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Peer Instruction and Secondary School Students Achievement in Vectors

Susan Ouko Catherine Aurah Maurice Amadalo
School of Education. Masinde Muliro University, P O box 190-50100, Kakamega, Kenya.

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Abstract
The importance of raising students competence in mathematics in a developing country such as Kenya cannot be overstated. This is because to produce professionals in areas such as engineering, medicine and accounting requires a good score in mathematics. Students that will further their studies in these areas will find that vectors is pre requisite knowledge. The purpose of this study was to document the impact of peer instruction on students achievement in vectors. The study used a modified version of the Solomon four group experimental design. Intact classes were randomly assigned to the four treatment groups in the Solomon four design. The study used both probability and non probability sampling procedures to select 479 form three learners for the study. Two achievement tests were used to collect data. The t-test and ANOVA were used in data analysis. Results revealed that peer instruction had a marked positive impact on the students achievement in vectors than when conventional methods of instruction were used. It is therefore recommended that where there is need to substantially improve achievement in vectors peer instruction should be used.
Key Words: Achievement, Peer Instruction, Learning vectors

1. Background to the Study

Studies on the effectiveness of instructional technology are neither new nor have they been fully exhausted. A great deal of research has been carried out comparing one instructional technique to another with the aim of revealing their suitability for improving learners achievement in mathematics. Greenwood et al. (1990) says that the teacher mediated instruction is less effective compared to the use of peer instruction in mathematics. A baseline survey conducted by Strengthening Mathematics and Science Education (SMASE) in Bungoma County found that the teachers of mathematics largely used teacher centered instruction. Other studies, (National Council of Teachers of Mathematics: NTCM, 2000, 2008; Longaretti. et al.; 2002) reveal that instruction at the high school level remains overwhelmingly teacher centered resulting in dismal performance in mathematics examinations.

The importance of raising students competence in mathematics in a developing country, such as Kenya, cannot be overstated. This is because to produce professionals in areas such engineering, medicine and accounting requires a good score in mathematics examination. An analysis of the performance in the past five years in Kenya Certificate of Secondary Examinations (KCSE), reveals that less than 15% of the students score quality grades of B- and above. More than 70% of the students score grades D+ and below. This poor performance in mathematics has been the concern of the Bungoma District Education Committee (BDEC, 2009) in a county which posts fairly good results in other subjects.

The Kenya National Examination Council (KNEC) examination report of 2012 cites questions on vectors are not popular with candidates. Those who attempted such questions did so with a 50% failure rate. Similar reports for 2008, 2009, 2010 and 2011 suggest it is an area in which learners' experience challenges. Goodlad & Hirst (1989) points out that, students intending to further their studies in various fields of mathematics will find that vectors a is prerequisite knowledge in such courses.

2. Purpose of the Study

The purpose of this study was to document the impact of peer instruction and conventional methods of instruction on students achievement in vectors.

3. Study Objective

The study objective was to determine the achievement in vectors by learners taught using peer instruction and those taught using conventional methods. From the objective it was hypothesized that there will be no difference between achievement scores in vectors of learners taught using peer instruction and those taught using

conventional methods.

4. Theoretical Framework

The study was guided by the social learning theory (SLT) advanced by Bandura (1977). According to SLT, people learn new information by observing others. In learning by observation, the learner acquires knowledge by observing a model. Peers were chosen as the desired models because according to SLT one pays more attention to the model when they think of the model as being similar to them. Burton (1998) posits that an interesting model or a novel aspect to a situation increases attention to learning. In peer instruction learning from a student brings about variety in the normal classroom routine thereby capturing the learners attention. O'Donnel (2006) says that the ability to remember information is dependent upon its processing. In peer instruction learners critique each other's suggestions in working out assigned tasks hence processed the information thoroughly facilitating retention.

5. Research Design

The study used a modified version of the Solomon four group experimental design. Intact classes were randomly assigned to the four treatment groups in the Solomon four design. The design was considered rigorous enough to control threats such as testing effect which would otherwise undermine the experiments validity. The study designed an experiment where the teaching approaches were the independent variables while the students achievement was the was the dependent variable. Peer instruction was the treatment while conventional instruction was the control. The researcher was attempting to justify the inclusion of peer instruction as an instructional innovation in schools.

The study was conducted in Bungoma County in western part of Kenya along the Kenya-Uganda Boarder. It boarders Busia, Kakamega and Trans Nzoia Counties. It is a densely populated region with many schools within a walking distance of one another. It has been noted that afternoon lessons are usually disturbed by noise from the rain as some of the classrooms have tin roofs and lack ceiling boards. Within the county we have different school categories such as Boy's, Girl's and Co- educational schools. Despite posting impressive results in national examinations, performance in mathematics has remained poor.

6. The Target Population

The form three class is comprised of students in the third year of the secondary cycle of the 8-4-4 system of education. There are about 4200 form three students in the county. The form three class was selected because of their relevance to the topic of investigation. They have covered vectors I in form 2 which is prerequisite knowledge to vectors II on which the peer instruction model was designed.

7. Sample and Sampling Techniques

The study used both probability and non probability sampling procedures to select the desired sample for the study. A total of 16 schools were selected using stratified random sampling. Purposive sampling technique was used to select the form three class. Where more than one stream existed simple random sampling was used to select one stream. Selected streams were randomly assigned to treatment groups. In total 479 students were sampled for the study of which 240 were in the control treatment groups and 239 in the experimental treatment groups.

8. Data Collection Tools

The study used two achievement tests (Vector-I and Vector-II) to collect data. In both tests, the question items covered three cognitive domain levels of knowledge, comprehension and application. Vector-I served as the pre-test, it was a six item test on vectors in two dimensions to be done in 40 minutes. Its purpose was to establish the entry behavior of the learners to ascertain they were matched. Vector-II served as the post test, it was a six item achievement test on vectors II to be done in 40 minutes. It was used to determine the impact of the treatment (peer instruction) on the respondents.

The researcher scored both tests out of 30. The minimum achievement score that a learner could attain was 0 and the maximum was 30. A score in the range 0-10 was indicative of low achievement, 11-20 indicative of average achievement and 21-30 was indicative of high achievement. The interval between the pre-test and the post-test was four weeks.

Expert reviewers drawn from teachers of mathematics in secondary schools were used to examine content and face validity. Two schools in Bungoma county were conveniently sampled for piloting of the instruments. Piloting was done to determine whether the time allocated for each paper was adequate and observe whether the

space left for working out each question was adequate. A reliability coefficient of 0.82 for the Vector-I and 0.8 for Vector-II confirmed that the tests were reliable.

9. The Treatment

The experimental treatment groups learnt vectors via peer instruction over three weeks. The control treatment groups learnt the same content over the same duration of time via conventional methods. This was equivalent to 14 hours of instruction for both groups. During the experiment, the researcher occasionally participated in the classroom activities in the experimental schools to ascertain that the peer instruction model of learning was being used as prescribed. The researcher also visited the classrooms in the control schools and ascertained that the peer instruction model was not used.

10. Data Analysis and Presentation

The instruments of data collection yielded quantitative data which was analyzed using descriptive and inferential statistics. Descriptive statistics used in this study included percentages and means while for inferential statistics the study used the t-test as well as one way analysis of variance (ANOVA). These were generated by the statistical package SPSS version 12.0. The hypotheses were accepted or rejected at 0.05 level of significance. The subjects were evaluated in a pre-test: Vector-I and a post test: Vector-II. A table of frequencies and means was generated for each treatment group. The t-test was used to evaluate if the differences between the means in the pre-test were significant. One way analysis of variance (ANOVA) was used to evaluate whether the differences between the means in the post test were significant. The researcher compared the post test scores of groups E_1 and E_2 to investigate if the pre test had any effect on the post test. The researcher compared the pre-test scores of groups E_1 and C_1 to establish the entry behavior of the two groups. This was to confirm that any difference in their mean scores in the post-test could be attributed to the treatment.

10.1 The Pre-Test Results

The learners in E_1 and C_1 sat for a pre test. The mean scores of the learners in the pre-test for the control group C_1 and the experimental group E_1 are presented in Table 1.

Table 1 Means, Standard Deviation and t-value of the E_1 and C_1 groups in the Pre-Test

Treatment group	N	$\bar{X}$	σ	t-critical	t-calculated
E_1	120	11.54	4.651	± 1.645 at $\alpha = 0.05$	-0.3929
C_1	119	11.75	3.491		

Table 1 shows low mean scores for experimental and control groups (11.54 and 11.75 respectively). The result shows a value of t-calculated was -0.3929 and its corresponding t-critical was $\pm$ 1.645 at 0.05 level of significance and 237 degrees of freedom. By comparison the t-calculated was less than the t-critical, hence there was no significant difference between means of the treatment groups E_1 and C_1. The two groups entry behavior was comparable.

10.2 The Post-test Results

The means and standard deviations of the students performance in the post-test are presented in Table 2.

Table 2: Means by Treatment Group in the Post-test

Study unit	N	$\bar{X}$	σ	Gain in mean between pre-test and post-test
E_1	120	20.12	5.1	8.58 (74.35%)
C_1	119	13.95	4.827	2.2 (18.72)
E_2	119	18.57	5.734	
C_2	121	12.26	5.179	

Table 2 shows that the experimental treatment groups E_1 and E_2 posted high means of 20.12 and 18.57 respectively. The control treatment groups C_1 and C_2 posted low means of 13.95 and 12.26 respectively. The mean scores without the treatment are both low while the mean scores with the treatment are both high. The gain in mean by E_1 was 74.35% and was higher than the gain by C_1 which was 18.72 %. This indicates that the results after the treatment are improved. To find out if the differences between these means were statistically significant, an ANOVA was run and the results are presented in Table 3.

Table 3 Summary of ANOVA Results on Achievement in the Post-test

	Sum of squares	Degrees of freedom	X̄ square	*F*	*Sig.*
Between groups	50002.396	3	1667.465	61.195	0.00
Within groups	12943.023	475	27.248		
Total	17945.420	478			

Results of ANOVA at 0.5 level of significance revealed that the differences between the means of the study units E_1,C_1, E_2 and C_2 were significant. This indicates that the treatment worked and at least two groups had different means. To find out which of these differences were significant Fisher's Least Significant Difference (LSD) post hoc test was run and the results presented in Table 4.

Table 4 Fisher's LSD Multiple Comparisons per Treatment Group.

Treatment Group	LSD	Significance
E_1 to C_1	6.175*	0.000
E_1 to E_2	1.554	0.099
E_1 to C_2	7.869*	0.000
C_1 to E_1	-6.175*	0.000
C_1 to E_2	-4.622*	0.000
C_1 to C_2	1.693	0.059
E_2 to E_1	-1.554	0.099
E_2 to C_1	4.622*	0.000
E_2 to C_2	6.315*	0.000
C_2 to E_1	-7.869*	0.000
C_2 to C_1	-1.693	0.059
C_2 to E_2	-6.315*	0.000

* the mean difference is significant at the 0.05 level

Table 4 reveals that for the E_1: E_2 and C_1: C_2 the differences were least significant. This indicates homogeneity in achievement of the experimental treatment groups. The control groups achievement was also homogeneous. The difference between the means of the experimental treatment groups and the control treatment groups were

significant. The greatest significant difference between the means was for the E_1 and C_2 study units. To identify homogeneous subsets Turkeys HSD[ab] post hoc test was run and the results presented in Table 5.

Table 5 Turkeys HSD[ab] on the Post-test per Treatment Group.

Study unit	N	1	2
C_2	121	12.26	
C_1	119	13.95	
E_2	119		18.57
E_1	120		20.13

*Means for groups in homogenous subsets are displayed in one column

*Uses Harmonic mean sample size = 119.744

Table 5 shows that the means for the experimental groups were homogenous. The means for the control groups were also homogenous. This indicates that the pre-test did not influence the results of the post-test. None of the experimental groups means was homogeneous to the control groups. This indicates that the treatment worked in that the higher means of the experimental groups was due to the treatment.

11. Discussion

The improvement in achievement after using peer instruction is consistent with other studies. (Hooker; 2010, Mynard & Almarzouqi; 2006, Greenwood, Carter & Kamp; 1990, Armstrong ; 2012, Webb ; 1989). Hooker (2010) found that peer instruction improved students developmental mathematics course. This was attributed to the tutees and tutors being closer in age and status, thus tutees are freer to express opinions, ask questions and risk untested solutions. Mynard & Almarzouqi (2006) reports improvement in mathematics scores when peer instruction was used. In their study it was noted that peer instruction gave the learners room to work without judgment thus eliminated the fear of failure or criticism enabling learners bring out their mathematics abilities. Greenwood, Carter & Kamp (1990) compared teacher mediated to peer mediated instruction and documented fewer advantages for learners instructed by teacher mediated methods. Besides the learning of academic skills, the study also reports enhancement of peer relations as well as a more cooperative and pleasant classroom atmosphere. This is similar to findings by Webb (1989) which holds that peer mediated strategies were more effective when compared to teacher mediated strategies. Armstrong (2012) says that when using peer instruction there is conceptual learning which leads to enhanced performance. Similarly Tokoz (2007) investigated the effect of peer instruction on students physics achievement and attitude towards science lesson and reported that peer instruction had a greater effect on students science achievement and retention than conventional instruction.

12. Conclusion

The study found that PI had a marked positive impact on the students achievement in mathematics than when conventional methods of instruction were used. This means that peer instruction is a superior method compared to the conventional method of instruction.

13. Recommendations

From the study findings, it is recommended that peer instruction be adopted in teaching and learning of vectors and by extension mathematics to substantially improve achievement in mathematics.

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