

Effect of Co-operative Versus Inquiry Based Learning on Student Mathematics Achievement in Kaptumo Location in Nandi County

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This study examined the effects of co-operative versus inquiry based learning on student mathematics achievement in Kaptumo Location in Nandi County. The study used a multiple treatment experimental design. The sample consisted of forty two secondary school students in Kaptumo Location. The participants were sampled using stratified random sampling technique. Data were collected using a researcher prepared mathematics achievement test and analyzed using mean scores, standard deviations and t-test for independent groups. The findings indicated that student mathematics achievement is significantly better when teachers use inquiry method than students taught using co-operative method. Students taught using inquiry based learning performed better than those taught using whole class discussion method. There was a significant difference in mathematics achievement between students taught using the inquiry approach and those taught using whole class discussion method, but there was no significant difference in mathematics achievement between students taught using co-operative learning and whole class discussion method.

Keywords: Co-operative learning discussion, inquiry based learning, mathematics, pre-test and post-test.

Background to the study

Inquiry based learning (IBL) is a learner centred that enables the learner to develop solutions to problems on their own. As observed by Oguz-Unver and Arabacioglu (2011), IBL approach starts by posing questions, problems or scenarios rather than simply presenting established facts or portraying a smooth path to knowledge. Oguz-Unver and Arabacioglu (2011) further observe that the teacher in the learning process acts as a facilitator to guide learning. Learners act as researchers and will identify an issue or question and re-

search on it to develop their knowledge or solutions. IBL begins with the teacher asking a question, the learners investigate and form solutions to the question, the possible solutions are shared in groups as a discussion and reflections are made for possible modifications to be made.

It is the American educator and philosopher John Dewey however who was largely responsible for promoting “learning by doing” (Dewey, 1933). Dewey further argue that for education to be at its most effective, children should be given learning opportunities that enable them to link present content to previous experiences and knowledge. From

this, learners are left to interact with the environment to solve problems and the teacher acts as a facilitator.

IBL is a student or learner-centred approach as observed by (Kember, 1997) in which the focus of the teaching is on student learning rather than on communicating defined bodies of content or knowledge. “Active learning is about learning by doing” (Gibbs, 1988; Roberts & Healey, 2004) and may involve, “for example, students discussing questions and solving problems” (Prince & Felder, 2006). Furthermore, “IBL is a constructivist theoretical basis which proposes that students construct their own meaning of reality where students create knowledge rather than knowledge being imposed or transmitted by direct instruction.” (Bruner, 1990). Banchi and Bell (2008) explained that teachers should begin their inquiry instruction at the lower levels and work their way to open inquiry in order to effectively develop students’ inquiry skills. These findings indicate that a teacher plays a minimal role in the learning process using IBL.

Teacher Development Courses (TPD) in Kenya

Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA) has been conducting professional development courses to science and mathematics teachers to improve on their methodologies with the aim of improving their attitudes and that of the learners. The courses conducted by CEMASTEAs encourage the teachers to shift the teaching approaches from teacher-centred to learner-centred pedagogies.

CEMASTEA conducted an impact analysis in 2018 on the use of IBL in classrooms. According to CEMASTEAs (2018), the study found out that there are changes in the student’s attitudes in science and mathematics. The report indicated that “the students hold a positive attitude towards science and mathematics.” The report further affirms that “on learner centredness” of lessons, the students reported that for every two weeks 71% of their lessons were learner-centred. Teachers rarely

made changes in the material as presented in the course books. This means that the development of pedagogical knowledge is good but there were gaps in the development of content knowledge.” The report also indicates that “there are also more students with special needs. It is increasingly becoming necessary to differentiate instructions on this basis.” These findings from CEMASTEAs indicate that IBL is operational in schools, despite the challenges noted.

Tsung and Cruickshank (2011) used a mixed method design to examine the outcome of an inquiry project completed by students in Hong Kong with the assistance of multiple educators. Tsung and Cruickshank (2011) results of an inquiry project show that the children were more motivated and academically successful compared to the control group. This finding also indicates that IBL is an effective method of learning.

Dewey’s View on Inquiry Based Learning

Dewey (1938) encourages students to formulate problems related to their own experiences and augment their emerging understandings with their personal knowledge. Dewey believed that “the teacher should not simply stand in front of the class and transmit information to be passively absorbed by students”. He notes that instead, “students must be actively involved in the learning process and given a degree of control over what they are learning and emphasize that the teacher’s role should be that of facilitator and guide.” He felt that “the purpose of education was to help students realize their full potential, to strengthen democracy and to promote the common good.” (Dewey, 1944).

From the Alberta Initiative for School Improvement (AISA) project “engaging students in disciplinary-based inquiry had a significant positive impact on student achievement on standardized provincial examinations.” Friesen (2010) specifically found that “the aggregate achievement scores of students in schools designated as high inquiry schools significantly exceeded provincial norms on provincial achievement tests.” These findings in-

dicates that inquiry based inquiry is an effective learning method, as noted from the increased performance.

As noted, “inquiry involves a spirit of investigation always linked to a particular topic or field of study. He further observes that inquiry moves away from a purely teacher or student centred approach to a form of learning that takes its cue from what field of study requires of those coming to know it.” He notes that “as they pose guiding questions, problems or tasks that professionals in the field would recognize as important, students and teachers work and learn from experts to develop responses and performances of learning that are meaningful, sophisticated and powerful.”

According to Bransford (2000); Darling-Hammond (2008); Hattie (2009); Heritage (2010), along with scaffolding, a large body of research concludes that the learning gains engendered by formative assessment were amongst the largest ever reported among any educational interventions. This same body of research found that these learning gains are most dramatic with low-achieving students. The study indicates that formative assessment must be embedded in the cycle of learning so that students receive ongoing descriptive feedback to improve the quality of their work and understanding.”

Heritage (2010)’s review of the literature asserted that feedback designed to improve learning is most effective “when it is focused on the task and provides the student with suggestions, hints or cues, rather than offered in the form of praise or comments about performance.” Heritage further affirms that “students should be provided opportunities for self-assessment based on clear assessment criteria. Teachers can then use the knowledge gained from this process to adjust their teaching to foster the desired competencies.”

The above studies have addressed various aspects of inquiry based learning, i.e. improved learner attitudes; learner-centred lessons; improved academic performance and improved motivational levels amongst students. The study find-

ings shall be confirmed from the findings obtained in Ontario and Alberta which noted improved academic performance among learners as an effect of inquiry based learning.

Statement of the Problem

Performance in the national examinations, Kenya Certificate of Secondary Education (KCSE) in particular, is still low in some of the subjects especially in mathematics and sciences, as noted in the Kenya National Examinations Council (KNEC) report released every year. Efforts by several stakeholders in improving performance in these subjects have been made especially on teacher capacity development (TPD) courses. Some of the courses have been effective while the performance by most of the students is still low. The vision 2030 and the Big Four Agenda in Jubilee Government rely much in mathematics and science related careers. These are STEM subjects and their performance should still be improved in order to achieve the set targets by the government. Most questions failed by students in mathematics and sciences during national examinations (KCSE) fall on the higher order skills majorly applications, synthesis and evaluation areas, as read from the KNEC reports released every year. This indicates that students have the content but cannot be able to apply the content to address related problems. Inquiry based learning (IBL) and co-operative learning methods are learner-centred approaches that are likely to address this gap/problem and enable the learners perform better since they enable learners to conceptualize on the question, research on it widely and apply it to solve varied problems.

Review of literature shows that no study has been conducted to compare the effects of co-operative and inquiry based learning on mathematics achievement in Kenya. Therefore this study examined the effect of co-operative versus inquiry based learning on student mathematics achievement in Kaptumo Location in Nandi County.

Research Questions

1. What is the effect of co-operative learning on students' mathematics achievement among secondary school students in Kaptumo Location?
2. What is the effect of inquiry based learning on students' mathematics achievement among secondary school students in Kaptumo Location?
3. What is the difference between mathematics achievement of students whose teachers use co-operative learning and inquiry methods?

Research Hypothesis

- H_1 : There is a relationship between co-operative learning and students' mathematics achievement.
- H_2 :There is a relationship between inquiry based learning and students' mathematics achievement.
- H_3 :There is a relationship between the type of active learning method used and student mathematics achievement.

Theoretical Framework

This study was guided by Piaget's Constructivism theory (1969) and Social Learning theory. Constructivism is a theory based on observation and scientific study about how people learn. Piaget (1969) suggested that through processes of accommodation and assimilation, individuals construct new knowledge from experiences. He further affirms that "when learners assimilate, they incorporate the new experience into an already existing framework without changing the framework."

Demetriou, Shayer, and Efklides (1992) observe that "learners construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. In a constructivist classroom, it means encouraging students to use active techniques such as experiments to create more knowledge. Constructivists view learning as an active process where learners should learn to discover principles, concepts and facts for themselves. Most approaches that have

grown from constructivism suggest that learning is accomplished best using hands on approach. Learners learn by experimentation and not being told what will happen."

Demetriou et al. (1992), as cited by Onchonga (2013) "indicates that constructivist teachers encourage students to constantly assess how an activity is helping them gain understanding." They further indicate that "when they continuously reflect on their experiences, learners find their ideas gaining in complexity and power and they develop increasingly strong abilities to integrate new information. One of the teacher's main roles becomes to encourage this learning and reflection process and hence is expected to play the role of a facilitator." Piaget (1969) states that "human intelligence is developed through a process of adaptation in order to fit with its circumstances. A person constructs concepts from the experiences the person gains." He further says that, "to know an object is to act on it. To know it is to modify, to transform the object and to understand the processes of this transformation as a consequence to understand the way of the object is constructed. The learners are also expected to acquire new ideas by reconciling such ideas with the previously acquired ideas." All the above are the facts about IBL which gives room for the learner to develop solutions to problems.

Piaget, Tomlinson, and Tomlinson (1929) points out that "the purpose of education was not intended to merely multiply the quantity of knowledge in an individual's possession, but was to create an environment with numerous possibilities and continuous encouragement for the student to conceive new ideas. Piaget asserted that each individual begins to build and rebuild a personal framework of reality at birth." In Piaget's view, individuals accomplished the building of a personal framework through interactions with other individuals and objects as mental abilities grow and improve. Piaget strongly asserted "the building process was not simply memorizing new information.

According to Bandura (1977), Social Learning Theory points out that "an individual learn by

watching other people's actions, approaches and results of the individual's actions or approach." This is an aspect of inquiry based learning where the learner interacts with the environment, by observing activities around it and constructs new knowledge.

Constructivism theory fails to cater for individual differences among students, strong students will always learn faster than weak students who learn slowly. Strong performers require a complex environment than weak learners. Some learners may also not link what they already know to the new finding he/she is getting.

On the other hand, Social Learning theory explains that a child copies the behaviour of someone else and hence there is a likely hood of a child coping wrong things too, hence a weakness in this theory. It fails to explain some complex behaviour and does not account for how people develop a whole range of behaviour.

Inquiry based learning is therefore guided by these two theories as the learner is left to interact with the environment and generate meaning out of the existing environment. Learners make observation and make inferences from the observations made.

Methods and Research Design

Pre-test post-test control group experimental design was used to conduct the study. Three groups of learners were formed: A, B and C. Members were assigned to the three groups at random. Groups A and B were experimental groups while group C was the control group. A pre-test was administered to the three groups, marked and scores recorded. Co-operative learning method was used to teach students in group A and inquiry method was then used to teach the experimental group B, while discussion (old method) was used to teach the control group. A post-test was then administered to the three groups at the end, after two weeks, marked and the scores recorded. Pre-test scores and post-test scores were then compared.

Target Population

A target population of the study was form 3 and form 4 secondary school students in Kaptumo Location. These students had been taught a form 2 topic in their schools that was used to conduct the study and hence were suitable to participate in the study.

Sample

21 form 3 and 21 form 4 students, totaling 42 in Kaptumo Location participated in the study. These students comprised of boys and girls and they are from different levels/categories of schools, ranging from national school, Extra County, County, Sub-County and private schools. The students were selected using stratified random sampling techniques.

Instrument

A Mathematics Academic Achievement Test was used to collect the data. It consisted of twelve questions, multiple choice types with instructions included.

Validity of the Instruments' Results

A research expert and a mathematics teacher were requested to validate the academic achievement test.

Reliability of the Instruments' Results

Test-retest method was used to test for the reliability of the research instrument. This involved administering the research instrument to a small group of students, scoring the instrument and the same instrument was administered to the same group of subjects after a week and were scored. The responses obtained in the two occasions were compared and Pearson's product moment correlation coefficient was calculated to show the relationship between the results obtained in the test and those of the re-test. A coefficient of 0.8 was obtained and hence acceptable.

Data Collection Procedures

Two research assistants (mathematics teachers) were trained on the entire process of the research. Venues (homes) were identified to conduct the study and learners were invited, based on the schedule prepared. Instructions were read out to the learners, pre-test was conducted, teaching then followed for one week and a post-test was done during the second week.

Data Analysis Procedures

Academic achievement scores for pre-test and post-test were entered in the computer software using the Statistical Package for Social Sciences (SPSS), version 21. Data was analysed using descriptive statistics and inferential statistics. Means scores, frequencies, percentages and standard deviation were computed and independent samples t-test was used to find out relationships between the methods of learning and students' achievement scores in mathematics.

Results

Demographic Characteristics of Participants.

Table 1 shows demographic characteristics of participants

Table 1
Demographic Characteristics of Participants

Gender	n	%
Boys	21	50
Girls	21	50
Class		
Form 3	21	50
Form 4	21	50

Comparison of Effects of Co-operative and Inquiry-Based Learning

Pre-test and post-test mean scores and standard deviations for each method of teaching appear in Table 2.

Table 2
Results by method of teaching

Method of Teaching	Pre-test		Post-test		d
	n	m	sd	m	sd
Experimental Groups					
Co-operative Learning	14	14.3	5.68	16.1	5.09
Inquiry Approach	14	15.8	5.21	19.7	3.52
Control Group					
Whole Class Discussion	14	13.9	4.0	14.0	3.84

Post-test mean scores in Table 2 shows that experimental groups performed better than the control group. The inquiry approach group was the best followed by the co-operative learning group with the whole class discussion group being the worst.

Tests of Hypotheses

Three null hypotheses were tested at 0.05 level of significance.

$H_{01} : \mu_1 = \mu_2$ - There is no significant difference between mean mathematics achievement scores of students taught using co-operative learning method and those taught using usual teaching methods.

$H_{11} : \mu_1 \neq \mu_2$ - There is a significant difference between mean mathematics achievement scores of students taught using co-operative learning methods and those taught using usual teaching methods.

$H_{02} : \mu_1 = \mu_2$ - There is no significant difference between mean mathematics achievement scores of students taught using inquiry approach and those taught using usual methods of teaching.

$H_{12} : \mu_1 \neq \mu_2$ - There is a significant difference between mean mathematics achievement scores of students taught using inquiry approach and those taught using usual methods of teaching.

$H_{03} : \mu_1 = \mu_2$ - There is no significant difference between mathematics achievement scores of students taught using co-operative and inquiry based learning methods

$H_{13} : \mu_1 \neq \mu_2$ - There is a statistically significant difference between mathematics achievement scores of students taught using co-operative and inquiry based learning methods

Null Hypothesis 1

H_{01} : There is no significant difference between mean mathematics achievement scores of students taught using co-operative learning and whole class discussion method.

The results are summarized in Table 3.

Table 3

Means, standard deviations and t-statistic for co-operative learning method of teaching and mathematics achievement

Method	Mean	SD	t
Co-operative learning	16.1	5.09	1.23
Control group	14.0	3.84	

P = 0.05

Since t-calculated (1.23) is less than the critical value (2.16), at $\alpha = 0.05$, we do not reject the null hypothesis H_{01} . Therefore, we conclude that there is no significant difference between mathematics scores of students taught using co-operative learning method and those taught using whole class discussion method.

Null Hypothesis 2

H_{02} : There is no significant difference between mean mathematics achievement scores of students taught using inquiry method and those taught using whole class discussion. The results are shown in Table 4.

Table 4

Means, standard deviations and t-statistic for inquiry and whole class discussion methods and student mathematics achievement

Method	Mean	SD	t
Inquiry Method	19.7	3.52	4.02
Control group	14.0	3.84	

Since t obs (4.02) is greater than t critical (2.16), we reject the null hypothesis H_{02} and conclude that there is a significant difference between mean mathematics scores of students taught the inquiry method and those taught using whole class discussion method.

Null Hypothesis 3

H_{03} : There is no significant difference between mean mathematics achievement scores of students taught using inquiry and co-operative based learning methods. The results of t-test for independent groups are shown in Table 5.

Table 5

Means, standard deviations and t-statistic for inquiry and whole class discussion methods and student mathematics achievement

Method	Mean	SD	t
Co-operative Learning	16.1	5.09	2.12
Inquiry Learning	19.7	3.52	

From Table 5, the calculated value of t (2.12) is less than the critical value of t (2.16). Therefore, we do not reject the null hypothesis and conclude that there is no significant difference between mean mathematics scores of students taught using inquiry based learning and co-operative learning methods. This indicates that there is no relationship between the type of active learning method used and student mathematics achievement.

Discussion

The results of this study support the theory that learner learning methods are more effective than teacher centred teaching methods. However the results of this study do not support the contention that co-operative learning is more effective than the inquiry approach.

Conclusion

It was concluded that teaching and learning processes that reflect learner-centred pedagogy are more effective in the teaching of mathematics than teacher-centred approaches.

Recommendations

On the basis of the findings and conclusion of this study, the following recommendations are made.

1. Teachers are encouraged to adopt inquiry based learning methodology in their interactions with learners during lessons as it enables the learners to be problem solvers through research.
2. Teachers should be given adequate training on the use of co-operative and inquiry based learning.

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