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Effectiveness of Integrating Science Process-Skills in Teaching Mathematics on Students' Achievement in Secondary Schools in Tharaka-Nithi County, Kenya

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Abstract
The current study attempted to determine the effectiveness of integrating science process-skills in teaching mathematics on students' achievement in quadratic equations amongst the Form Three students. Quasi Experimental design was utilized where non-equivalent control group design was used. Data was collection from eight schools selected purposively. Teachers in Experimental groups were inducted on the use of ISPS during learning experiences. The students in control groups were taught through conventional Instructional approaches (CIA) Mathematics Achievement Test (MAT) was designed and used in data collection. It measured the level of students' competency and performance relative to treatment and conventional teaching approach on quadratic equations. The data analysis was done using means, t-test and analysis of variance (ANOVA). The study findings indicated that students exposed ISPS had higher meanscores than those taught by CIA. This led to the conclusion that application of ISPS is more effective than conventional instructional approaches. Teachers should be encouraged to integrating science process skills in their teaching approaches to improve the mode of content delivery and grow professionally.
Keywords: Integrated Science-Process Skills, Secondary schools, Achievement in Mathematics

Introduction

Education provide standards to good citizenry in search for solutions to problems such as corruption, gender discrimination and emerging issues including global warming, religious radicalization and terrorism (Cakıroglu, 2007; Frykholm & Glasson, 2005). Mathematics education is imperative towards sustainable technological growth without a compromise on the environment safety and wellbeing (Aydogdu, 2014). Mathematics is conceptualized as the nature of numbers, patterns, procedures and relationships of functions empirically (Fresham, 2002).

Mathematics is well utilized in banking, medicine, aviation, climatic-change monitoring and demographic feasibility studies (Gedik et al., 2002). Acquisition of computational and algorithmic skills makes a strong foundation for learners not only in secondary but also higher learning institutions.

Science process skills are broad transferable abilities which scientist utilizes when studying or investigating natural phenomena. These skills will inspire reflective thinking and innovativeness towards problem solving processes (Sevilay, 2011). American Association for the Advancement of Science (AAAS, 2001) identified at least twelve science process skills which include: observing, measuring, classifying, communicating, predicting, inferring, questioning, controlling variables, hypothesizing, formulating models, designing experiment and interpreting data.

Integration of Science Process-Skills in teaching methods has been noted to improve students' performance in chemistry and biology (Abungu, 2014; Chebii, 2008; Myers, 2004). They awaken and stir student reasoning abilities towards problem solving and improving their perception and understanding of concepts during learning experiences (Ozgelen, 2012).

Conflation of science process-skills in teaching methods in will assists students to retrieve prior knowledge and anchor new incoming information in their cognitive frameworks. Studies by National Council of Teachers of Mathematics (NCTM, 2000) in USA have recommended that the mathematics curriculum be organized by focusing on developing the skills of planning, organizing, hypothesizing and predicting. The development of mathematical problem solving ability is dependent on five interrelated components, namely, concepts, skills, processes, and metacognition which at long run improve academic achievement.

A cross-international study conducted by Trend in International Mathematics and Science Study (TIMSS) revealed a huge drift from low to high performance in mathematics between 1995 and 2003 among Asian countries like Singapore, Korea, Japan, Hong Kong and China. The same was noted in Asia-Pacific countries like Branzil, Columbia and West Indies who outshined less developed countries in Africa including Nigeria, Botswana and South Africa (TIMSS, 2003). Mathematics skills are pillars to technological advancement in the 21st century globally not only in developed countries but also in less developed countries including Kenya. Achievement in mathematics may be demonstrated by learner's abilities to recall, comprehend, and analyse problems in learning experiences or in examinations. Integrating of science process skills in teaching of mathematics may not only improve learner's metacognitive skills but also a remedy to foster problem solving abilities the essence of achievement. One of the possible causes of the poor performance in mathematics is poor instructional approaches used by teachers. Persistent low performance in mathematics achievement among secondary school students in Kenya implies inadequacy in computational skills to creatively solve novel problems. Studies by Bhukala (2009); Okere et al (2014) noted that secondary school students joining job market, Technical, Industrial, Vocational and Entrepreneurship Training institutions (TIVETs) and universities have weak competency in mathematics resulting to levels of achievement. Nevertheless the researchers restricted to investigate the effectiveness of integrating science process-skills in teaching mathematics on student's achievement in secondary schools in Tharaka-Nithi County, in Kenya.

Hypothesis of the Study

The hypothesis of the study stated that there is no statistical significant difference in mathematics achievement in between students exposed to science process-skills and those not exposed to it.

Literature Review

The progressiveness of a country is much dependent on the generation of new ideas to initiate industries and development of technologies. Every kind of job will depend on people who have knowledge to work. Achievement in mathematics is dependent of cognitive abilities based science processes skills which empowers learners in areas such as writing, arithmetic, speaking, and listening. Ability to read and translate, analyze and integration, explore and plan bottom-line to in execution and implementation of ideas and concept in mathematics (Rehorek, 2004).

Science process skills are cognitive skills employed in problem solving, problem identification, data gathering, interpretation and communication. Science process skills enhance creativity, problem solving and conceptual achievement in mathematics and sciences (Eilam, 2002; Akinbobola & Afolabi, 2010).

According to studies carried out Wolfinger (2000); Aydogdu (2010); Ozgelen (2012) on the use of appropriate teaching methods in science and mathematics, teachers should helps the learners to develop abilities like predicting, hypothesis, classifying, questioning, investigating, experimenting, discussing, evaluating, inferring, recording and interpreting of information. Abdullahi (2007) pointed out that the aims of integrating science process skills in teaching is to encourage students refine old and new ideas, discarding inferior ideas for further possibilities to solve novel problems.

According to Akinoglu and Tandogan (2007) integration of science process skills in problem solving abilities results to improves coordination of previous experience, knowledge and intuition in effort to determine outcomes of a situation whose procedures to determine the solutions were unknown. Students leaving high school with adequate science process skills are able to carry out algebraic procedures more accurately than those have not acquired them.

Mei et al (2007) investigated the impact of the Science Alive Programme on students. The finding indicated that application and acquisition of science process skills improved learner problem solving abilities and understanding science concepts with the application of real-life events. The results findings indicated that science process skills acquisitions were highly collated to achievement in science. Also in a study conducted by Lydia and Divina (2008) on science process skills proficiency in the elementary Diocesan schools of Baguio and Banquet, Trinidad found that the level of science process skill proficiency influenced the learners' academic achievement. This implied that science process skills improve learning in class.

Durun and Ozdemir (2010) conducted a study to investigate the effects of scientific process skills on science and technology in turkey. The findings revealed an improvement in academic achievement. Rabunda and Fraser (2004) conducted a study in south africa on perceptions of teachers of the application of science process skills in the teaching of geography in secondary schools. The study findings showed that introduction of science process skills to the teaching of

geography enabled learners to learn with insight and understanding. The report further showed that learners could think critically and code information.
The interaction of concepts and process-skills invoke meta-cognitive aptitudes in knowledge construction. Mathematics competency has to be developed starting from early schooling years and be consolidated in secondary school in preparations for life after secondary education (Catherine et al., 2011). Oluwafunmilayo (2012) carried out a study to determine the relationship between acquisition of science process skills and achievement in science in bauchi state, Nigeria. The study findings showed a positive relationship between formal reasoning ability and acquisition of process skills. Baseline studies done by SMASSE (2000) indicated that the overall performance of students at the Kenya certificate of secondary education (KCSE) was not satisfactory. The present study is restricted investigating the effectiveness of integrating science process skills in teaching mathematics on students' achievement in secondary schools in tharaka nithi county.

Methodology

The study applied Solomon Four Group Design. The design assesses the effects of the experimental treatment relative to control conditions, interaction between pre-test and treatment conditions. Checks on effects of post-test relative to pre-test before administration of the treatment. The figure 1 shows Solomon's Four Group Design as adapted from Shuttleworth (2009).

Group	Pre test	Treatment	Post test
Experimental- E_1	01	X	02
Control - C_1	03	_	04
Experimental- E_2	_	X	05
Control C_2	_	_	06

Figure 1: Solomon's Four Non Equivalent Control Group Design
E_1 & E_2 - Experimental groups
C_1 & C_2 - Control groups
(O_1O_2) - Observations at pretest phase
O_3 O_4 O_5 O_6) - Observations at post-test phase
(X) - Indicates treatment
(----) - Indicates the use of non-equivalent groups.

The schools were randomly assigned to four groups. Groups E_1 and E_2 taught through integrated science process skills module while groups C_1 and C_2 were taught conventionally. Prior to treatment groups E_1 and C_1 were exposed to pre-test (O_1 and O_3). After five weeks of instructions all the groups were post-tested (O_2 O_4, O_5 and O_6). The post-test 0_5 and O_6 assisted in ruling out any interaction between pre-testing and treatment.

Study Population

The study targeted student population in public secondary school in Tharaka-Nithi County and accessible population of 4068 Form three students.

Sampling Procedure and Sample Size

Stratified random sampling was used to draw the eight schools involved of which four were Boys' only schools and other four Girls' only schools. Simple random sampling was applied to assign the schools to experimental groups (E_1 & E_2) and control groups (C_1& C_2). In schools with more than one stream in form three, all students participated but a simple random sampling was once again used to select one of the streams for data analysis. Table 1 shows summary of the sample size.

Table 1: Summary of the Sample Size:

Group	Group Type	Boys	Girls	Total
I	Experimental	49	34	83
II	Control	43	36	79
III	Experimental	51	46	97
IV	Control	34	35	69
Total		177	151	328

Data Analysis

The data collected from pretest and posttests was organized, categorized and coded for analysis using both descriptive (means & standard deviations) and inferential statistics (t-test & ANOVA). Hypotheses were tested at alpha α = 0.05 level of significance. The t-test and ANOVA were applied to find out if there is any difference between the means by gender of those exposed to teaching integrated with science process skills and those not.

Results and Discussion

The participants were subjected to Pretest to find out their entry behavior prior to treatment and subsequent post test.

The data in Table 2 presents the meanscores and standard deviations of MAT.

Table 2

Pre-test Means and S D on MAT

Test	Group of Students	N	Mean	SD	Std. Error Mean
MAT	E1	83	20.78	6.96	.7641
	C1	79	18.90	6.22	.6993

The information in Table 2 indicates that the meanscores of group E1 was higher than in group C1. To determine if this difference was statistically significant an independent sample t-test was run. The results are shown in Table 3.

Table 3
Independent Samples t-test on MAT

Test		t	df	Sig 2-tailed
MAT	Equal Variances Assumed	1.814	160	0.072
	Equal Variances not Assumed	1.819	159.36	0.071

Results in Table 11 show that the difference in MAT scores between E1 and C1 were not statistically significant (t_{160} =1.814 P>0.05). These results imply that the groups used for the study were homogeneous before administering the treatment.
The objective of the study sought to establish the effects of Integrating Science Process-Skills in teaching mathematics on students' achievement in mathematics in secondary schools. In order to determine effects of integrating science process skills in teaching approaches on students' mathematics achievement posttest scores were analyzed as presented in Table 4

Table 4
Mean Scores and SD on MAT

Group	N	Mean	Sd
E1	83	56.27	11.0112
C1	79	36.90	7.4809
E2	97	55.16	10.6592
C2	69	36.17	9.84132

Results shown in Table 4 indicate that groups E1 and E2 attained 56.27 and 55.16 respectively while groups C1 and C2 had 36.90 and 36.17 respectively. E1 and C1 gained 34.94 and 18.99 respectively in the posttest against pretest. However experimental groups outperformed control groups. To determine whether difference was statistically significant, ANOVA was run. The results of in Table 5

Table 5
ANOVA on MAT

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	29738.587	3	9912.862	100.997	.000
Within Groups	31800.632	324	98.150		
Total	61539.220	327			

Results in Table 5 indicate that a statistically significant difference exists between the groups ($F_{3, 327}$ = 100.997 P<0.05). The results led to rejection of the fourth null hypothesis ($H_0$4) which stated that there is no statistical significant difference in mathematics achievement between students exposed to science process-skills and those not exposed to it. To determine which groups differed Bonferroni test of multiple comparisons was run. Results are shown in Table 6.

Table 6
Bonferroni Post Hoc on MAT

(I) Group	(J) Group	Mean D (I-J)	Std. Error	Sig.
E1	C1	19.36633*	1.55722	.000
	E2	1.10011	1.48135	1.000
	C2	20.09115*	1.61400	.000
C1	E1	-19.36633*	1.55722	.000
	E2	-18.26621*	1.50142	.000
	C2	.72482	1.63244	1.000
E2	E1	-1.10011	1.48135	1.000
	C1	18.26621*	1.50142	.000
	C2	18.99104*	1.56023	.000
C2	E1	-20.09115*	1.61400	.000
E1	C1	-.72482	1.63244	1.000
	E2	-18.99104*	1.56023	.000
	C1	19.36633*	1.55722	.000

* The mean difference is significant at the 0.05 level

The results in Table 6 show that the there existed significant differences in groups E1 Verses C1 and E verses C2 were significant. These results suggest that the intervention of ISPS had positive effects on students' levels of creativity in learning mathematics. This implied that ISPS had positive effects in improving achievement among high students in mathematics.

The students exposed to science process skills outperformed those not exposed. ISPS was effective in enhancing students' achievement in mathematics. This finding is in agreement to study findings by Turpin and Cage (2004) on the effects of an integrated, activity-based science curriculum, science process skills, on student achievement, and science attitudes. The findings showed that science process skill significantly influenced achievement of students in mathematics. Present research findings has indicated that science process skills do influence achievement in mathematics this concurs to the findings of a study by Fah (2008) on influence of science process skills, logical thinking abilities, attitudes towards science, and locus of control on science achievement among form four students in Malaysia who reported that science process skills highly influences academic achievement.

The findings of the present study are parallel to the findings of Mei et al (2007); Lydia and Divina (2008) whose studies showed science process skills uplifted learners understanding of science concepts and problem solving abilities. Abungu et al (2009) investigated the effect of science process skills teaching approach on students' achievement in chemistry concurs to the present study results. The findings revealed that SPS had a significant effect on students' achievement in chemistry. However the current study finding has showed that science process skills influence achievement in mathematics.

Conclusion

The students' exposure to science process skills improved their acquisition of problem solving abilities in learning of mathematics. This implied that could teachers in secondary schools incorporate science process skills in teaching mathematics meaningful learning would be enhanced. Students' exposure to science process skills refined their computational skills not only their classroom learning but also when tackling examination questions and problems encounter novel situations. This significant improvement in achievement in mathematics and competencies in science oriented courses at colleges and universities. When students are exposed to science process skills gains and solidifies basic mathematics concept, skills and knowledge they could apply to broaden their mental flexibilities and creativity the essence achievement in mathematics.

Recommendations

On the basis of the present study findings should adequately utilize ISPS in teaching of mathematics to achieve meaningful learning and improved achievement among the students. This could be reinforced through Ministry of Education in collaboration with KICD putting up guidelines for mathematics teachers on development of innovative instructional materials. Secondary teachers should create and maintain conducive learning environment favouring freedom of expression for learners to articulate and brainstorm during learning experiences to improve acquisition necessary skills and creativity abilities in solving general life problems.

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