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Jigsaw Learning Strategy and Secondary Schools Students' Mathematics Achievement by Gender in Laikipia County, Kenya

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Abstract

Gender differences in mathematics achievement have continued being a challenge in the society today. This difference has important implications for the under-representation of women in the field of science. In Kenya, students' gender difference in mathematics achievement is evident in 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 gender stereotypes. 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' achievement 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 achievement test (MAT) for students was used to collect the required data. A total of 188 Form three secondary school students (i.e., 84 girls and 104 boys) wrote the MAT. The MAT was piloted in a school which was not used in the study in Laikipia County and its reliability estimated to be 0.95 using KR-21 formula. Data were analyzed using posttest mean and t-test at alpha (ά) level of .05. Gender did not affect students' achievement in mathematics when students were taught using Jigsaw Cooperative Learning Strategy ($t(92) = -.835$, $p=.423$). The findings are expected to be useful to teachers in secondary schools because they will be able to identify learning strategies which will reduce gender disparities in learners' mathematics achievement. 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 achievement, Gender.

Introduction

Mathematics is the basis for modern scientific and technological developments and an important means of cogent, concise and unambiguous communication (Cockroft, 1982). 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.

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 LaikipiaCounty 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.

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.

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 by gender 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 achievement 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 achievement 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.

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)

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

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.

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 Achievement Test (MAT) was used to collect the required data during school days. The pre-test and post-test MAT was developed by the researcher. The pre-test MAT was a 36 item instrument which tested the student's knowledge on the perquisite knowledge of the topics surds and further logarithms with a total score of 80 marks.

The post-test MAT was a 36 item instrument which tested the student's knowledge on the topics 'surds' and 'further logarithms' after learning with a total score of 80 marks. The post-test MAT was set on all the subtopics of 'surds' and 'further logarithms' with the questions distributed according to the table of specification of blooms taxonomy (see Table 5). The items were allocated between 1 to 4 marks each. The instruments were pilot tested in a co-educational school that was not used in the main study in Laikipia County.

Table 5: Table of specification for MAT pre-test and post-test

Ability	Knowledge	Compre-hension	Applic-ation	Anal-Ysis	Synt-hesis	Evalu-ation	Totals items
Surds	3(3)	4(8)	2(4)	3(6)	3(9)	2(6)	17 (36)
Logarithms	3(5)	3(6)	5(10)	3(6)	3(9)	2(8)	19(44)
Total marks 8		14	14	12	18	14	80

Note: The numbers in parenthesis indicates the total marks for the associated items.

3.6.1.1 Validity of the MAT

The developed MAT was modified to answer the set objectives of the study. The MAT was validated by the researcher and also the education experts from the School of Education, Laikipia University, to assess the content, construct and face validity. Their comments were incorporated into the instrument before being used for data collection. This ensured that the items in the instrument were precise and comprehensive enough to provide the anticipated type of data and also determine construct and content validity.

3.6.1.2 Reliability of the MAT

According to Gay and Airasian (2003), the more reliable a test is, the more confident we can have that scores obtained from the administration of the test are essentially the same scores that would be obtained if the test were re-administered. The MAT was pilot tested in a co-educational school which was not used in the study in Laikipia County. According to Coolican (1994), there is a significant need for a researcher to carry out a pilot study before the actual field work so as to discover the flaws in research instrument and hence provide for their necessary refinement. The reliability of the MAT was estimated by use of the KR21 formula because the instrument was administered once and had continuous data. The formula is; $r = (k/k–1)\ [1–M\ (k–M)\ /k\acute{o}^2]$ where k is the number of items which was 36, M is the means which was 27.82, and $\acute{o}^2$ is the variance which was119.42. The MAT reliability coefficient (r) was found to be 0.95. The instrument met the threshold reliability coefficient of 0.70 which is recommended for social sciences research (Mugenda & Mugenda, 1999).

Results

4.2.4 Pretest Analysis of Achievement by Gender

The pre-test MAT was analyzed in terms of gender to establish whether there was a difference between boys and girls before exposure to the treatment. The means of the boys and the girls of the groups E_1 and C_1were first compared as shown in the Table 6.The mean of boys was higher than that for girls and further analysis using t-

test was done to establish whether the difference was statistically significant for the groups E_1 and C_1. The results are as shown in the Table 7.

Table 6: The pre-test mean score on Achievement by Gender

	Gender of the student	N	Mean	Std. Deviation	Std. Error Mean
	Male	57	29.4737	11.37997	1.50731
	Female	31	25.0667	15.03773	2.74550

Table 7: Independent Samples t-test of pre-test scores on MAT based on gender

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Achievement Pre-test score	Equal variances assumed	1.404	.239	.740	86	.129	4.40702	2.87508	-1.30941	10.12345
	Equal variances not assumed			1.407	46.910	.166	4.40702	3.13206	-1.89419	10.70822

The results in the Table 7 above indicate that there were no statistically significant gender differences in MAT in the pretest scores using (t (86) = .740, p= .129) at alpha level of .05. This is an indication that the gender groups were homogeneous and comparable with respect to MAT prior to treatment.

4.6 Jigsaw Learning Strategy and Students' Mathematics Achievement by Gender in Secondary Schools

The objective sought to examine the moderating effect of gender on the students' mathematics achievement by Jigsaw Cooperative Learning Strategy in secondary schools in Laikipia County, Kenya. The following null hypothesis was formulated in order to accomplish this objective:

Ho1: There is no significant effect of gender on students' mathematics achievement when taught using Jigsaw Cooperative Learning Strategy in secondary schools in Laikipia County, Kenya.

The hypothesis, therefore presumed that Jigsaw learning strategy has no effect on students' mathematics achievement by gender. To achieve this objective, the MAT scores were analyzed to determine if there was any difference between boys and girls on achievement when taught using Jigsaw learning strategy. First, the post-test achievement analysis by gender was obtained as shown in Table 8. Then, the achievement gain analysis by gender was done and the results are shown in the Table 9.

Table 8: MAT Post-test Mean Score analysis by gender

Gender of the student	N	Mean	Std. Deviation
Male	51	46.2353	11.21533
Female	43	44.3953	11.33713

Table 9 : Achievement Gain Analysis by Gender

Grouping		Gender of the student	N	Mean gain	Std. Deviation
Experimental (E_1)	Achievement gain	Male	28	15.8571	9.30836
		Female	16	20.0000	10.16530
Control (C_1)	Achievement gain	Male	29	2.3103	3.99199
		Female	15	1.6000	3.08915

The Table 8 indicates that there was a difference between the post-test mean scores by gender in the experimental groups (who were taught by Jigsaw) where males had a slightly higher mean score than females. Table 9 confirms that the females had a higher achievement gain ($\dot{X}$= 20.00) than the males ($\dot{X}$ = 15.85) in the experimental group. However, in the control group achievement gain was very low. Males had a higher gain ($\dot{X}$=2.3103) and the females had the lowest ($\dot{X}$= 1.6000). The increase in achievement gain in the experimental groups was as a result of the intervention of Jigsaw cooperative learning strategy which also increased girls' mathematics achievement. Therefore, Jigsaw learning proved to be an effective learning strategy that decreases gender stereotypes on mathematics achievement. However, when one looks beyond stereotypes to actual mathematics achievement, boys do not consistently outperform girls. In the U.S., there is older research reporting that high-school girls score lower than boys on standardized mathematics assessments but newer findings indicate that gap is narrowing or non-existent, at least up to the final years of high school. On the other hand, if one looks at achievement on international standardized mathematics achievement tests, a gender gap favoring boys still exists among U.S. elementary- school students. In Asian countries there is no gender gap in mathematical achievement at any age (Organization for Economic Co-operation and Development [OECD], 2011).

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

		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference
Experimental	Equal variances assumed			-.835	92	.432	1.83995
	Equal variances not assumed	.788	92	-.835	89.004	.433	1.83995

Note:*means significant at α = .05

Analysis by using independent samples t-test was also done to establish if the differences between the combined experimental groups by gender were significant. The results are as shown in the Table 10 which confirms that there is no statistically significant difference between boys and girls post-test mean scores in the experimental groups (t(92) = -0.835, p= .423. Therefore, the null hypothesis suggesting that was no significant moderating

effect of gender on students' mathematics achievement when taught using Jigsaw Cooperative Learning Strategy in secondary schools in Laikipia County, Kenya was accepted at .05 level of significance.

Discussion, Conclusions and Recommendations

The discoveries of this research demonstrated that there was no statistical significant difference in mathematic achievement amongst young men and young ladies when educated by the utilization of Jigsaw learning system. It was additionally found that both young ladies and young men would do well to mean scores when presented to Jigsaw learning procedure than the individuals who were educated through ordinary instructing strategies. In spite of the fact that there are recorded sex contrasts in mathematic achievement at KCSE examination (KIE, 2001; KNEC, 2002), contemplates directed by Mondoh (2001) showed that young ladies can execute in the event that they are allowed to collaborate and talk about science idea openly in mathematics classrooms. In this study, students' gender did not disadvantage them in the learning of mathematics. Therefore, the use of Jigsaw learning system in schools' mathematics instruction could be utilized to lessen sexual orientation dissimilarity in KCSE mathematics examinations. Much research has been done with respect to sexual orientation contrasts in achievement in mathematics. As indicated by Mondoh (2001), there is little sex contrasts in general reaction to mathematics among 11-year-old youngsters. Be that as it may, amid auxiliary school years, young ladies' dispositions towards mathematics weaken more than that of male learners. At 15 years old male learners have a tendency to underrate, while young ladies have a tendency to misrepresent the trouble level and downgrade their own aptitude in the subject (Mondoh, 2001). In summary, the findings of this study support the idea that if both males and females are taught using interactive strategies such as the Jigsaw cooperative learning strategy, gender cannot be a factor in students' mathematics achievement.

This study has 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 achievement and reduce gender disparities in achievement 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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