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JIGSAW COOPERATIVE LEARNING STRATEGY AND STUDENTS' SELF-CONCEPT IN MATHEMATICS

NAOMI W. MBACHO[1], DR. ROBERT MWEBI[2]

SCHOOL OF EDUCATION, LAIKIPIA UNIVERSITY, KENYA

ABSTRACT

Knowledge of mathematics as a tool for use in everyday life is important of any individual and society. In schools, it equips students with a unique and powerful set of skills to understand the world and also become productive members of the society. Secondary school students in Kenya have continued to perform poorly in mathematics in the Kenya Certificate of Secondary Education (KCSE) examinations. This raises concern to all stakeholders in education given the importance they attach to mathematics. Although there could be a variety of reasons influencing performance in mathematics, research demonstrates that factors such as inadequate facilities in the schools like the text books, poor attitude towards the subject by the students and teachers, gender stereotyping, lack of role models, low mathematics self-concept and the ineffective instructional methods used by teachers have been attributed to causing mainly poor performance in the subject. There is however inadequate documented information in research conducted in Kenya on the effect of the use of Jigsaw Cooperative learning Strategy on students' self-concept in subjects such as mathematics. This study therefore sought to investigate the effect of using Jigsaw Cooperative learning Strategy as a teaching method on learners self concept in mathematics. The study used a quasi-experimental research design by adopting the Solomon four non-equivalent control group design. Two experimental groups received the Jigsaw cooperative learning Strategy as treatment and two control groups were taught using the conventional learning/teaching methods. Four co-educational secondary schools were randomly selected from a target of 67secondary schools in Laikipia County. A mathematics self-concept scale (MSC) was administered to form three students as the unit of analysis in the selected schools. The MSC was piloted in a school which was not used in the study in Laikipia County and its reliability estimated. The reliability coefficient of the MSC was found to have a Cronbach alpha coefficient of 0.96 .The collected data were analyzed using t-test, ANOVA and Scheffe post hoc to test hypotheses at the .05 level of significance. The study revealed that students who were taught mathematics using Jigsaw learning strategy had a higher mathematics self-concept score compared to those taught using the conventional teaching methods. The study recommends that

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teachers should adopt the use of Jigsaw learning strategy in mathematics instruction in order to improve learners self concept in mathematics.

Keywords: Jigsaw, Strategy, cooperative learning, self-concept.

INTRODUCTION

Mathematics is applied in various fields and sectors that contribute towards the socio-economic development of any country. Furthermore, it takes a significant position in human civilization as a medium of social function in our everyday world (Mondoh, 2005). The social functions include buying and selling, banking, social gatherings among others. Mathematics helps to develop powers of logical thinking, accuracy and spatial awareness (KIE, 2002). Mathematics also provides an inherent interest and appeal to most children and adults (Mondoh, 2005).This perceived usefulness of mathematics in one's life has forced the Kenyan Government to make the study of mathematics compulsory for all primary and secondary school students in the country. However, despite the emphasis, students continue to perform poorly in the subject in national examinations as reflected in the Kenya Certificate of Secondary Education (KCSE) mathematics examinations results (KNEC, 2010). For example the students' mean score in mathematics at KCSE national examinations by gender in the year 2009 and 2010 as depicted in Table 1 shows a below average performance in the subject

Table 1. Students' Percentage Mean Score in Mathematics at KCSE for the years 2009 and 2010

Year	Male	Female	Grand mean
2009	23.63	18.11	20.87
2010	25.75	19.71	22.73

Source: KNEC (2010)

This underachievement and gender differences in mathematics performance is partly attributed to low mathematics self concept which may have been caused by the ineffective teaching methods employed by teachers in teaching of mathematics lessons (O'Connor, 2000). Despite the government's efforts in coming up with in-service programmes for mathematics teachers such as SMASSE (KIE, 2002), the subject continues to be performed poorly over the years. Consequently, there has been a lower uptake in terms of admissions into mathematics related careers at institutions of higher learning (Shikuku, 2009).

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Performance of mathematics in Laikipia County where the study was done has not been good either, tending to reflect that of the national level (table 2). This is a clear indication that the performance was below the average of 6 out of 12 points.

Table 2. KCSE Mathematics Results for Laikipia East District for the years 2008 to 2012

Year	2008	2009	2010	2011	2012
Mean score	2.9340	2.6115	2.834	2.7034	2.8031

Source: District Education's Office, Laikipia East District (2012)

Although some research studies as demonstrated elsewhere above indicate that there are a variety of factors that could be attributed to the poor performance, there is a dearth of research done to establish how students self concept influences performance in mathematics especially when moderated by the jigsaw learning strategy. Marsh and Craven (1997) maintain that "enhancing a child's academic self-concept is not only a desirable goal but is likely to result in improved academic achievement as well" (p. 155). The anticipated improvement of student performance is based on the existence of a reciprocal relationship between self-concept and academic achievement (Marsh, Trautwein, Ludtke, Koller & Baumert, 2005).

Mathematics self-concept (MSC) is the learners' self-perceptions of their perceived personal mathematical skills, ability, mathematical reasoning ability, enjoyment and interest in mathematics (Marsh, 1990, 1996). Both self-concept and interest in mathematics are influenced by educational settings and teaching styles. Research suggests that particular aspects of instructional quality in mathematics classrooms such as classroom management, classroom climate, and cognitive activation relate to students' attitudes and emotions concerning mathematics (Frenzel, Goetz, Pekrun & Watt, 2010).

The basic dimension of cognitive activation refers to characteristics of instruction, which promote students' conceptual understanding by including, for example, challenging tasks or enhancing different and non-routine problem solving (Lipowsky, Rakoczy, Pauli, Drollinger - Vetter, Klieme & Reusser, 2009). Additionally, discursive effectiveness, which refers to students' opportunity to co-construct knowledge by participating in mathematics classroom discourse, is viewed as a mechanism to activate cognitive processing (Walshaw, 2007). Participating in cognitively challenging classroom discourse facilitates students' emotional well-being and thus is linked to students' interest in mathematics classrooms (Lipowsky, Rakoczy, Pauli, Drollinger-Vette, Klieme & Reusser, 2009) and students' mathematics self-concept (Lazarides & Ittel, 2012). In the present study Jigsaw cooperative learning strategy, which

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encourages students' interaction with each other and with the teacher, was used in teaching mathematics. How the strategy affected the learners self concept was the central focus of the study. According to Aronson (2000), Jigsaw is a cooperative learning strategy that enables each student of a 'home' group to specialize in one aspect of a learning unit. Students meet with members from other groups who are assigned the same aspect and after mastering the material, return to the 'home ' group and teach this material to the group members. Jigsaw can be used whenever learning material can be segmented into separate components. Each group member becomes an expert on a different concept or procedure and teaches it to the group (Panitz, 1996). Just like a Jigsaw puzzle, each piece (student part) is essential for the completion and full understanding of the final product. Therefore, each student is essential for the understanding of the whole concept being taught. Aronson (2000) says that the advantage of Jigsaw learning strategy is that students perform the challenging and engaging tasks in their expert groups with enthusiasm since they know they are the only ones with that piece of information when they move to their respective home groups. Students who tutor each other must develop a clear idea of the concept they are presenting and orally communicate it to their partner (Neer, 1987).

STUDY OBJECTIVE

The following objective guided this study:

To compare the mathematics self concept between students taught using jigsaw cooperative leaning strategy and those taught using the conventional methods of teaching

HYPOTHESIS OF THE STUDY

The following Null hypothesis was tested at the .05 level of significance;

Ho: There is no statistically significant difference in students' mathematics self-concept between those taught using Jigsaw Cooperative Learning Strategy and those taught using Conventional teaching methods in secondary schools in Laikipia County, Kenya.

RESEARCH METHODOLOGY

The study used a quasi-experimental research design to explore the relationship between variables, as the subjects are already constituted and school authorities don't allow reconstitution for research process (Borg & Gall, 1989). Solomon 4-group; non-equivalent control group design was used because it is appropriate for experimental and quasi-experimental studies (Ogunniyi, 1992). The design overcomes external validity weaknesses found in other designs and also provides more vigorous control by having two control groups as compared to other experimental designs

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Premised on this design, two schools were randomly picked as experimental schools in which one received post-test only while the other received pre-test and post-test. on the other hand, two other schools were randomly selected as control schools of which one received post-test only while the other school received pre-test and post-test. The effects of maturation and history were controlled by having two groups taking pre- test and post-tests. To avoid contamination, the treatment and control groups were from different schools. The regression effects were taken care of by two groups not taking pre-tests. The pre-test was treated as a normal classroom test that students regularly take in the course of instruction while the post test was taken as a normal test that is administered after a topic has been covered. The mathematics teachers in the two experimental schools were given a guide on how to teach the topics by the researcher when students were on recess.

How Jigsaw Learning Strategy was administered

The topics that were taught by use of Jigsaw cooperative learning strategy are Surds and Logarithms. The subtopics of Surds are; rational and irrational numbers, operation on Surds, rationalizing the denominator and applications of Surds. The subtopics of Further Logarithms are logarithmic notations, laws of logarithms, logarithmic expressions and, logarithmic equations. Appropriate group work for each of the sub topics were constructed and used during instruction at the beginning of each mathematic lesson. For each of the subtopic to be taught the ten steps of creating and use of Jigsaw learning strategy as recommended by Aronson (2000) were followed. The group work was assigned to the groups and each student in the group assigned questions. The students with the same questions formed the expert group where they discussed their questions. The students then went back to their initial group to present their findings to the other members of the group. All this was done with close supervision of the teacher. The teacher then evaluated the learners by asking questions and marking the students' work. Later, the students were given the MSC scale to fill.

Population of the Study

The schools that participated in the study were from Laikipia County. The study targeted all the form three secondary school students in Laikipia County studying in co-educational public schools.. According to Laikipia county data sheets (2013), the County had about 5000 form three students and there are 67 secondary schools among them 4 boys schools, 6 girls schools and 57 co-educational schools. The co-educational schools were used for this study because they constituted the highest percentage of secondary schools in the county and also so as to capture the boys and girls in the same class subjected to the same learning environments.

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Sampling Procedure and Sample Size.

Purposeful sampling was used to sample out 57 co-educational secondary schools out of the possible 67 secondary schools in the county. This is because this study required the co-educational schools only. Simple random sampling was employed to select four schools out of the possible 57 co-educational schools in the County. Balloting was used to select the sample schools. Four schools were chosen because the Solomon 4 group design requires four groups (Ogunniyi, 1992). Each school formed a group in the Solomon 4 group design so that interaction by the subjects was minimized during the exercise. The assignment of groups to either experimental or control groups was done by simple random sampling. One class in each of the group was used for the study. The required data was collected using the Mathematics Self Concept (MSC) scale which was adopted for this study. The mathematics self-concept scale was developed by Opachich and Kadijevich (1998). They assumed that self-concept represents an organized system of beliefs about mathematics, supplemented by behavioral and emotional reactions regarding the value of mathematics and mathematical way of thinking as well as confidence in and motives for learning mathematics. In their view, mathematical self-concept is included in the hierarchical model of general self-concept proposed by Shavelson, Hubner, and Stanton, (1976). In this model, general self-concept is represented by the highest factor of hierarchy. A lower level in the hierarchy is represented by academic and non- academic self-concepts. The latter is divided into sub-ordinate self-concepts that are social, emotional, and physical whereas the former is built to specific school subject self-concepts, and mathematics self-concept belongs to that lower level in the hierarchy. The mathematical self-concept scale has 29 items covering several indicators in mathematics.

Item Scoring in the MSC

The 29 items covering the mathematics self-concept are presented in the form of statements and the response was obtained on a five point Likert-scale (Opachich & Kadijevich, 1998). The scores were: 1 (the lowest), 2, 3, 4, 5 (the highest), represented by strongly disagree (SD), Disagree (D), Moderate (M), Agree (A), and Strongly Agree (SA) respectively. Items 3, 8, 9, 15, 17, 18, 20, 22, 24, 28 and 29 are stated in a negative manner, and their scoring were reversed before being added in the responses total. That is, for these items SD = 1, D = 2, U = 3, A = 4 and SA = 5 respectively. The total individual score for mathematics self-concept were determined by summing the responses for all items.

Reliability of the Scale

The instrument used by Opachich and Kadijevich, 1998 initially consisted of 59 Likert-type items, which assessed the students' mathematical self-concept. After the administration of the

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instrument to 123 students from four ninth-grade classes, the authors eliminated some items because of their inadequate formulation or items redundancy. The psychometric characteristics of the remaining items were then analyzed. The final scale consisted of 29 items, and the reliability of the mathematics self-concept scale under some measurement models is summarized in Table 5.

Table 5. The Reliability of the Mathematics Self-Concept Scale under some Measurement Models

Reliability under the classical measurement model		
Guttman	Lambda 1	0.86
Guttman ,Cronbach's alpha	Lambda 2	0.89
Guttman	Lambda 3	0.93
Reliability measures of the first principal component		
Lord-Kaisser-Caffrey	Beta	0.90
Reliability measures under Guttman's measurement model		
Guttman-Nicewander	Rho	0.94

According to Opachich and Kadijevich (1998), the reliability under all models satisfied the demands of psychological measurement. In this study, piloting was done and the reliability of the MSC was also estimated by use of Cronbach's alpha coefficient, which is suitable when items are not dichotomously scored (Frankel & Wallen, 2000; Gall, Gall & Borg, 2003). The result of the reliability estimate of the MSC was obtained as 0.96. The instrument had almost the same reliability as in Table 5 and also met the threshold reliability coefficient of 0.70 and higher which is recommended (Frankel & Wallen, 2000; Gall & Borg, 2003; Mugenda & Mugenda, 1999).

Validity of the Scale

According to Opachich and Kadijevich (1998), the mathematics self-concepts scale has sufficient number of indicators (i.e., face validity and the chosen sample of indicators show that they measure the same thing (i.e., indicator convergence).The representativeness of the mathematics self-concept scale is shown in Table 6.

Table 6. The Representativety of the Mathematics Self-Concept Scale

Kaiser, Mayer, Olkin measure of sampling adequacy	Psi 1	0.94
Kaser, Rice	Psi 2	0.78

Data Collection Procedures

The study commenced after obtaining the research permit from the National Commision of Science, Technology and Innovation (NACOSTI)- Kenya upon receiving a letter of introduction from Graduate School of Laikipia University. Then the Director of Education Laikipia County was approached to seek permission to carry out the experiment in the county. The researcher then moved to the schools which were used for the research and approached the principals seeking permission to be allowed to collect data in their schools and also requesting them to provide the Form three KCPE mathematics scores. The researcher then agreed with the teachers in the experimental schools on the appropriate date for training. Before the experimentr was done, the study subjects in the selected schools were required to fill the MSC scale in order to determine the MSC score before the intervention. The topics surds and further logarithms were taught in the experimental schools for three weeks using Jigsaw learning strategy. The topics were also taught in the control schools at the same time using teacher centered (conventional) teaching methods. After the intervention period, the students in both experimental and control schools were given the MSC to fill. With both pretest and post test MSC scores ready, the researcher embarked on data analysis

RESULTS

Self-concept by Learning Groups

Prior to treatment, data was collected from the subjects in experimental group 1 (E1) and control group 1 (C1) using the MSC on their mathematics self-concept to make it possible for the researcher to assess the homogeneity of the groups before treatment application. Table 7 shows the pretest results obtained by groups E1 and C1 on the MSC. The scores of the learners were fed to the computer and SPSS program was used to generate the results.

Table 7. The Pre-Test mean scores of groups E1 and C1

	Learning groups	N	Mean	Std. Deviation	Std. Error Mean
Self-concept pre-test mean	E1	43	3.5325	1.13125	.17251
	C1	50	3.4579	1.02461	.14490

The mean self-concept score for the experimental group was 3.5325 while that of control group was 3.4579. This implies that there was a mean score difference of .0746. In order to find if this difference was significant, a t-test was run and the results are as shown in the Table 8.

Table 8. Independent Samples t-test of pre-test scores on MSC based on groups E1 and C1

	t-test for Equality of Means		
	T	Df	p (2-tailed)
Self-concept pre-test mean	.333	91	.740

Note: t not significant at $\alpha = .05$ (2 tailed)

From Table 8, it can be clearly observed that the independent sample t-test for MSC pre-test mean score for groups E1 and C1 were not significantly different, (t(91)= .333, p= .740). This implies that the groups were initially similar in all aspects.

Effect of Jigsaw learning strategy and Conventional teaching methods on students' mathematics self- concept

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This study sought sought to compare the effect of Jigsaw learning strategy and Conventional teaching methods on students' mathematics self-concept in secondary schools. The following null hypothesis was formulated in order to accomplish this objective:

Ho: There is no statistically significant difference in mathematics self-concept between those students who are taught using Jigsaw Cooperative Learning Strategy and those taught using Conventional Teaching Methods in secondary schools.

The hypothesis, therefore presumed that Jigsaw learning strategy had no effect on students' mathematics self-concept. To ascertain the veracity of this assumption, post mean scores of the MSC were analyzed. Table 9 shows the MSC mean scores obtained by the four groups.

Table 9. The self-concept post-test Mean Score

	N	Mean	Std. Deviation
E1	43	4.1524	.21954
E2	40	4.0925	.41733
C1	50	3.7090	.38783
C2	50	3.8483	.49624
Total	183	3.9359	.43361

The combined mean of the experimental groups E1 and E2 were found to be higher than the means of the control groups C1 and C2 as confirmed by Table 10.

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Table 10. The self-concept post-test Mean Score of the Experimental and Control Groups

	Grouping	N	Mean	Std. Deviation
Self-concept post-test mean	experimental (E1 and E2)	83	4.1232	.33050
	Control (C1 and C2)	100	3.7786	.44859

There is a strong indication that before the start of teaching the mathematics topics, self-concept levels were similar in that their differences were not significant in the MSC pretest (see Table 7). However, after exposure to the topics Surds and Logarithms by teaching using the jig saw method, there was a marked difference on their mean post-test scores in the experimental and control groups (see Table 10). The difference in the self-concept means of the control (C1 and C2) and experimental (E1 and E2) groups was analyzed using the t-test to find out whether they were significant. The result of the t-test is shown in Table11.

Table 11. The t-test of the Self-concept post-test Mean Scores

	t-test for Equality of Means		
	T	df	p(2-tailed)
Self-concept post-test mean	5.833*	181	.000

*Significant at $\alpha = .05$ (2 tailed)

Table 11 confirms that the differences between the two experimental and the two control groups was statistically significant (t (181) = 5.833, p= .000). Further analysis using one-way ANOVA was deemed necessary to establish whether or not the difference in the groups mean scores were statistically significant at alpha level of .05. The results are shown in Table 12.

Table 12. One-way ANOVA of the Self-concept post-test Mean Scores

	Sum of Squares	Df	Mean Square	F	P
Between Groups	5.979	3	1.993	12.620*	.000
Within Groups	28.428	179	.158		
Total	34.407	182			

*Significant at p<0.05

Table 12 indicates that the differences in self-concept between the four groups were statistically significant (F (3,179) = 12.620, p = .000). After establishing that there was a significant difference between mean scores in MSC, it was important to carry out further test on various combinations of means to find out where the differences occurred. The Scheffe's method was preferred since the sample sizes selected from the different populations were not equal (Githua & Nyabwa, 2008). Table 13 shows the results of Scheffe' post hoc multiple comparisons.

Table 13. Scheffe's post hoc multiple comparisons of the post-test MSC

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	P
E1	E2	.05985	.08675	.924
	C1	.44340*	.08265	.000
	C2	.30409*	.08265	.004
E2	E1	-.05985	.08675	.924
	C1	.38355*	.08373	.000
	C2	.24424*	.08373	.040
C1	E1	-.44340*	.08265	.000
	E2	-.38355*	.08373	.000
	C2	-.13931	.07948	.383
C2	E1	-.30409*	.08265	.004

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E2	-.24424*	.08373	.040
C1	.13931	.07948	.383

The results in Table 13 reveal that there is a statistically significant means score difference between the experimental groups and control groups. The results also indicates that there is no statistically significant mean score difference between two experimental groups or two control groups. For instance, the mean difference between E1 and C1 and between E2 and C2 was statistically significant. But the mean difference between E1 and E2 and between C1 and C2 was not statistically significant.

Therefore, the null hypothesis suggesting that there was no statistically significant difference in students' mathematics self-concept between those taught using Jigsaw Cooperative Learning Strategy and those taught using Conventional Teaching Methods in secondary schools was rejected at .05 level of significance.

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

The findings of this study have shown that there was a statistically significant difference in favour of experimental groups in students' mathematics self-concept between those taught using Jigsaw Cooperative Learning Strategy and those taught using Conventional Teaching Methods in secondary schools in Laikipia County. This is an indication that the use of Jigsaw learning was more effective in improving students' mathematics self-concept as compared to the conventional teaching/ learning methods. These finding agrees with research work of Aronson and Osherow (1980) which claim that increased liking for a student is fundamental to that child's acceptance, which in turn is a prerequisite for the development of positive self-concept. They further assert that negative self-concept may adversely affect academic performance. Similarly, a study by Araragi (1983) generally shows positive effects on academic performance, liking for school and liking for peers. Aronson (2000) claim that positive effects on academic performance are due to students' increased participation in learning, combined with reduced anxiety. They claim that empathic role-taking increases and that individuals'attributional patterns for success and failure change. An experiment by Walker &Crogan (1998) shows that the Jigsaw method is effective in Australian social conditions in producing positive changes in academic performance, self-concept to the jigsaw classroom peers and prejudice. The findings of this study and in other cited studies support that Jigsaw cooperative learning strategy is an important strategy in improving self-concept in mathematics. It can therefore be concluded that jigsaw learning strategy can be used as a method of improving learners self concept especially in mathematics. This study has

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implications to teachers and teacher education institutions and its recommended that School Quality Assurance and Standards Officers in education should encourage teachers to use this strategy of teaching mathematics in order to improve the mathematics self-concept among students. The teacher training colleges and universities should also embrace Jigsaw learning strategy as a modern method of teaching in teacher education classes so that pre-service teachers develop skills of implementing the strategy later in classroom.

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