THE EFFECT OF THE MATHEMATICAL SKILLS ACQUIRED IN WOODWORK ON STUDENTS' ACHIEVEMENT IN MATHEMATICS

Richard P. Kimiti, Samuel N. Waweru
Kenyatta University, Nairobi, Kenya
Email: prickimiti@yahoo.com, sawaweru@yahoo.com

David M. Mulwa
University of Pune, India
Email: davimulwa@yahoo.com

Elizabeth N. Muema, Titus M. Kituka
Machakos Teachers' College, Kenya
Email: muemaelizabeth04@gmail.com, tkituka@yahoo.com

Abstract

Economic status of students, gender and family size have been found to affect students' achievement in mathematics. However, there seems to be limited research on the effects of knowledge and affective skills acquired from other subjects on students' achievement in mathematics. The research objectives of the study were to determine whether the cognitive and practical skills acquired in woodwork affects students' achievement in mathematics. The study also sought to find out whether the learning of similar topics in woodwork affected students' achievement in mathematics. The research methodology applied was ex-post facto design. The study was carried out in four secondary schools which offered woodwork in Machakos County, Kenya and involved a student sample of 158. Data was collected by use of three mathematics tests and a questionnaire for woodwork students. The results revealed that cognitive and practical skills acquired in woodwork have a positive effect on students' achievement in mathematics. The learning of similar topics in woodwork and mathematics has a positive effect on students' achievement in mathematics.
Key words: *cognitive skills, practical skills, students' achievement*.

Introduction

Achievement in sciences and Mathematics in the Kenya National Examinations has been persistently low for the last three decades (Kombo, 2000). For instance, Eshiwani (1986) observed that the failure rate in 1986 in Mathematics at the secondary school level was 50%. In the 8-4-4 system of education, achievement in mathematics has been also very low (KNEC, 1995). For example, in 1989, the failure rate was 55% at the Kenya Certificate of Secondary Examination. In 2000, it was 63.2% whereas in 2001, it was 63.76%. The failure rates for the years 2002, 2003 and 2004 were 69.3%, 67.5% and 68.6% respectively (KNEC, 2005). More recently, achievement in mathematics and mathematics related subjects at the university level

is also declining (Maritim, 1995). The argument for this low achievement is that the students are inadequately prepared at the secondary school level (Ibid.1).

Despite the persistently low achievement in mathematics, it is regarded as one of the important subjects in the secondary school curriculum. It is indeed the backbone of most applied subjects, that is, it is a pre-requisite for studying science and technical subjects. Further, educationists argue that the development of a stable economy, especially in scientific and technological fields demand a strong foundation in mathematics (Todaro, 1977). Developments in the commerce and industry also rely heavily on mathematical knowledge.

Several studies have been carried out to unearth the factors which contribute to low achievement in mathematics (Makau, 1985; Eshiwani, 1990). These factors have been categorized into exogenous and endogenous variables. Exogenous variables are those that are located outside the institution of the school process (Haladyana and associates 1982, cited in Maundu, 1986). These factors include the students' socio-economic status, gender, family size and siblings. Endogenous factors on the other hand, are those variables which can be directly influenced by school in some way. These include teaching strategies, school facilities, teaching and learning resources, learning environment and school administration (Ndege, 1992; Maritim, 1985).

A study carried out by Coleman revealed that students' socio-economic factors are positively related to academic achievement and that when these factors are statistically controlled, school characteristics accounted for only a "small fraction" of differences in academic achievement (Coleman and associates, 1966 cited in Maundu, 1986). These results implied that if schools are equalized (by having similar learning resources or having equally trained and experienced teachers), this would not significantly reduce variation in student achievement. Similar findings were reported by Jencks, 1972 (as cited in Eshiwani, 1990) in his study in American Elementary schools. In this study Jencks (1972) reported that provision difference in achievement by 3% or less. The study also reported that equalization of school quality reduced variation in students' achievement by 1$ whereas such as equalization of family background accounted for 25% - 40%.

In another study Plodwen (1967) found out that school and teacher characteristics accounted for 28% of the variation in students' achievement while socio-economic background such as, reading opportunities and parental assistance explained 20% of the student achievement (Plodwen, 1967 cited in Maundu, 1986). Unlike in the Coleman's study, this investigation reported that the competence and experience of the teacher accounted for a substantial difference in students' achievement.

From the reports recorded for the above three studies it is evident that students' socio-economic background is a strong predicator variable on students' achievement than school based variables. Several other studies have also been carried out on the relationship between gender differences and mathematics achievement. The factors considered include; culture, environment and expectations (Carley, 1982 cited in Eshiwani, 1990). The results of this study report that culture and environment play a very great role in determining achievement in mathematics in Western countries. According to Carley, what the culture expects from girls and boys significantly influence their attitudes toward mathematics and consequently their achievement in mathematics. Other studies show that girls achieve high in tests of verbal fluency, arithmetic fundamentals, reading and rote memory. Boys on the other hand, have been found to achieve high in tests of special, reasoning and computation (Maritim, 1985). Although there is evidence of extensive research into factors that contribute to low achievement in mathematics, the real challenge to mathematics and educationists is how to improve students' achievement in mathematics since it has continued to decline particularly at the secondary level of education.

Despite researchers' identification of both exogenous and endogenous variables affecting student achievement, there seems to be limited research on the effects of knowledge and affective

skills acquired from other subjects on students' achievement in mathematics. This study was therefore undertaken in order to fill this gap. Thus this study was set to investigate whether the mathematical skills acquired in woodwork affect students' achievement in mathematics at the secondary level of education.

Purpose of the Study

The purpose of this study was to investigate the effect of the mathematical skills acquired in woodwork on students' achievement in mathematics. This purpose was facilitated through the following research objectives:

- To determine whether the cognitive skills acquired in woodwork affect students' achievement in mathematics.
- To determine whether the practical skills acquired in woodwork affect students' achievement in mathematics.
- To determine whether the learning of similar topics in woodwork and mathematics affect students' achievement in mathematics.

Methodology of Research

Research Design

The research methodology used in this study was the ex-post-facto design. This research design was selected for the present study due to its suitability, since the variables investigated in this study had already manifested in the field. Secondly the researcher was not in a position to manipulate the study variables within the time frame for the study.

Locality of the Study

The study was conducted in Machakos County, Kenya. The County lies in the foreland plateau between the Eastern Rift Valley and Nyika plateau. It is divided into six administrative districts namely; Machakos Central, Mwala, Kathiani, Masinga, Yatta and Kangundo. The study was limited to the Machakos Central and Kangundo districts. The two districts were selected because all the schools which offered woodwork were located there.

Research Instruments

The research instruments used for collecting data in this study were three mathematics tests and a questionnaire for the woodwork students. The mathematics tests were categorized into theory and practical papers. The papers one and two dealt with theoretical questions which focused on cognitive skills. In the data collection procedure the theory papers were labeled as Continuous Assessment Tests one and two. The two theory papers were administered because it was thought that they could yield a better reflection of students' achievement as compared to a single paper. However, this was not the case for the practical section because of time and financial constraints.

The papers one and two focused on cognitive skills. These were; recall application, comprehension, analysis and synthesis. The two papers were developed by the researcher. Several question items were borrowed from past papers of the Kenya Certificate of Secondary Education (hereafter referred to as K.C.S.E) for the years 1999 - 2004 and the rest were developed by the researcher. In order to minimize direct replication of the items extracted from

the K.C.S.E past papers, some moderations were made. The moderations involved changes in the question structures and alteration of the numerical values. The questionnaire for the woodwork students was developed by the researcher. In developing the questionnaire, the following factors were put into consideration; language level of respondents, biasness of items, structure, ambiguity, length of items and relevance.

Validity and Reliability of Research Instruments

The tools were piloted in a secondary school in a neighbouring district before the commencement of actual data collection. The data collection instruments were administered by the researcher through a test-re-test design. In the original papers used in the pilot study, paper one had 13 items but these were reduced to ten (10) in the final one used in this study. The items eliminated after the pilot study were those which were not answered correctly by 50% of the pilot sample. The original paper two was also made of 13 questions but these were reduced to 10 after the pilot study. The reasons for eliminating these three questions was similar to the one provided above together with discovering that two of them were very difficulty.

The reliability of the mathematics tests was established by the use of test-re-test design. The research mathematics tests were first piloted using 15 students and repeated with the same respondents after two weeks. The respondents were Fourth Form students who studied woodwork in the pilot school. This decision was made because all the other students in that school studied at least one of the other practical oriented subjects. However, during the re-testing stage the researcher experienced a problem of mortality effect. The sample population for the pilot study reduced from 15 to 10 students. The researcher therefore correlated the scores of the 10 respondents who participated in the two sittings in the pilot study. The constituted 66.7 % of the target population and hence considered as a reliable sample for the pilot test. The reliability coefficient of each paper was calculated using the Pearson's Product Moment Correlation. The reliability coefficient of paper one was 0.89, 0.98 for paper two and 0.76 for paper three which were very high and substantial relationships respectively. The reliability of the woodwork questionnaire was established using the same respondents used for the mathematics tests. The reliability coefficient for the questionnaire was 0.76. This value pointed out a substantial relationship and hence considered reliable for the study.

Sampling Procedures

Four secondary schools were purposively selected with respect to the study objectives. The sampling technique applied in this case was purposive sampling method.

The study sample consisted of Fourth Form students drawn from the selected schools. Form four students were selected because it was thought that they had covered most of the subject matter pertaining to 8-4-4 mathematics and woodwork syllabuses. There were a total of 79 form four students who studied woodwork in the selected schools and were purposively selected. The number of students who did not study woodwork was greater than that of students who studied woodwork. Therefore in order to select an equal number of non-woodwork students to that of the woodwork students a simple random sampling procedure was applied. 79 non-woodwork students were selected using the blindfolding method. Therefore, the study sample was made of a total of 158 students. 79 of these studied woodwork and the rest were non-woodwork students. This constituted 43.9 % of the target population and hence a reliable sample representative for the study.

Statistical Techniques for Data Analysis

The data collected from the students' scores in the mathematics test and responses in the questionnaire was analyzed using both descriptive and quantitative statistics. First, the students' achievement in the respective items in the research tests were tallied into frequency tables and percentages calculated showing the number of students who passed or failed in cognitive and practical skills from each group of students. Since this method of analysis could not show significant relationships between the variables under study, the data was then analyzed using the chi-square technique (χ^2) to find out whether there was any significant difference in achievement for the two groups of students. The students' scores in each item were categorized into either pass or fail. This implied that 2 by 2 contingency tables were constructed for the computation of the chi-square (χ^2) values. Therefore in the computation of the chi-square statistics (χ^2) the Yates Cor   nula was applied, as shown below:

$$\chi^2 \quad = \quad \frac{(\left[f - f \right] - 0.5)^2}{f}$$

Where f   =   the observed frequency
f   =   the expected frequency

The chi-square (χ^2) computations were calculated at 0.05 level of significance and one degree of freedom. This relationship was confirmed by computing the contingency coefficient using the formula shown below:

$$C \quad = \quad \frac{\chi^2 + N}{N}$$

Where C   =   the contingency coefficient
χ^2 =   the chi-square value
N   =   the total number of students

Third, the three null hypotheses were tested using the t-test. All the three null hypotheses were tested using the pooled variance model shown below:

$$t \quad = \quad \frac{m - m}{\sqrt{\frac{\sum X^2 + \sum X^2}{(n + n - 2)} \frac{(1+1)}{(n + n)}}}$$

Where m   =   the mean score of woodwork students
m   =   the mean score of non woodwork students
$\sum X$ =   the variance of the group of woodwork students
$\sum X$ =   the variance of the group of non woodwork students
n   =   the total number of woodwork students
n   =   the total number of non woodwork students.

These null hypotheses were tested at 156 degrees of freedom and 0.05 level at significance.

Results of Research

Testing of Hypotheses

The three null hypotheses in this study were tested using the t-test technique. This statistic was selected because it is the most appropriate method of testing mean differences between two groups of students.

*Ho1: The Cognitive Skills Acquired in Woodwork have no Significant Effect
on Students' Achievement in Mathematics*

The hypothesis examined the following cognitive skills, recall, application, comprehension, analysis and synthesis. A chi-square computation gave a value of 12. 56. This value was significantly greater than the critical one of 3.84 at 0.05 level of significance. Therefore this implied that there was a difference in students' achievement between the two groups of students. The data analyzed further revealed that the woodwork students achieved better scores than the non-woodwork ones. This was strengthened by the finding that the woodwork student achieved higher scores than the non-woodwork students in 7 out of 10 questions tested in paper one. Their achievement was outstanding in the following skills; accuracy, interpretation of instructions, mastery of construction principles, use of conventional methods of construction and labeling of diagrams. A summary of the students' achievement in cognitive skills in Paper One was as given in the table that follows.

Table 1. Percentages and Chi-square Computations for Students' Achievement in Cognitive Skills in Paper One.

	Woodwork Students	Non-Woodwork Students	Total	χ^2 Value	df	C	p
Passed	70 (44.3)	15 (9.35)	85 (53.8)				
Failed	9 (5.7)	64 (40.51)	73 (46.2)	12.56	2	0.27	0.05
Total	79	79	158				

In paper two, the woodwork students also achieved higher scores than the non-woodwork students' in six (6) out of ten questions. Their achievement was outstanding in the following areas; selection and use of scales, general construction principles and use of appropriate methods. This implied that they had outstanding achievement in the following cognitive skills; recall, comprehension, application and analysis. Computations of a chi-square yielded a value of 11.48. This value was also greater than the critical value of 3.84. Therefore, this pointed out a difference in students' achievement in paper two between the woodwork and non-woodwork students. These results were strengthened by a contingency coefficient of 0.27 which pointed a moderate relationship. A summary of the students' achievement in these cognitive skills is shown in the table 2 below.

Table 2. Percentages and Chi-square Computations for Students' Achievement in Cognitive Skills in Paper Two.

	Woodwork Students	Non-Woodwork Students	Total	χ^2	df
Passed	48 (30.62)	20 (12.66)	68		
Failed	31 (19.62)	59 (37.34)	90	11.48	1
Total	79	79	158		

The data analyzed to test this null hypothesis further showed that the t-test administered obtained a t-statistic of 5.73. This t-test value was significantly greater than the critical value of 1.96 at 0.05 level of significance. Therefore, since the computed t-test statistic was greater than

the critical value then, Ho1: The cognitive skills acquired in woodwork have no significant effect on students' achievement in mathematics was rejected. This implied that the cognitive skills acquired in woodwork have positive effect on students' achievement in mathematics. The above finding was confirmed by the fact that the mean score for the woodwork students was higher than that of the non-woodwork students in papers one and two as shown in Table 3.

Table 3.   Computations of t-test for Students' Achievement in Cognitive Skills.

	Woodwork Students	Non-Wood-work Students	df	t-test
Mean	56	46		
Standard Deviation (a)	10.95	10.86		
Variable (0^2)	119.82	117.90	156	5.73
Summation of X ($\sum X$)	4424	3634		
Summation of Square Deviation from the Mean $\sum X^2$	9456	9314		

Ho2: The Practical Skills Acquired in Woodwork have no Significant Effect on Students' Achievement in Mathematics

The practical skills examined in this null hypothesis were observing, imitation, practicing and adapting. The data analyzed when scoring paper three showed that the woodwork students achieved higher scores than the non-woodwork students in all the three questions tested in this paper. It was also found that 65.5 % of the woodwork students passed in all the practical skills tested. The rest 34.2 % failed in these skills. On the other hand, 32.9 % of the non-woodwork students passed in these practical skills whereas 67.1 % failed in them.

A chi-square test administered yielded a value of 15.83. This value was greater than the critical one of 3.84 at 0.05 level of significance. Thus this signified that there was a difference in students' achievement between the woodwork and non-woodwork students. These findings were confirmed by a contingency coefficient of a 0.30 which denoted a moderate relationship. A summary of the students' achievement in these practical skills is shown on Table 4 below.

Table 4. Percentages and Chi-square Computations for Students' Achievement in Practical Skills in Paper Three.

	Woodwork Students	Non-woodwork students	Total	χ^2	df	C	p
Passed	52 (32.91%)	20 (12.66%)	78				
Failed	27 (17.09%)	53 (33.54%)	80	15.83	1	0.3	0.05
Total	79	79	158				

The t-test statistic computed on the data analyzed students' achievement in practical skills further yielded a value of 5.23. This statistic was significantly greater than the critical value of 1.96 at 0.05 level of significance. This t-test value indicated that the Ho2: The practical skills acquired in woodwork have no significant effect on students' achievement in mathematics was rejected. Consequently this indicated that the practical skills acquired in woodwork have positive effect on students' achievement in mathematics. The above findings were confirmed further by the observation that woodwork students obtained higher scores than the non-woodwork in the practical test paper three as given in Table 5.

Table 5. Computation of t-test for Students' Achievement in Practical Skills.

	Woodwork Students	Non-Woodwork Students	df	t-test
Mean	59	50		
Standard Deviation (a)	11.93	9.40		
Variable (0^2)	142.3	88.28	156	5.23
Summation of X ($\sum X$)	4661	3950		
Summation of Square Deviation From the Mean $\sum X^2$	11242	6974		

Ho3: The Learning of Similar Topics in Woodwork and Mathematics has no Significant Effects on Students' Achievement in Mathematics

This null hypothesis was tested using the overall mean score of students in the three mathematics tests. Therefore a student's score for this null hypothesis was as shown below:

$$Z = \frac{X + Y}{2}$$

Where Z = students' overall mean score
 X = students' mean score in the cognitive skills in paper one and two
 Y = students' score in the practical skills.

The data analyzed shows that a t-test value of 6.57 was obtained which was also significantly greater than the critical value of 1.96 at 0.05 level of significance. This implied that, Ho3: The learning of similar topics in woodwork and mathematics has no significant effect on students' achievement in mathematics was rejected. Therefore the above findings suggest that the learning of similar topics in woodwork and mathematics has a significant effect on students' achievement in mathematics. The above finding was confirmed by the average overall score of the two groups of students as shown in Table 6 below.

Table 6. Computation of t-test for the Effect of the learning of Similar Topics on Students' Achievement in Mathematics.

	Woodwork Students	Non-Woodwork Students	df	t-test
Mean	57.5	48		
Standard Deviation (a)	9.17	8.89		
Variable (0^2)	84.14	79.06	156	6.57
Summation of X($\sum X$)	4532.5	3792		
Summation of Square Deviation From the Mean $\sum X^2$	6646.75	6246		

Discussion

The findings of this study revealed that cognitive skills acquired in woodwork have a positive effect on students' achievement in mathematics. In the mathematics papers one and two, the woodwork students achieved higher scores as compared to non-woodwork students. The

woodwork students excelled in the following cognitive skills; recall application, comprehension and synthesis. The study also showed that the woodwork students had better mastery of the basic geometrical construction principles, interpretation, accuracy and application of mathematical laws from one topic to another.

These results were in agreement with those of Kalmer (1973) and Borthwick (1973). Borthwick (1973) reported that training students in strategies of answering questions in mathematics had greater effects on students' achievement in mathematics than no training. The above finding was confirmed by the fact that those students who were trained in these question strategies had higher scores in the mathematics test. In the current study, the woodwork students were informally trained on the basic terminologies needed in geometrical constructions as shown in the woodwork syllabus. This was not the case in the mathematics syllabus. Therefore, the woodwork students were well versed with the technical words used in geometrical constructions as compared to the non-woodwork students. This suggestion was evident during the scoring of the mathematics tests in this study, where majority (78.9 %) of the woodwork students had no problems in distinguishing between external and internal tangents; types of scales (such as reduced, full and enlarged), scale factors (such as linear, area and volume). The vice versa was true for the non-woodwork students.

The data analyzed when testing the second null hypothesis indicated that the practical skills acquired in woodwork have a positive effect on students' achievement in mathematics. In the process of marking the practical skills examined in paper three, this study revealed that the woodwork students achieved higher scores in all the four skills. These results were in agreement with those of McNeil (1975, Kerr and Booth 1978, cited in Mazur, 1989). These studies showed that different amount of practice is positively related to achievement. In the present study, it can be reasonably argued that the woodwork students were constantly learning and practicing these practical skills unlike the non-woodwork students. This implied that woodwork students were perfecting their abilities in these skills. Further, most topics in mathematics require visualization of questions in three dimensions. Therefore, since the woodwork students were used to questions of this nature in the topic of orthographic projection and pictorial views, it seems reasonable to argue that this opportunity helped them to enhance their understanding of mathematics. More so, the woodwork students made practical objects in woodwork lessons. This made it easier for them to interpret mathematics questions which involve three dimensional solid figures. Table 4 showed that 12.9 % of the non-woodwork students achieved higher than 34.2 % of the woodwork students. This suggested that the practical skills acquired in woodwork do not exclusively attribute to students' achievement in mathematics. Although these practical skills can also be acquired in other technical subjects such as metal work, electricity or power mechanics., this was not a contributing factor in this study as this cluster of students were left out in the study. However, there are other science subjects such as physics, chemistry and biology which also offer the same skills. Their effects were not considered as strong predictor variables in this study because the researcher found out that geometrical constructions cover only 0.1 % of the subject matter taught in these subjects.

The findings of the third null hypothesis indicated that the learning of similar topics in woodwork and mathematics has a positive effect on students' achievement in mathematics. It was found out that in all three mathematics tests the mean score of the woodwork students was higher than that of the non-woodwork students. This result concurred with the response of 80 % of the woodwork students who had said:

> When woodwork students appreciate the importance of geometrical constructions in practical lessons in woodwork this gives one the more courage and interest in doing more questions in the topic. Consequently, this practice helps one in improving his / her tackle such questions with a lot of confidence.

According to these students the opportunity to learning similar subject matter in the two areas under investigation was a major contributing factor to their achievement in the research tests. This was confirmed by the finding that those students with the above observation also scored high in the mathematics. Basing on this observation it was therefore suggested that the learning of similar subject matter in mathematics and woodwork helps students to achieve good results in mathematics. The above suggestion was also strengthened by the discovery that the topic on geometrical construction was given emphasis in woodwork as compared to mathematics. Apart from that, the more a student encounters similar questions in the cause of one's revision the more the student becomes acquainted and competent in answering questions of that nature. Therefore since the woodwork students had the opportunity to learn these topics in the two subjects under investigation, this helped them to improve their understanding and hence high achievement in mathematics. The studies conducted on transfer of learning seem to be in agreement with the findings of this study. Carroll (1963, cited in Bloom, 1982) found out that individual students may need very different types and qualities of instruction to achieve master of certain phenomenon. For Carroll (1963) the same content and objectives of instructions may be learned by different students as a result of different types of instructions. There is much evidence that some students can learn quite well through independent learning efforts while others need highly structured teaching-learning situations. Similarly, some students will need more concrete illustrations and explanations than others. Other students may need more examples to get an idea than do others and some may even need to have several repetitions of the explanation while others may be able to get it at the first instance. In this study, the students who studied woodwork enhanced their understanding of the principles acquired in topics on geometrical construction. Moreover, it can be argued that the learning of similar topics was very helpful to the slow learners in the group of students who studied woodwork as it acted as a remedial exercise in the similar topics between mathematics and woodwork. This opportunity was not available for the non-woodwork. This opportunity was not available for the non-woodwork students and hence the difference in achievement in the research tests.

Conclusions

From the empirical data analyzed for the first null hypothesis Ho1, the t-test computed revealed a significant difference on students' achievement between the woodwork and non-woodwork students. It was also shown that the woodwork students achieved higher scores in the cognitive skills examined in paper one and two than the woodwork students. On the basis of these findings, it was therefore concluded that the cognitive skills acquired in woodwork positively affect students' achievement in mathematics.

The second conclusion deduced for this study was that the practical skills acquired in woodwork positively affect students' achievement in mathematics. This conclusion was arrived at, from the finding that in all the practical skills examined in paper three, the woodwork students achieved higher scores as compared to the non-woodwork students. This difference in achievement was strongly attributed to the fact that the woodwork students received thorough training in these practical skills in woodwork classes and this enhanced their level of precision in practical work.

As evident in the organizational structure of the woodwork and mathematics syllabuses, the woodwork students learned similar subject matter in the two subjects. This opportunity enabled the woodwork students to improve their understanding in the similar topics during the learning of mathematics. The data analyzed revealed that 70 % of the papers as compared to the non-woodwork and mathematics positively affect students' achievement in mathematics.

The conclusions drawn from the empirical testing of the three null hypotheses generally

indicated a positive correlation. The investigators therefore arrived at a general conclusion that the mathematical skills acquired in woodwork positively affect students' achievement in mathematics.

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Advised by Julius K. Maiyo, Masinde Muliro University of Science and Technology, Kakamega, Kenya

Richard P. Kimiti	Doctorate Student, Kenyatta University, P. O. Box 43844-00200, Nairobi, Kenya. Email: prickimiti@yahoo.com
David M. Mulwa	Doctorate Student, University of Pune, P. O. Box 1264-90100, Machakos, Kenya. Email: davimulwa@yahoo.com
Samuel N. Waweru	PhD, Associate Dean, School of Education, Kenyatta University, P. O. Box 43844-00200, Nairobi, Kenya. Email: sawaweru@yahoo.com
Elizabeth N. Muema	Lecturer, Machakos Teachers' College, P. O. Box 124-90100, Machakos, Kenya. Email: muemaelizabeth04@gmail.com
Titus M. Kituka	Lecturer, Machakos Teachers' College, P. O. Box 124-90100, Machakos, Kenya. Email: tkituka@yahoo.com