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Classroom Interaction Patterns and Students' Learning Outcomes in Secondary School Mathematics in Kenya

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Abstract: ***Dismal performance in mathematics continue to persist in all levels of basic and secondary learning institutions yet performance and attainment in this subject is deemed crucial for students' admission to scientific and technological professions in higher institutions of learning in Kenya. This is despite the continued efforts made by the government to increase performance in this subject such as introduction of the Strengthening of mathematics and sciences in secondary education project. Knowledge on the effect of classroom interaction patterns on learning outcomes in mathematics is scanty and undocumented. The purpose of this study therefore was to establish the relationship between the Classroom Interaction Patterns (CIPs) used and the students' learning outcomes in secondary school mathematics in Mt. Elgon Sub-County. To achieve this objective, a quasi-experimental design was employed. A sample of 450 learners from 10 secondary schools and 10 teachers of mathematics were used in the study. Data was analysed using both descriptive and inferential statistics. Inferential statistics encompassed use of Pearson Product Moment Correlation and t-tests. Results showed that classroom interaction patterns significantly (P<0.05) influenced learning outcomes in mathematics in secondary schools in the study region. The study recommends teachers of secondary mathematics to promote interactive lessons for better learning outcomes***

Keywords: Classroom interaction patterns, Mathematics learning outcomes, Classroom performance

1. Introduction

Over the past decade, public dissatisfaction with school performance in Kenya has included dissatisfaction with mathematics attainment. Many countries in the world are working hard in order to achieve a mathematics economy in which numerical skills prosper. However, many students in countries like Kenya continue to perform poorly at the subject and the situation is wanting given that many professional careers such as medical courses, engineering, architecture and many others require knowledge of mathematics (Ayodo, 2009). Even other competitive engagements like the banking and finance services industry, teaching and real estate ventures are underpinned by advanced mathematics. Mathematics is taken to be a crucial subject for entry into almost every single profession in the world, be it a Chief Executive Officer (CEO), a rocket scientist, a biologist, a real estate agent, a customer service representative, a cashier, a teacher, a nurse, etc. Surprisingly, even entry level qualifications and starting jobs in fields seemingly unrelated to mathematics require mathematics skills, and therefore it is next to impossible to live an independent life in a competitive global economy without mathematical skills (Wile, 2017). Establishing the factors that would eventually improve performance in mathematics therefore has been an area of concern and study across many countries for many years.

Research done on classroom interaction practices in Kenya by Ackers and Hardman (2001), found an overwhelming dominance by the teacher in classroom activities. Much of the communication was teacher-directed. The teacher directed the question and answer exchanges with the students, and that a vast majority of these questions were found to be 'closed' questions as opposed to 'open' questions, which when used generate a lot of conversation between the parties. The classes were also heavily characterized by the teacher recitation approach, where interrogation of the pupils' knowledge and understanding of the subject matter turned out to be the most common form of teacher-pupil interaction. Ackers and Hardman (2001) also found that classroom interaction practices were highly hampered by the lack of the learning materials and the poor physical condition of the classrooms. Due to lack of learning materials, the learners hardly enjoyed the lessons since they had limited activities they could be participate in in their classrooms. The students also experienced a lot of discomfort because of the uncondusive learning conditions. The classrooms appeared poorly arrangement, not cleaned well, lacked storage facilities, lacked appropriate furniture and also lacked adequate ventilation. Learning could have appeared like a punishment after all. This study was done on primary schools and in mathematics, English and science lessons in a few selected schools. However, the sample was not big enough to generalize the findings among all primary schools in Kenya, neither does it reveal nor confirm that similar if not same practices and challenges are observed or encountered in secondary school classrooms. Some evidence on the kind of interaction practices that go on in secondary mathematics classrooms was meant to help generalize the findings to both the primary and secondary school levels, since many students in the Kenyan secondary schools perform poorly in this subject.

Over a long time, teachers have adopted the traditional approach of teaching where the learners rely heavily on the content presented by their teachers. Interaction among learners and teachers and amongst learners themselves has almost been absent. But with the changing nature of education in the whole world, methods of teaching are also changing. There is a lot of demand for student interaction during learning rather than just listening to teachers in order to enhance understanding of concepts. Use of imaginative and creative approaches in teaching could be the way out to improving performance in mathematics. According to Ayodo (2009) countries such as china and japan are technology savvy because their learners are taught simplified mathematics and how to apply the subject in their day to day life activities.

Many Classroom Interaction Patterns (CIPs) have been adopted in classrooms worldwide. These are ways through which students and teachers communicate in the classroom for the purpose of enhancing understanding of concepts and achieving lesson objectives (Pontefract and Hardman, 2005). The common patterns include; teacher-student, student-student, student-teacher, and student-learning resources. These are formal patterns but informal ones also do exist in classrooms, e.g. cultural inhibitions. Both the formal and informal CIPs have an impact on the learners' behaviour in the classroom, though the latter seems to bring up problems that hinder learning, e.g. drop-out, pregnancies, etc. The researcher has no control over these informal interactions and therefore they are not a centre of focus in this study. Limited interactive practices in the classroom impact negatively on the lesson activities and in most cases the teachers will dominate the lesson while the students remain passive. The more real, alive and accessible lessons (Nkwalume, 2005), will never be realized without adequate interactive activities in the classroom between the teacher and the students and among students themselves. Students enjoy learning when the teacher gives them good attention and provides a variety of learning activities that enable them to participate fully in the lesson and feel appreciated. The teachers need to realize that through various interaction practices in the classroom, learners are able to learn more through exploration, discovery and use of their senses.

Consequently, research done on secondary mathematics achievement in Kenya revealed that the poor performance is largely due to reasons such as; students' poor attitude towards the subject, quality of teachers and the poor teaching skills, lack of and ineffective use of learning resources, gender disparities and problems of access (Mondoh, 1986; JICA, 2013; Bunyi, 2004; Wambui 2005). Such research findings continue to be disseminated to the teachers through the SMASSE sessions to sensitize teachers on better and improved if not quality ways of presenting mathematics lessons in the classroom for improved learning outcomes in the subject. However, some sub-counties still post dismal performance in the subject as compared to others as evidenced by the Kenya National Examination Council(KNEC) yearly reports (2014, 2015, 2016 and 2017), which imply that several factors may be contributing to mathematics performance than have been revealed. Minimal study has been done to establish how well the teachers of mathematics make use of appropriate CIPs to promote mastery of mathematical concepts in secondary schools in Kenya in order to improve students' learning outcomes in the subject. It was against this elaborate background that the study was designed to investigate into the effectiveness of the classroom interaction patterns utilized in secondary school mathematics classrooms on the students' learning outcomes.

2. Methodology

The study adopted a Quasi-experimental research design. The researcher randomly assigns subjects to the experimental and control groups then exposes both groups to a pre-test to establish if they differ significantly before being exposed to the study. The experimental group further undergoes treatment; the group was exposed to different interaction patterns through classroom mathematics teaching. The researcher then measured the differences between the two groups on the students' secondary school mathematics learning outcomes. The teachers of this group were encouraged to plan for their teaching and teach as planned as well as evaluate their learning to establish whether a change in behaviour had occurred. They were also required to involve learners in many relevant activities as they also adopted improvisation where learning materials are limited. The control group was taught using the normal classroom practices that had been used before the onset of this study and the teachers of this group were not manipulated; they were not sensitized on the need to adopt the classroom interaction patterns in their teaching. All the groups were then given a post-test for comparison purposes among them. See Figure 1 below.

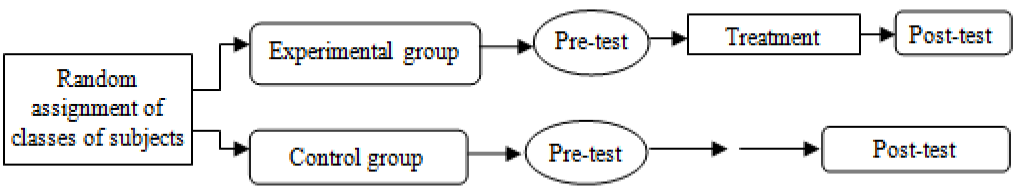

Figure 1: Procedure for a quasi-experimental research design
Source: Adopted from Patidar (2013)

A sample of 10 schools, 450 students, 10 teachers of mathematics and one Quality Assurance and Standards Officer participated in the study, giving a total of 461 respondents. A multi-stage sampling procedure was adopted to group and select the schools to participate in the study, in which case the sample was picked in stages using different sampling procedures. The researcher utilized the stratified random sampling, purposive sampling and simple random sampling techniques to select the sample for schools, teachers of mathematics and one form three class per school or stream in cases where the school had more streams. Data was collected by use of Students' achievement tests, a Classroom Observation Schedule (COS) and questionnaires for teachers of mathematics. The Pearson product moment correlation coefficient (Pearson r) was applied on the instruments to help establish their reliability. Both qualitative and quantitative data were collected and therefore data analysis was done using descriptive and inferential statistics. Means and standard deviations were calculated then a t-test applied on the quantitative data, while the qualitative data was analyzed thematically. All this was aimed at evaluating a null hypothesis (H_o) that: there was no significant relationship between the CIPs used and the students' learning outcomes in secondary school mathematics in Mt. Elgon Sub-County. The selected schools were randomly assigned to the two groups in equal measure (experimental and control). Each of the two groups had 3 mixed schools, 1 boy school and 1 girl school.

3. Results and Discussion

Two tests were given to all the learners; one (pre-test) at the begging of the study and another (post-test) after about six weeks of teaching. Classroom observation was done in all the sampled schools and notes taken to supplement explanations of results obtained from the questionnaires and the tests. The learners posted 95.6% response rate in the pre-test and the questionnaire and 91.1% for the post-test (Table 1). The difference in percentage in the post-test among learners occurred due to absenteeism, especially in the control group classes.

Table 1: Students' Response rate on the Pre-test and the Questionnaire

	Experimental Group		Control Group		Total
	Boys	Girls	Boys	Girls	
Mixed Schools	65	58	67	68	258
Boy Schools only	48	0	39	0	87
Girl Schools only	0	43	0	42	85
Total	113	101	106	110	430
Grand Total	214		216		
	(95.10%)		(96%)		
	430(95.6%)				

From Table 1, it can be noted that the expected sample of 450 students was not achieved since the total number of learners in some of the classes sampled never matched the number proposed by the government of 45 per stream. Some classes had less than 45 students in class while others had more than 45. Eventually, the accessible sample turned out to be 430 (95.6%) students and among them were 211(49.1%) girls and 219 (50.9%) boys. The preliminary results from the pre-test were computed to produce the average performance (means) for the two groups before the experimental group was exposed to treatment. The mean for the experimental group was 1.6074 with a standard deviation of 0.0972 while that for the control group was 1.5198 with a standard deviation of 0.0866. Comparatively the two means were similar and the difference between them (0.0876) was insignificant indicating that the two groups were comparable (See Table 2).

Table 2: Differences in average performances for the Pre-test

Control Group		Experimental Group		Difference in Means	t-value
N	Mean	N	Mean		
214	1.5198	216	1.6074	0.0876	0.6747

A t-test was computed to further compare the means of the two groups. The t-value (0.6747) obtained was low showing that the difference between the two means was not statistically significant and that the two groups had a similar entry behavior at the beginning of the study. To establish the relationship between CIPs and learning outcomes, the Pearson product moment correlation was applied. Various classroom interaction patterns were correlated with the performance of students in mathematics the post-test. The significance level was tested at 5% ($p<0.05$), meaning that a confident level of 95% was achieved, and that the researcher was 95% sure that the result would be the case even when the study would be repeated elsewhere on a similar sample, see Table 3.

Table 3: Relationship between CIPs and Students' Learning Outcomes

CIP	Pearson r	P-value
Have enough books to use during maths lesson	0.0307	0.0459
I enjoy maths lesson when i do sums on the board	0.1431*	0.013
I experienced a bad lesson coz of doing nothing	-0.1544*	0.0174
I prefer having maths lesson daily when I teach others	0.0946	0.0396
Illustrations make understanding of difficult concepts easier	0.0537	0.0034
We are given a chance to express opinion in class	-0.0669	0.0258
We enjoy working out sums in groups with friends	0.0484	0.0411
We share ideas during the lesson	0.0744	0.0228
Prefer discussing concepts for easy understanding	0.1900*	0.0011
* Significant at 5%		

From Table 3, the findings showed that three classroom interaction patterns; whose r value had an asterisk (*) were statistically significant in explaining variations in the students' learning outcomes. Their respective p-values were less than 0.05 ($p<0.05$) and this indicated strong evidence against H_o. That meant that giving learners an opportunity to work out sums on the Chalk Board (CB) made them enjoy mathematics lessons. Similarly, discussing concepts in groups or in pairs promoted easy understanding, while experiencing bad lessons because of little participation in class activities made them not to enjoy learning (See Table 4). This implied that there was a significant relationship between the CIPs used and the students' learning outcomes in secondary mathematics; the interaction patterns influenced understanding of the concepts taught in the classrooms.

Table 4: Experienced a bad Mathematics Lesson

Experienced a bad Math lesson	Frequency	%	Cumulative Frequency
No	102	24.58	24.58
Yes	313	75.42	100.00
Total	415	100.00	

An examination of the figures in Table 4 indicates that only 415 students responded to this question from both the control and experimental groups. Among them 102 (24.58%) had never experienced a bad lesson while a majority, 313 (75.42%) alluded to it. This finding implied that many of the mathematics lessons were not appealing to many students and that perhaps learning never took place in some of them after all. Some of the other reasons given by the learners (respondents) for experiencing bad lessons included the speed of teaching; that their teachers were too fast for them to understand concepts, and that some them were too harsh and always canned them if they did not work out the sums correctly instead of guiding them, among other reasons. Each of these reasons can be quantified as follows (See table 5).

Table 5: Reasons for experiencing a bad Lesson

Reasons	Frequency(f)	%
Lesson was boring	63	15.18
Topic was difficult to understand	141	33.97
Was canned	55	13.25
Teacher was too fast	57	13.73
Failed all the sums given	47	11.34
Teacher was harsh	52	12.53
	415	**99.98**

About 15% explained that the lessons were bad because they found them to be very boring while 34% said that the topics being taught were so difficult and that is why they were experiencing bad lessons. Among the 415 learners, 205 were from the experimental group and 210 from the control group. On checking their responses separately, 77.22% in the experimental group said that they had experienced bad lessons while 76.45% from the control group agreed with them. This indicates that before the experimental group was given treatment, learners from both groups had a similar perception towards mathematics lessons.

Similarly, two variables examined in Table 3 had a negative sign on their r value (-0.1544 and -0.0669) implying that their increase or presence resulted in reduction in performance in the test. The more the learners encountered bad lessons, the lower the performance achieved in the subject due to lack of good understanding of concepts. It also followed that though the learners were given opportunities to express their opinion during mathematics lessons, this practice had no positive influence on understanding concepts taught and therefore learners never showed any better performance even in the assignments given. For instance, 71.59% of the sampled students in the control group and 73.2% from the experimental group said that they enjoyed mathematics lessons, but still this was never reflected in their performance in the test; their outcomes in the pre-test was low. Again about 77.22% of the learners had experienced bad lessons and still 78.82% said that they were normally given a chance to express their opinions or ideas in class as way of making them participate in the lesson and yet this had no significant impact on their performance in in the first test.

Findings from the teachers' questionnaire (80%) indicated that it was possible for students to share wrong ideas when doing pair work or group discussions. In this case the teacher may not have been quick to realize the mistake and therefore failed to correct it or clarify. The learners would then easily end up mastering wrong concepts. The teachers (70%) also pointed out that in their daily practice; learners are given an opportunity to express their opinions at times in groups and in the absence of the teacher. The learners end up misinterpreting and mastering wrong concepts.

The negative correlations as seen in Table 3 again raised eye brows on whether it was the classroom teaching techniques chosen by the teacher that made the learners enjoy the lessons even if though they failed to promote good mastery of concepts. The CIPs emerge from the teaching techniques applied during the lesson. It follows that the students could have enjoyed lessons where the teacher played a major role by giving all the explanations, demonstrating and illustrating ideas, quoting relevant and interesting examples and giving them an opportunity to share ideas or where they were left to work without supervision. While it is good to create opportunities for learners to interact with each other and express their opinions during lessons, it is imperative that teachers ensure good supervision and also give proper guidance for learners to share correct mathematical ideas or information for better learning outcomes to be realized.

The correlation coefficients of the remaining five variables in Table 3 above had a positive sign on their r values with respect to performance in the test. This implied that an increase in the said variable or its presence indicated an increase in the learning outcomes. The corresponding p-values were also found to be less than 0.05 ($p<0.05$) indicating a strong evidence against the null hypothesis that: there is no significant relationship between the common CIPs used and secondary school mathematics learning outcomes in Mt. Elgon sub-county. The researcher therefore rejected this hypothesis. From the above findings it can be concluded that there is a significant relationship between CIPs utilized by the teacher during the lesson and mathematics learning outcomes. That, the teacher's choice of CIPs to use when teaching mathematics will influence the learning and conceptualization as well as mastery of the concepts being taught. Notably, proper guidance in the teacher-learner pattern combined with learner-learner and learner-learning resources patterns seemed to yield better mastery of concepts.

The teachers in the experimental classes would explain, discuss and demonstrate to learners how to solve sums on the chalkboard, while those teachers in the control group classes, would just start the lesson in a less captivating manner, proceed to write sums on the chalkboard as students copied in their exercise books, and finally asked them to do an exercise; either written on the board or from textbooks. In the control classrooms students showed less interest in the lesson, at times dosing off and sleeping or even just writing their own things without caring whether it was correct or wrong. The teacher would mark a few books then conclude and end the lesson. Checking students' exercise books revealed that little learning took place; the learners hardly mastered the correct procedure of working of sums given to them and therefore failed the sums. The teachers in these control classes did not bother to even correct the sums on the CB to help those who failed the very sums correct the mistakes.

4. Conclusion and Recommendations

From the findings above, this study concluded that Classroom interaction patterns have a great influence on learning and mastery of concepts for the benefit of better learning outcomes in secondary school mathematics in Mt. Elgon sub-county. Learners need and prefer an interactive classroom and this can be enhanced through learner-centered teaching approaches. There is need for learners to interact with the teacher, their colleagues and learning materials. It is the teacher's initiative to be more innovative and creative in order to offer such interactive sessions in class for better learning outcomes to be realized.

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