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THE EFFECT OF JIGSAW COOPERATIVE LEARNING STRATEGY ON STUDENTS' MATHEMATICS SELF-CONCEPT BY GENDER IN SECONDARY SCHOOLS IN LAIKIPIA COUNTY, KENYA

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ABSTRACT

Students' gender differences in mathematics self-concept have important implications for the under-representation of women in science. Typically, students' gender differences in mathematics self-concept emerge at the beginning of high school which has consequently led to female students performing poorly in the subject in the Kenya Certificate of Secondary Education (K.C.S.E) examinations. That has raised concerns among the stakeholders in education due to the importance attached to mathematics. The factors that are attributed to the female students' dismal performance in the subject include; poor attitude towards the subject by the students and teachers, gender stereotypes, lack of role models, low mathematics self-concept and the instructional methods used by teachers. This study sought to address the problem of ineffective instruction methods used by teachers and low mathematics self-concept by gender. This is as a result of inadequate information in research conducted in Kenya on effects of the use of Jigsaw Cooperative learning Strategy on students' self-concept in mathematics by gender. Solomon Four non-equivalent control group design was used in the study. A simple random sample of four co-educational secondary schools was selected from Laikipia County. The sample size was 4 schools out of the possible 67 schools with a population of about 20,800 students in Laikipia County. A mathematics self-concept scale (MSC) for students were used to collect the required data. A total of 183 Form three secondary school students (i.e., 85 girls and 98 boys) filled the MSC questionnaires. The MSC was piloted in a school which was not used in the study in Laikipia County and it's reliability estimated. The reliability coefficient of the MSC was computed to be 0.96 using Cronbach alpha. Data were analyzed using posttest mean and t-test at alpha (ά) level of .05. The study revealed that gender did not affect students' mathematics self-concept when students were taught using Jigsaw cooperative learning strategy (t (81) = -1.345, p =.155). The findings are expected to be useful to teachers in secondary schools because they will be able to identify learning strategies which will improve learners' mathematics self-concept and their achievement in the subject. Curriculum developers and education officers are likely to benefit from this study in deciding on the appropriate learning strategies for learners to improve the quality of mathematics in the country. The research recommends use of Jigsaw cooperative learning strategy in mathematics instruction in secondary schools in Kenya to improve and also reduce gender disparities in the mathematics achievement.

Keywords: Jigsaw learning strategy, Mathematics self-concept, Gender.

INTRODUCTION

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, 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 poor performance in mathematics could be attributed to low mathematics self-concept of learners among other factors. 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 is the basis for modern scientific and technological developments and an important means of cogent, concise and unambiguous communication (Cockroft, 1982; Ndimbirwe, 1995). This perceived usefulness of mathematics in one's life has motivated 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. This is reflected in the Kenya Certificate of Secondary Education (KCSE) mathematics examinations results (KNEC, 2016). The students' mean score in mathematics at KCSE national examinations by gender in the year 2013 to 2015 are shown in Table 1.

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Table 1: Students' Percentage Mean Score in Mathematics at KCSE for the years 2013 to 2015

Year	Male	Female	Grand mean
2013	35.46	28.79	32.43
2014	33.00	26.76	30.11
2015	34.52	28.64	31.78

Source: KNEC (2016)

The report of the Kenya National Examinations Council indicated grand mean scores of less than 35 per cent with the female candidates below 30 per cent. This low achievement in mathematics performance and gender disparities is partly attributed to ineffective teaching methods employed in mathematics classrooms (O'Connor, 2000). The persistent poor performance in mathematics and gender disparities is also registered in Laikipia County as shown in Table 2.

Table 2: KCSE Mathematics Results for Laikipia County for the years 2011 to 2015 by Gender

Years	2011	2012	2013	2014	2015
Female	2.165	2.945	2.909	2.824	2.987
Male	4.925	4.955	4.887	4.404	4.475
Mean score	3.545*	3.950*	3.898*	3.614*	3.731*

Note: * Mean score range (0-12) points.
Source: County Education's Office, Laikipia County (2016)

The mathematics KCSE examination results from Laikipia County shown in Table 2 indicate that the performance index for females was below 3 points out of 12 points for five consecutive years as compared to males with above 4 points. The poor performance in mathematics could be attributed to low mathematics self-concept of learners among other factors. 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).

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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. According to Aronson (2000), 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).

The Jigsaw learning strategy can be used to learn most of the topics in secondary schools mathematics syllabus. The effect of the strategy in the learning of the topics Surds and Further logarithms was studied. These are major topics in the secondary school mathematics curriculum. The topics are regularly tested in the KCSE for the past years as shown in Table 3. The topics are taught at secondary Form Three level (KIE, 2000).

Table 3: Testing of Surds and Logarithms at KCSE (2008-2014)

Year	2008	2009	2010	2011	2012	2013	2014
Paper	1, 2	2	2	1, 2	2	1, 2	2
Question No.	9, 13	14	8	6, 10	15	4, 14	11

Source: KCSE (2008-2014) Mathematics past papers

In Table 3, question number denotes the question in either paper one or two that tested the topics surds and logarithms. The Table 3 shows that the topics surds and logarithms were tested annually from 2008 to 2014, indicating the importance attached to the topics. They have been among the challenging areas for students to learn in the secondary school mathematics syllabus in Kenya. This is evident in the baseline survey by SMASSE Laikipia East trainers where the topics Surds and Logarithms were second and third respectively in order of difficulty to the learners as shown in Table 4.

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Table 4: Topics found Challenging in Secondary School Mathematics during Baseline Survey by SMASSE Laikipia East Trainers, Kenya.

Topics	Form One	Form Two	Form Three	Form Four
Topics in order of difficulty	i) Survey ii) Integers	i) Linear motion ii) Similarity ii) Indices and Logarithms (Negatives)	i) Vectors ii) Surds iii) Logarithms iv) Errors and approximation v) Compound proportion	i) Linear Inequality ii) Locus iii) Transformations

Source: SMASSE (2000a)

The findings of the research are relevant to Laikipia County because Laikipia East is an administrative District in the county. According to KIE (2000-2007), Surds and Logarithms was among the areas that students performed poorly in 2006 and 2007 national examinations. In the present study, Jigsaw learning strategy was used to learn the topics Surds and Logarithms and assessed if it would affect the students' mathematics achievement in Laikipia County, Kenya.

OBJECTIVE OF THE STUDY

The following objective guided this study

To determine the effect of Jigsaw cooperative learning strategy on students' mathematics self-concept by gender in secondary schools in Laikipia County, Kenya.

HYPOTHESIS OF THE STUDY

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

Ho: There is no statistically significant difference in the mathematics self-concept between boys and girls when taught using Jigsaw cooperative learning strategy in secondary schools in Laikipia County, Kenya.

RESEARCH METHODOLOGY

Research Design

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. This design involves a random assignment of intact classes to four groups.

Figure 1: The Solomon 4-group, non-equivalent control group design.

GROUP	NOTATION
E_1	o_1 o_2 x (Experimental group)
C_1	o_3 o_4 - (Control group)
E_2	o_5 – x (Experimental group)
C_2	o_6 - - (Control group)

In Figure 1, the variables are defined such that: o1 and o3 are pretest observations; o2, o4, o5, o6 are post-test observations; and x is treatment. Group E1 received pre-test, treatment and posttest; Group C1 received pre-test and post-test without treatment; Group E2 received the treatment and post-test; Group C2 received post-test only. Two schools were experimental schools and in the experimental schools one received post-test only while the other received pre-test and post-test. The other two schools were control schools and in the control schools, 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. However, only the results from one stream in each school were analyzed and used for the testing of the hypotheses of the study. This is because the sample size was one stream.

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Population of the Study

The schools that participated in the study were from Laikipia County. The target population was secondary school students in Laikipia County. The accessible population was form three students in the co-educational secondary schools in Laikipia County. 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

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 with a total of 188 students. 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. According to Mugenda and Mugenda (1999), the required sample size is at least 30 per group.

Instrumentation

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, & 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. In this study, the MSC was also pilot tested locally to check whether it can be used in the context of this study.

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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 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 3	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). Cronbach's alpha assesses the homogeneity of the items and uses one administration of the instrument. The result of the reliability estimate of the MSC was obtained as 0.96. The instrument had almost the same reliability as in Table 6 and also met the threshold reliability coefficient of 0.70 and higher which is recommended (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

Table 6 indicates that the representativety was found to be high thus the instrument had the required validity to be adopted in the study.

RESULTS

Pre- Test Analysis

Data was collected before treatment to the E1 and C1 groups using a pre-test MSC to assess the homogeneity of the groups in mathematics self-concept with reference to gender as shown in Table 7..

Table 7: The pre-test mean score on Self-Concept

	Gender of the student	N	Mean	Std. Deviation	Std. Error Mean
Self-concept pre-test mean	Male	59	3.5044	1.06128	.13817
	Female	34	3.4716	1.10053	.18874

The means of the boys and the girls were not much different and further analysis was done using t-test to establish whether the difference was significant at alpha level of .05 as shown in the Table 8.

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Table 8: Independent Samples t-test of pre-test scores on MSC based on gender

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	Df	Sig. (2-tailed)
Self concept pre-test mean	Equal variances assumed	.002	.960	.142	91	.888
	Equal variances not assumed			.140	66.913	.889

Note: t not significant at α = .05 (2 tailed)

The results in the Table 8 above indicate that there are no statistically significant differences between boys and girls in the pretest scores (t(91) =.142, p= .888) at alpha level of .05. This is an indication that the gender groups are homogeneous and comparable.

The effect of Jigsaw cooperative learning strategy on students' mathematics self-concept by gender in secondary schools

The objective sought to determine the effect of Jigsaw learning strategy on students' mathematics self-concept by gender in secondary schools. The following null hypothesis was formulated in order to accomplish this objective:

Ho: There is no statistically significant difference in the mathematics self-concept between boys and girls when taught using Jigsaw Learning Strategy in secondary schools.

The hypothesis, therefore presumed that Jigsaw learning strategy has no effect on students' mathematics self-concept by gender. To ascertain this assumption, post mean scores

of the MSC were analyzed. First, the post-test means of the experimental and control groups by gender were obtained as shown in the Table 9.

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Table 9: The post-test means of the experimental and control groups by gender

Grouping		Gender of the student	N	Mean	Std. Deviation
Experimental (E1 & E2)	Self-concept post-test mean	Male	44	4.0752	.27918
		Female	39	4.1795	.37982
Control (C1 & C2)	Self-concept post-test mean	Male	54	3.7835	.44812
		Female	46	3.7729	.45402

The self-concept post-test mean of females was higher than for males in the experimental groups while it was lower than for males in the control groups. The differences between the male and the female self-concept post-test mean for experimental and control groups were found to be .10425 and .01066 respectively. Then, the experimental groups (i.e., E1 & E2) and control groups (i.e., C1 & C2) were separated by gender and the differences between boys and girls post mean scores analyzed using t-test as shown in Table 10.

Table 10: Independent samples t-test of Self-Concept Post-Test means by Gender

	Learning Groups	t	df	p(2-tailed)
E1	Self-concept post-test mean	-.655	41	.516
E2	Self-concept post-test mean	-1.493	38	.144
C1	Self-concept post-test mean	.679	48	.500
C2	Self-concept post-test mean	.035	48	.972

Table 10 confirms that there is no statistically significant differences between boys and girls post-test mean scores in the experimental groups, E1 ($t(41) = -.655$, $p = .516$) and E2 ($t(38) = -1.493$, $p = .144$). Further analysis was done using independent samples t-test to establish if the differences were significant. The results are shown in Table 11.

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Table 11: Independent samples t-test of Self-Concept Post-Test means by Gender

		T	df	P (2-tailed)
Experimental (E1 and E2)	Self concept post-test mean	-1.435	81	.155
Control (C1 and C2)	Self concept post-test mean	.118	98	.906

Note: * means significant at α = .05

Table 11 indicates that the difference between the self-concept post-test mean score is not significant at .05 by gender in the combined experimental groups (t (81) = -1.435, p = .155). Thus, the hypothesis that there was no statistically significant difference in the mathematics self-concept between boys and girls when taught using Jigsaw learning strategy in secondary schools was accepted at .05 level of significance and the conclusion made that gender of a student does not influence mathematics self-concept when taught using Jigsaw learning strategy.

DISCUSSIONS

The findings of this study have shown that there was no statistically significant difference in MSC scores between males and females when students were taught using Jigsaw learning strategy. In the study, students assisted one another in the learning process and it was the duty of each member to make sure that other group members had mastered the concepts learnt in expert groups. The girls and boys learnt together because the activities required teamwork to accomplish. The method resulted in better student-student and student-teacher interactions thereby improving the students' mathematics self-concept hence demystifying the subject. Each type of classroom reward structure promotes a different pattern of interaction among students (D'amico & Schumid, 1997). The findings of this study that gender is not a factor in shaping mathematics self-concept supports earlier studies by Fox, Sonnert and Nikiforova, (2011) who asserts that one factor why women remain under-represented in science, technology, engineering, and mathematics fields is lack of self-concept in mathematics.

CONCLUSION

Based on the results of the study, the following conclusion was arrived at, with regard to County co-educational secondary schools in Laikipia County of Kenya; Gender does not affect students' self-concept in mathematics when students are taught using Jigsaw learning strategy.

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Implications of the Study

The use of Jigsaw learning strategy in teaching results in better students' performance in mathematics. The use of Jigsaw learning strategy is therefore a suitable method for teaching. Curriculum developers should encourage teachers to use this method in teaching mathematics to improve the current trend of dismal performance in mathematics especially in Co-educational schools. The teacher training colleges and universities should emphasis Jigsaw learning strategy as an effective method of teaching mathematics.

Recommendations

The findings of this study suggest that the use of the Jigsaw learning strategy can be an effective approach to mathematics instruction. From these findings, this study proposes the following recommendations:

i) Mathematics curriculum developers should include the teaching of mathematics using Jigsaw strategy as part of the teacher education syllabus during the training of mathematics teachers. This makes it part of the curriculum which may address the problem of dismal performance and gender disparities in the subject.

ii) Teachers should be encouraged by education stakeholders such as the inspectorate and the K.I.E to use Jigsaw learning strategy in teaching mathematics. However, it should be used to the topics where it is applicable.

iii) During in-service training of teachers organized by the Ministry of Education Science and Technology (MOEST), such as SMASSE, the use of Jigsaw learning strategy in teaching mathematics should be incorporated. This is because the quality of teachers and the kind of training they have is a major determinant of the quality of education in any nation.

iv) Teachers in other subjects may use the different strategies of cooperative learning. This is because, similar improvement in achievement and self-concept may be found.

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