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Influence of Instructional Practices on Secondary School Students' Achievement in Mathematics

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Abstract
Mathematics is a key subject which students cannot avoid if they have to lead a bright future. Despite the introduction and implementation of different teaching methods and strategies suggested by researchers the achievement of students in mathematics at school level has persistently been poor, hence the need to explore the influence of different instructional approaches. The purpose of this study was to find out the extent to which instructional practices influenced students' achievement in secondary school mathematics. This entails the use of Behavioral Objective- Based (BOB), Peer Instruction enriched with Concept Tests (PICT), both BOB and PICT (BO-PICT) and Conventional Instruction (TI). The theoretical framework which guided this study was social constructivism theory. The study adopted quasi-experimental, utilizing pretest posttest non-equivalent group design. The target population for the study was all the 3056 form three students in the 38 secondary schools in Mumias sub-county. Disproportionate stratified sampling and simple random sampling was used to select 327 students who took part in the study. Mathematics Achievement Test (MAT) was used to collect data. Data was analyzed using both descriptive and inferential statistics. Findings revealed that there was a significant difference in achievement, between all Experimental groups (BOB, PICT and BO-PICT) and the control group in favor of the Experimental groups. There was a significant difference between means of groups that used BOB and BO-PICT as well as PICT and BO-PICT. Those ones who used BOB and PICT were found to have similar achievement in the learning of mathematics. Based on the findings, BOB, PICT and BO-PICT were found to be viable instructional strategies that could promote performance in mathematics.
Keywords: Instructional practices, Influence, Students' interaction and Students' Achievement.

1. Introduction

Mathematics is at the heart of many successful careers and successful lives (National Council of Teachers, 2000). It has been described as a model of thinking (lji 2008), which encourages learners to observe, reflect and reason logically about a problem and in communicating ideas making it the central intellectual discipline and a vital tool in science, commerce and technology (Imoko and Agwagah, 2006). In the words of Salman (2005) mathematics is a precursor of scientific discoveries and inventions. It is the foundation of any meaningful scientific endeavor and any nation that must develop in science and technology must have a strong mathematical foundation for its youths. (Hersh 1986 defines mathematics as ideas; not as marks made with pencils or chalk, not physical triangles or physical sets). Underlying his view of mathematics is that knowing mathematics is making mathematics.

There is a widespread interest among both industrialized and developing countries in improving the levels of mathematics achievement in schools. A part from the economic benefits it is argued that competence in mathematics better prepare young people for their numeracy demands of modern work places, as well as raising the overall skills levels of the work force; there are also social benefits tied to improving access for larger numbers of young people to post school education and training. This explains why mathematics is one of the core courses in Kenyan Secondary Schools. Despite the recognition accorded to mathematics due to its relevance **since the** ancient period, Elekwa (2010) remarked that students exhibit non-chalant attitude towards mathematics, even when they know that they need it to forge ahead in their studies and in life. Analysis of Kenya Certificate of Secondary Examination (KCSE) results shows that Students' performance in mathematics are consistently poor (KNEC, 2008).

Many reasons have been cited for this; first, mathematics is highly abstract. It is concerned with ideas rather than objects; with the manipulation of symbols rather than objects. It is a closely-knit structure in which ideas are interrelated. Mathematical concepts are hierarchical and interconnected, much like a house of cards. Unless lower-level concepts are mastered, higher-level concepts cannot be understood. Students who discover some of the structures of mathematics are often impressed by its beauty. They note the lack of contradiction, and they see how a new technique can be arrived from one that has already been learned.

Second, studies in Mathematics have shown that the mode of instruction, especially at the secondary school level remains overwhelmingly teacher-centered, with greater emphasis on the lecture mode of instruction and the use of textbooks than engaging students in critical thinking across subject area and applying the knowledge acquired to real-world situations (Butty, 2001). This has subsequently impacted on students' performance.

Third, teaching and learning of mathematics is a complex activity and many factors determine the success of this activity. The nature and quality of instructional material, the presentation content, the pedagogic skills of the teacher, the learning environment, the motivation of the students are all important and must be kept in view in any effort to ensure quality in teaching-learning of mathematics in an effort to improve students' performance.

Forth, achieving improvement in mathematics teaching and learning requires seeing mathematics as multidimensional, for example including procedures and concepts, as well as strategies, ways of reasoning, attitudes and dispositions (Kilpatrick et al, 1991). Researchers emphasize the need to develop students' understanding of mathematical connections among topics, across representations, and between contextualized and decontextualized settings. Developing these connections often requires more attention to mathematical discussion and argumentation in the opportunity to struggle with challenging mathematics (Hiebert and Grows, 2007). It also requires students to explore and engage with challenging mathematics, for example by managing the cognitive load (Chandler and Sweller, 1991) and enabling a more interactive, exploratory path into difficult mathematics (Kaput et al, 2007).

Improving mathematics teaching and learning is therefore the most important challenge facing educators worldwide. In recent decades, there have been strong calls for change in mathematics education, and in particular for change in classroom practices. Teachers have been forced to organize instruction so that students participate in more collaborative, discussion – based activities with an eye to supporting a community of learners, rather than a set of individuals working on mathematics (National Council of Teachers of Mathematics (NCTM), 1991). Organizing these kinds of collaborative practices, however, has proven to be very challenging (Ball, 1993). Teaching of mathematics is not only concerned with the computational know-how of the subject but is also concerned with the selection of the mathematical content and communication leading to its understanding and application. So while teaching mathematics one should use the teaching methods, strategies and pedagogic resources that are much more fruitful in gaining adequate responses from the students than we have ever had in the past.

In an era of standards-based reform in education, many believe the best way to raise student academic achievement is through improved teaching (Birman, Desimone, Porter & Garet, 2000). To that end, Porter and Brophy (1988) maintained that student learning can be improved only if teachers' practices are of high standard; however, they concluded that many teachers are not prepared to implement practices that reflect high standards. What is more, professional development for teachers could serve to fill the gap between standards-based reform and pre-service teacher preparations (Birman et al., 2000). Unfortunately, many times the professional development provided to teachers does not adequately prepare them for the rigors of standards-based student achievement (Corcoran, 1995; Darling-Hammond, 1996; Hiebert, 1999; Little 1993; Sparks & Loucks-Horsley, 1989).

No single factor is sufficient to change mathematics education (Roschelle et al, 2008). Intrinsically, improving mathematics achievement requires paying attention to a three way relationship among teachers, students, and instructional resources (where resources include curriculum, assessment and technology). Researchers have repeatedly found out that changing one relationship (such as giving students new handled technology) requires corresponding changes in teacher – student interaction and how teachers use instructional resources to be effective (Roschelle et al, 2000). For example, powerful new representations only increase student understanding if teachers engage students in probing the meaning of the representations. Likewise, a change in the teacher – student interaction (such as a teacher giving students more responsibility to solve challenging mathematics problems), can be supported by giving students new tools, for example, a new tool that enables exploration of a mathematical construct in terms of actions and consequences (Bransford et al, 2000). Of course, aligned and sustained teacher professional development is essential to such instructional change (Wei et al, 2009).

The emphasis on the use of instructional teaching practices in the teaching and learning of mathematics in Kenyan secondary schools becomes more urgent considering the teacher dominated approach to schooling and teaching. Most schools in Mumias sub-county are well equipped considering the fact that Mumias Sugar Company has sponsored most of them. Despite its exemplary performance, mathematics performance is still wanting. Mathematics results have remained a drawback, thus pulling the sub-county mean grade in the negative direction.

Because of the potency of instructional practices to improve education and ameliorate most of the ineffectiveness in the schooling process, it is not known whether teachers use instructional practices effectively or not. It thus becomes necessary to asses instructional practices and students' achievement in mathematics.

1.1 Statement of the problem

The formidable problem currently facing mathematics education in Kenya is the need to improve the students' performance in mathematics. Mathematics is regarded by most people as essential and useful. Its usefulness ranges from social, aesthetic, utility and communication applications (Svinicki, 1999). Almost the entire mathematics course in Kenya is designed to enable the learners acquire attitudes and knowledge that will be relevant to students' life after school. It also aims at fostering a positive attitude towards appreciating the usefulness and relevance of mathematics to a modern society.

The government of Kenya in collaboration with the Japanese government developed the Strengthening of Mathematics and Science in Secondary Schools Education (SMASSE) in-service program for teachers of science and mathematics in 2005. An essential component of the program is the encouragement of teachers to use instructional approaches that could help improve students' achievement in mathematics. There are similar programs by other Non-Governmental Organizations (NGOs) spread throughout the country. However, even with such efforts, performance of students in mathematics continues to decline. It is not known the factors responsible for this observation. It may be due to lack of teachers' competency in instructional approaches or pupil related factors.

It is not a secret that classrooms are often composed of students from different backgrounds, with different levels of motivation and are also of a wide ability range. This poses challenges to the teacher and calls for a variety of methods and approaches to teaching. There is need for transforming mathematics lessons into students focused environment with meaningful activities that promote efficient learning of mathematics in our classrooms. Perhaps mathematics education in Kenyan secondary schools could greatly benefit from the use of multiple instructional practices that enhance the teaching of mathematical concepts, which are either difficult to teach by conventional methods of instruction or where students' motivation is low.

Teachers often state behavioral objectives in their lesson notes when preparing to teach and tell students to use group work when discussing some of the questions. They however fail to realize that behavioral objectives and cooperative group work could better be utilized to stimulate the learners for possible better outcomes. The study therefore investigated the effect of Behavioral Objective- Based (BOB), Peer Instruction enriched with Concept Tests (PICT), both BOB and BO-PICT and Conventional Instruction TI on students' achievement in mathematics.

1.2 The purpose of the study

The purpose of the study was to investigate the influence of instructional practices on secondary school students' achievement in mathematics. The study investigated the relative effectiveness of the Traditional Instruction (TI) with Behavioral Objective–Based (BOB), Peer Instruction enriched with Concept Tests (PICT) and both BOB and PICT (BO-PICT) strategies on students' achievement in mathematics on the topic of compound proportion and rates of work.

1.3 Research hypothesis

There is no significant relationship between achievement scores of students taught Compound proportion and rates of work using Behavioral Objective-Based (BOB), Peer Instruction enriched with Concept Tests (PICT) and both BOB and PICT (BO- PICT) and their counter parts in the control group.

1.4 Significance of the study

It is hoped that the findings of the study would have both practical and theoretical values. In terms of practical value,

- It has relevance to investigate and describe current mathematics practices for several reasons: First, the findings would assist teachers in seeing and using alternatives in terms of materials, teaching style and activities, content and organization hereof, second, the findings would help teachers to take into consideration the current interactive practices in the teaching of mathematics, third, the findings would provide direction to other educators such as Quality and Standards Assurance Officers (QSAO) and curriculum developers in supervision and development of materials that facilitate use of interactive approaches. Thus, an understanding of current practices is relevant to speculations on developing practice.
- The findings would help to determine what is working or is not working within practices, especially those which have hitherto not been well described. It is a means to develop methodology in describing practices. This is necessary for further work on describing how practices change, making it relevant in terms of determining the success of the Curriculum.

In terms of theoretical value, the finding would help in understanding the ramifications involved in interactive instructional approaches; this include the relationship between such approaches as collaborative learning, cooperation learning, problem based learning, project learning, BOB, PICT and BO-PICT and achievement in terms of motivation, cognitive development and positive attitudinal development.

Overall, the findings would thus influence the planning, implementation, and evaluation of actual initiatives in pre- and in-service training. Thus it is relevant as a basis for actions directed towards developing practice.

2. Theoretical framework

The underlying theory of this study is the social constructivism theory. Different groups of researchers investigating the effect of co-operative learning on students' achievement begin with different assumptions and conclude by explaining the effects in terms that are substantially unrelated or conflicting. In earlier work, Slavin (1995) identified motivationalist, social cohesion, cognitive-developmental and cognitive-elaboration as the four major theoretical perspectives held by different researchers on the achievement effects of co-operative learning.

Vygotsky (1978) contends that social relations among people underlie all higher cognitive functions and their relations. Also other proponents of constructivism view cooperative group work as an ideal environment for learners to construct knowledge. These include Cobb et al (1990) who claim that social interaction through cooperative group work constitutes a crucial source of opportunities to learn mathematics through constructing individual's mathematical knowledge. Constructivism asserts that all knowledge is constructed by the individual. Therefore what constitutes knowing is only interpreted as that which the individual conceptualizes. Much of what happens during group work forms the basis of construction and conceptualization of knowledge. "To a large extent, constructivism underpins that," mathematics is the construction of knowledge.

3. Method and materials

The study adopted quasi-experimental, utilizing pretest posttest non-equivalent group design. There were a total of 3056 form three students in 38 public secondary schools in Mumias Sub County. Stratified sampling was used to group secondary schools in the sub-county into three strata; Boys' schools, Girls' schools and Co- Educational schools. The researcher used disproportionate stratified sampling to choose two schools from three boys' schools, three from 10 girls' schools and three from 25 co Educational schools giving a total of 8 schools. The study had 4 groups of study E1, E2, E3 and C each comprising of form three students in two schools randomly selected giving a total of 327 students. The four groups were given a pre-test Mathematics Achievement Test (MAT) to get their entry behavior. Later on, the three groups (E1, E2 and E3) were treated. Group E1 used Behavioral Objective-Based (BOB) instructional strategy, group E2 used Peer Instruction enriched with Concept Tests (PICT), group E3 used both BOB and PICT strategies (BO-PICT), while group C used the conventional method (TI). All four groups were then given a posttest achievement test after the instruction.

4. Results and discussion

This study entails provision of empirical data that explains the extent to which the students' achievement in mathematics was related to instructional practices (TI, BOB, PICT and BO-PICT) under review. The research data obtained was analyzed and presented using both descriptive and inferential statistics.

The MAT scores formed the basis of data analysis. After scoring the instrument (MAT), the data was coded and data files prepared for computer analysis. Descriptive statistics that is frequencies, means, percentages and standard deviation were computed**.** Hypothesis was tested by employing ANOVA and t-test with pre-test score as covariates. The Scheffe post hoc analysis procedure was also employed to determine the relationship between means of different pairs of groups and the direction of significant difference observed on the ANOVA. These were used to describe the distribution of the variables in order to understand the inherent relationship between them (dependent and independent variables).

In order to determine the effects of BOB, PICT, BO-PICT and TI instructional methods on the students' achievement in mathematics, the students' pre and post test scores to MAT items were closely examined to identify any commonalities in students' scores on the test. Arithmetic mean, frequencies and standard deviation of pre- test scores were calculated for all groups (E1, E2, E3 and Control C) and results were as shown in table 1.

Table 1: mean scores and the standard deviation (S.D) of the pre- test scores on MAT

SCALE	GROUP E1	E2	E3	GROUP C
	N= 80	N=82	N=83	N=82
Pre-test mean	32.1	31.2	31.1	30.6
Standard deviation	12.83	11.82	12.59	10.54

From table 1, it can be seen that the mean scores of groups E1, E2, E3 and C were 32.1, 31.2, 31.1 and 30.6 respectively. It was necessary to establish if there is any difference between the mean scores of the groups. An ANOVA of the pre- test results on MAT was calculated at 0.05 level of significance and results were as shown in table 2.

Table 2: An ANOVA of pre-test scores on MAT

SOURCE	D.F	S.S	M.S	F-RATIO	CRITICAL VALUE
BETWEEN GROUPS	4-1=3	4276.2	1425.4	0.678	3.84
WITHIN GROUPS	327-4=323	679107.5	2102.5		
TOTAL	326	683383.7	3527.9		

Significance at 0.05 level, critical value 0.678< 3.84

From table 2, the F-ratio is lower than the critical value of 3.84. This implies that the means of the four groups were not different. The groups had similar entry behavior before the commencement of the lessons on compound proportion and rates of work. Hence the groups used in the present study were suitable for the study. To test whether the means of the four groups were statistically different, an independent samples t-test was calculated and results shown in table 3.

Table 3: Independent samples t- test results of the pre- test scores on MAT

Group	N	Mean	SD	DF	Cal t	Cri t	Remark
E1	80	32.1	12.83	161	1.013	1.658	No sig difference
C	82	30.6	10.54				
E2	82	31.2	11.82	163	0.343	1.658	No sig difference
C	82	30.6	10.54				
E3	83	31.1	12.59	164	0.273	1.658	No sig difference
C	82	30.6	10.54				
E1	80	32.1	12.83	161	0.464	1.658	No sig difference
E2	82	31.2	11.82				
E1	80	32.1	12.83	162	0.502	1.658	No sig difference
E3	83	31.1	12.59				
E2	82	31.2	11.82	164	0.053	1.658	No sig difference
E3	83	31.1	12.59				

Data in Table 3 showed that all the calculated t-values on MAT showing extent of difference between scores of subjects in experimental groups and control group are less than the t-critical value at 0.05alpha level. The calculated t-value of C and E1 ($t, _{1,161}$=1.013), C and E2 ($t_{1, 163}$=0.343), C and E3 ($t_{1,164}$=0.273), E1 and E2 ($t_{I, 161}$=0.464), E1 and E3 ($t_{1,162}$=0.502) as well as E2 and E3 ($t_{1,164}$=0.053) are less than the critical value non statistical difference. In fact, a further analysis of the difference using Scheffe post hoc analysis procedure yielded the trend C= E1=E2=E3 at p<0.05.It was concluded that there is no significant difference in the achievement capability between the Experimental groups and the Control group.

After the implementation of use of BOB, PICT, BO-PICT and TI strategies, it can be argued that the mathematics course benefitted all the students since the scores of the students on the test had improved remarkably. However the percentages obtained in the treatment groups were much higher than the control group. The results were summarized table 4.

Table 4: Comparison of mean scores, standard deviation and mean gain on MAT

Group	SD	No of students	Pre-test mean	Post-test mean	Mean gain
E1	14.61	N=80	30.1	60.2	30.1
E2	15.50	N=82	31.2	63.2	32
E3	12.87	N=84	31.1	66.4	35.3
C	10.54	N=82	30.6	42.4	11.8

From table 4, it is clear that the students in the Experimental groups attained greater mean gains than the control group. It also indicates a higher mean score of the treatment groups (E1, E2 and E3) who attained 60. 2, 63.2 and 66.4 in that order than for the control group (42.4). A close scrutiny reveals that E3 that used BO-PICT was superior to the rest of the experimental groups. To test whether the means of groups were different, an ANOVA on the posttest results was calculated and results shown in table 5.

Table 5: An ANOVA of post-test scores on MAT

SOURCE	D.F	S.S	M.S	F-RATIO	CRITICAL VALUE
BETWEEN GROUPS	4-1=3	52734.5	17578.17	61.77	3.84
WITHIN GROUPS	327-4=323	92202.15	284.57		
TOTAL	326	144936.65	17862.74		

Significance at 0.05 level, critical value 61.77> 3.84

From table 5, it is clear that the F-ratio (61.77) was greater than the table value (3.84) showing that there was a difference in performance between at least any two groups. To show the direction of the difference in the means of the four groups, an independent samples t-test was calculated and results shown in table 6.

Table 6: An independent samples t- test results of the post- test scores on MAT

Instructional approach	N	Mean	SD	DF	Cal t	Cri t	Remark
E1	80	60.2	14.61	161	8.62	1.658	sig difference
C	82	42.4	11.46				
E2	82	63.2	15.5	163	9.77	1.658	sig difference
C	82	42.4	11.46				
E3	83	66.4	12.87	164	12.66	1.658	sig difference
C	82	42.4	11.46				
E1	80	60.2	14.61	161	1.268	1.658	No sig difference
E2	82	63.2	15.5				
E1	80	60.2	14.61	162	2.87	1.658	sig difference
E3	83	66.4	12.87				
E2	82	63.2	15.5	164	1.24	1.658	No sig difference
E3	83	66.4	12.87				

From table 6, results for one pair of samples showed no significance difference. That is between E1 and E2 ($t_{1,\ 161}$=1.268). Otherwise between the rest of the pairs, there was significant difference. That is between C and E1 (t, $_{1,161}$=8.62), C and E2 ($t_{1,\ 163}$=9.77), C and E3 (t $_{1,164}$=12.66), E1 and E3 (t $_{I,\ 162}$=2.87) as well as E2 and E3 (t 1,164=1.84).

The findings revealed that the post-test mean scores of the students in the BOB and PICT did not differ significantly in contrary to the *a priori* expectation. It was expected that students in group E2 who used peer instruction enriched with concept tests (PICT), would perform better than their counterparts in group E1who used Behavioral Objective- Based (BOB). It is clear that the statistical analysis failed to show significant differences between BOB (E1) and PICT (E2).

The Scheffe post hoc analysis procedure that was carried out supported the results of the t-test. BOB (E1), PICT (E2) and BO-PICT (E3) groups are significantly different from control (C) group in favor of the experimental groups. The trend, BO-PICT (E3) > PICT (E2) BOB > C (TI) was yielded for MAT measure. Therefore the hypothesis which states that there is no significant relationship between achievements scores of students taught Compound proportion and rates of work using Behavioral objective- based (BOB), Peer Instruction enriched with Concept Tests (PICT) and both BOB and PICT (BO- PICT) and their counter parts in the control group TI was rejected at an α=0.05since the results were inconsistent with the null hypothesis.
In support of these findings are earlier discussions by Puma et al (1993). They said that Co-operative learning has established itself as a practical alternative to traditional teaching, and has proven its effectiveness in hundreds of studies throughout the world. Surveys found that a substantial proportion of teachers claim to use it regularly.

5. Conclusion

This study entailed the use of Behavioral Objective-Based (BOB) and Peer Instruction enriched with Concept Tests (PICT) instructional strategies in teaching and learning of compound proportion and rates of work in secondary schools for a period of three weeks. The purpose of the study was to investigate the influence of instructional practices on secondary school students' achievement in mathematics, particularly Behavioral Objective-Based (BOB) and Peer Instruction enriched with Concept Tests (PICT) strategies.

6. Recommendations

Whenever the matter at hand requires achievement, positive students' attitude towards the subject and a high level of motivation for effective learning, they should embrace the use of BOB, PICT and BO- PICT.

The ministry of Education should embark on a serious campaign through its various arms to enable teachers understand and appreciate that the teaching of mathematics would greatly be enhanced in the event that they use various instructional strategies like BOB, PICT and BO-PICT.

There should be in-service training for teachers to enable them learn more so that they are able to use more instructional practices in their lesson delivery to improve intellectual functioning of the students and ensure better performance in their studies.

The Government need to motivate their teachers to encourage them put in their best to ensure that all students receive proper learning of mathematics through various instructional practices like BOB, PICT and BO-PICT. Also, Government should recruit more qualified teachers to be able to cope with the increasing population of secondary school students.

School administrator should hold seminars and workshops on BO-PICT instructional strategy for teachers so that they can adopt it for effective classroom instruction and students' academic achievement.

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