achievement

The pre-test results indicated that there were no significant differences in the achievement of students. This is attributed to the nearly the same entry behaviours of the students who participated in the study before the treatment. Secondly, on the student's achievement in mathematics the results revealed that the students taught circle concepts with collaborative concept mapping instructional approach performed significantly better than the students taught with conventional methods of instruction. This implies that collaborative concept mapping teaching strategy has a positive effect on the students' achievement in mathematics. The experimental group involved in collaborative concept mapping was found to achieve significantly better than their control group counterparts in the mathematics achievement post-test. Analysis on students' achievement at level 2 (CCAT2) showed that students in experimental group (Experimental 1 and 2) had better and significant mean achievement compared to the control group (Control 1 and 2). The results suggest that CCM as a teaching strategy has significant contribution to conceptual understanding in mathematics. This is in accord with the findings of previous studies (Novak, Gowin and Johansen, 1983; Ault, 1985; Lehman, Carter and Kahle, 1985; Okebukola, 1986 and 1990 McClure, et al 1999; Safayeni et al 2005 Soyibo, 1995; Zantinget et al 2003), which provided evidence attesting to the efficacy of collaborative concept mapping in facilitating meaningful learning.

This finding agrees with the works of other scholars who found that the use of concept mapping instructional approach results in significant learning gains among students. Previous studies revealed that instructional method helps in imparting knowledge, skills, abilities and attitudes expertly to facilitate student's achievement (Ademzyk, 1994; Achimagu, 1995; and Ibiene, 2009). More so, Ryder (2004), observed that concept mapping attracts students' attention, motivate them, reduce anxiety and facilitates recall of information and hence, enhances their achievement. The findings are consistent with the findings of Nwoke et al (2015) and Githae, Keraro & Wachanga (2015) who found out that students taught mathematical concepts using concept mapping approach had better achievement than those taught using the traditional approach. Adeneye and Adeleye (2011) in a similar study, also discovered that concept mapping strategy enhanced student's achievement in mathematics. Moreso, Nwoke, B. I., Iwu, A. and Uzoma, P. O. (2015) in their study revealed that students taught mathematical concepts using concept mapping approach had better achievement than those taught using the traditional approach.

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

7.2 Effect of CCM on student's gender and Achievement in Mathematics Test

The results of this study have shown that boys and girls exhibit no statistically significant difference in achievement when exposed to the Collaborative Concept Mapping teaching strategy. The results also revealed that students (boys and girls) taught using CCM attained significantly higher mean score than those taught using conventional methods of instruction. From the findings of this study, it is evident that the mean achievement of male and female students in circle concepts topic in mathematics is not significant. This means that the difference between the achievement of male and females in mathematics is not significant. This further shows that collaborative concept mapping strategy produced the same effect on the mean achievement of the male and female students.

This empirical study showed that collaborative concept mapping is more effective teaching/ learning strategy than the conventional method in improving academic achievement of the students of both genders in the subject of mathematics. This is attributed to the fact that collaborative concept mapping teaching strategy presents topics/concepts bit by bit, from known to unknown, shows meaningful relationships between concepts and promotes creative thinking in both male and female students who also share their experiences during instruction. The results of this study extend the findings Bilesanmi-Aworderu (2002), Ahlberg and Ahoranta (2004), Malik (2009), Khawaldeh and Al-Olimat (2010), Snead and Young (2003), Czerniak and Haney (1998). This result is also in agreement with the findings of Nwoke et al (2015) and Githae, Keraro and Wachanga (2015) who found no statistical significant gender difference in mean achievement scores when students were exposed to concept mapping approach in mathematics and Biology learning. They further argued that given the same educational opportunities and a gender positive teaching approach, girls are likely to perform at par with boys. Similar results were obtained by Nwoke, Iwu and Uzoma (2015), Ahmed (2010) and Candan (2006) who observed no statistically significant difference between genders due to concept mapping teaching approach.

Collaborative Concept Mapping as revealed takes care of individual differences in the students and as well reduce to the barest minimum the bore on the students when taught with conventional methods of instruction. The finding of this study agrees with the findings of Onwioduokit and Akinyemi (2005), Ibiene (2009), Nsofor (2001), Yoloye (2004), and Agummuoh and Nzewi (2003). In the current study, the result of data analysis revealed no interaction between method and gender on students' achievement in mathematics and this result is supported by the work of Danmole and Adeoye (2004), which yielded a similar result. Furthermore, the result is in line with the work of Ibiene (2009), assertion that there was no significant difference when interaction effect of gender and instructional method was explored, showing that the males and females were affected positively by the method. Collaborative Concept Mapping strategy therefore, should be used for teaching both male and female students in mathematics as there are no gender differences in achievement in mathematics when the students are subjected to this method of instruction.

7.3 Effect of Collaborative Concept Mapping on Students' Attitudes toward Mathematics

The current study sought to investigate the effectiveness of Collaborative Concept Mapping (CCM) teaching strategy on the development of favourable Attitudes towards mathematics (ATM) among the form three secondary school 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. Results on the analyses of means on Post-ATM showed that students in the experimental group had higher mean than the control group. ANOVA results showed significant difference between the experimental (E1 and E2) and control group (C1 and C2) on ATM at α=0.05 level. The results suggest that CCM teaching strategy had significant effect on the development of positive ATM among students in the experimental groups. This led to the rejection of the null hypothesis which stated that there is no significant mean difference in Attitudes Towards Mathematics (ATM) subject between students taught using CCM teaching strategy and those taught using conventional method. The implication from the above interpretation suggests that the CCM teaching strategy exerted a more positive influence on the subjects' attitudes towards the mathematics course than the conventional method of instructional.

The findings suggest that students' attitudes towards mathematics improve after working with and experiencing concept maps. These findings are consistent with the results obtained by Rao, 2003; Kilici et al 2004 who found that concept mapping as an instructional tool influenced the achievements of students who also reflected a positive attitude towards concept mapping as an effective teaching strategy. However, the findings of this study contradicted findings in other studies. The opinions of students support the merit of collaborative concept mapping in the integration of knowledge (Ahlberg et al., 2005; Harpaz, Balik, and Ehrenfeld, 2004; Kinchin, De-Leij, and Hay, 2005; Lavigne, 2005; Novak & Gowin, 1984; Shavelson, Ruiz-Primo, and Wiley, 2005). The original intent of the concept mapping strategy (Ahlberg et al., 2005; Harpaz et al., 2004; Novak et al., 1983; Novak & Gowin, 1984) was to facilitate students' independent learning and thinking. The views of students and teachers in this study agree with this idea. Furthermore, most teachers pointed out that adopting the collaborative concept mapping strategy helped them reduce the barriers and promote the learner's interests in learning mathematics.

In terms of affective acceptance, the experimental group had a more affirmative attitude for using the collaborative concept mapping strategy. Most of the students believed collaborative concept mapping can be a feasible instructional strategy in mathematics. Most of the students liked and felt satisfied when taught using the collaborative concept mapping strategy. The students in the concept mapping group also believed that concept mapping could be easily applied to other topics in mathematics and in other subjects. These opinions are consistent with the successful examples of using concept mapping in other disciplines (Ahlberg et al., 2005; Chang et al., 2002; Freeman & Jessup, 2004; Harpaz et al., 2004; Ritchie & Volkl, 2000). The findings of this study have several implications to the teaching and learning of mathematics as they point to the need to use collaborative concept mapping strategy to reduce barriers to learning and increase learner's interest in the subject.

8. Conclusion

The study sought to find out whether collaborative concept mapping approach improves student's achievement in mathematics, the method removes gender inequality and it encourages students' classroom participation and interest and impacting positively on the attitude of students towards mathematics. In respect to the research questions about whether there would be any significant difference between the achievement, gender differences in achievement and attitudes towards the mathematics course of the subjects taught using the (CCM) Collaborative Concept Mapping teaching strategy and those taught using the conventional method of instruction. The findings of this study on all the two dependent measures are in the affirmative and not in the gender differences.

The major results obtained from this study based on data analysis reveal that Collaborative Concept Mapping method of teaching is more effective than the conventional methods of instruction in fostering achievement of students in mathematics. The difference between the mean achievement of students in the collaborative concept mapping group and conventional group is statistically significant, and in favour of the collaborative concept mapping group. The study has also revealed that Collaborative Concept Mapping method of teaching is more effective than the conventional methods of instruction in fostering the interest of students in mathematics and thus offers a remedy to the negative attitude towards the subject that has affected student performance in mathematics and other subjects. The study further reveals that collaborative concept mapping strategy has no differential impact on the achievement of male and female students in mathematics. In the same vein also, there is no significant interaction between gender and instructional method on students' achievement in mathematics.

These findings provide empirical evidence and basis for concluding that the use of a strategy such as CCM facilitates higher level of learning in mathematics. The implication from the above interpretation, suggests that the level of achievement in learning of mathematical concepts, is marked higher when the students are taught using the Collaborative Concept Mapping Teaching Strategy (CCM) than when the conventional method is employed. Therefore, serious considerations should be given to the adoption of collaborative concept mapping strategy as a teaching and learning tool in mathematics. This is because CCM strategy is a learner centered strategy that put the students in charge of their learning, and teachers as the facilitators and generally improves learner achievement. Teachers should make effort to adopt activity-based learning in their classroom presentation as it has a positive correlation with the achievement of learners.

9. Recommendations

The following recommendations are made to enhance effective instruction in Mathematics:

a) Teachers to integrate Collaborative Concept Mapping Teaching Strategy in Mathematics to enhance conceptual understanding and achievement in the subject.
b) Teachers should continue to demonstrate and foster positive attitude in Mathematics education through effective strategies such as CCMTS.
c) Teacher training institutions to incorporate CCM as one of the strategies in the teaching and learning of Mathematics. The current teachers in service can be retooled through seminars, workshops and symposiums to enable them to integrate CCM as a teaching strategy.
d) Mathematics curriculum developers to integrate and lay emphasis on collaborative concept mapping teaching strategy in the curriculum.

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