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EFFECT OF LEARNING SETTING AND ABILITY ON ERRORS IN MATHEMATICS AMONG MALE SECONDARY SCHOOL STUDENTS IN KISUMU COUNTY, KENYA

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ABSTRACT
Secondary school students may be classified into three ability levels namely high ability, medium ability and low ability. These ability levels can be used to learning settings. An individual learning setting may consist of students of the same ability level while a group learning setting consists of students of mixed ability. The purpose of the study was to determine the effect of learning setting and ability on error scores in mathematics. A factorial research design was used in the study. The independent variables were learning setting and ability level. The dependent variable was error score on a mathematics test. The population of the study consisted of 240 Form Three students from a public boys' secondary school. A stratified random sampling technique was used to select a sample of 48 students. The stratifying criterion was the ability level across streams. A mathematics achievement test and an observation checklist were used to collect data. Findings of the study indicated that student ability had a significant effect on error scores in mathematics ($p<.05$). However learning setting did not have a significant effect on error scores in mathematics ($p>.05$). The interaction between learning setting and ability did not have a statistically significant effect on error scores in mathematics ($p>.05$). Soliciting for explanations and getting help improved the performance of the medium and low ability students. The findings are of significance to teachers, educational policy makers, test developers and test users.

Key Words: Learning setting, Ability grouping, Ability level, Mathematics errors, Analysis of variance, Group interaction.

1. INTRODUCTION
1.1 Background to the Study

Achievement test results can be used to place students into learning units. The composition of the learning units may vary according to the ability level of the students. Student ability may be classified as high ability, medium ability and low ability, according to achievement test results. Students of high ability have a high capacity of conceptualizing and understanding the mathematics concepts presented to them. The capacity of the medium ability is lower than that of the high ability while that of the low ability students is lower than that of the medium ability students. The ability level can be used to establish different learning settings among the learners. Students of similar ability can be placed into one learning unit in a practice that is known as streaming according to ability. However students of varied ability can be placed into one learning setting. (Brulles et al., 2012)

According to Smith (2011), students in a similar ability learning setting may engage in individual learning of mathematics concepts. On the other hand the mixed ability learning setting can encourage students to consult with each other to enhance their learning opportunities. According to Nomi (2010), mixed ability grouping results on average to the improvement in the intellectual and scholastic progress of the students in all ability levels. It was noted that the increase in attainment is achieved without any noticeable holding back of the brighter students. This shows that the main effect of mixed ability grouping is the pulling up of the slow learners. Mathews et al (2013) noted that a similar ability learning unit may lead to the improvement of students in the upper streams while the performance of the lower streams deteriorates.

Mark (2011) observed that most learning units consist of students of mixed ability. Learning units are established in different ways in secondary schools in Kenya. In some schools the students are placed randomly into classes according to how soon they reported to school at Form one level. This random placement of students resulted in the formation of learning units consisting of students of similar or those of mixed ability. Mansor et al (2016) observed that some schools created learning units of similar ability in varied ways. In some schools, the bright students were purposively placed in one classroom while the weak ones were placed in another. This shifting of students can be done on a yearly basis. This system has been seen to encourage competition among the learners to enable them move to the upper streams. It was also noted that in some instances the bright students were asked to sit in front of the class while the weak ones sat at the back Forgasz (2010).

Though teachers may have mixed feelings about the most appropriate way of establishing learning units (Gallagher et al, 2011), learning settings may have some influence on the learning outcomes of the students. The design of a learning setting should be of major concern to school administrators since different kinds of learning settings encourage and optimize certain kind of behavior while minimizing and discouraging others (Dukmak, 2009). For instance it is perceived that a similar ability learning setting may promote competitive instincts while a mixed ability setting may encourage co-operation among the learners (Smith, 2011). The High ability students in a streamed setting may feel superior while the low ability students may feel inferior and would not perform any better even if they increased their effort. The learner therefore interacts with the learning environment, changes it and is in turn changed by the consequences of his actions (Hallam and Ireson, 2003).

The design of a learning setting is quite important in the learning of mathematics. Students make two kinds of errors when learning mathematics namely algorithmic errors and computational errors (Peterson and Janicki, 1979). Algorithmic errors are made due to poor understanding of predetermined guidelines, formulas or steps for arriving at the correct solutions. Computational errors are unrelated to the steps required in setting up or carrying out an algorithm. Group interaction can therefore be observed for content related to algorithms and computational

ISSN: 2582-0745
Vol. 3, No. 03; 2020

manipulations. This is to determine whether the nature of interaction and their experience in the group setting explains their performance at each ability level.

Before a school decides on which method to use in establishing learning units for its students it must consider the kind of learning environment that is being created. This can be better understood if the relationship between the learning setting, ability and student achievement is understood. Therefore the purpose of the study is to determine the relationship between learning setting, student ability and errors in mathematics.

Objectives of the Study

The objectives of the study were to:

(i) Determine the relationship between learning setting and errors in mathematics.
(ii) Determine the relationship between ability and errors in mathematics.
(iii) Determine the relationship between the learning setting, ability and errors in mathematics.

2. METHODOLOGY

Research Design

A factorial research design was used in this study. In a factorial design the researcher can modify certain variables and observe the effect of these modifications on the variable of interest (Kerlinger, 1986). In this design, every possible combination of factor levels was observed and therefore the set of factors was completely crossed. The design was therefore used to investigate the effects of learning setting and student ability on errors in mathematics. The independent variable is learning setting having two levels; individual and the group learning setting. Student ability had three levels namely high, medium and low ability levels. The dependent variable was the error score which was measured using a mathematics achievement test.

Population

The population of the study consisted of 240 Form Three students from an urban secondary school that streamed its students according to ability. The school was selected purposively because it is a boys' school that streamed its students according to ability. The school had six streams which were considered large.

Sample and Sampling Technique

Stratified random sampling technique was used to select 48 students. The stratifying criterion was based on the classification of streams in terms of ability.

Table 1 shows how a stratified random sample was selected with an equal number of students from four of the six streams.

ISSN: 2582-0745
Vol. 3, No. 03; 2020

Table 1: Student Sample by stream,

Stream	3A	3B	3C	3D	3E	3F	Total
Population	40	38	41	42	37	42	**240**
Sample	12	0	12	12	0	12	**48**

The 3A stream was classified as the high ability group. The medium ability group was represented by the 3C and 3D streams while the low ability group was represented by the 3F stream. The actual selection was done by putting names of all the students in a box and picking 12 of them at random. The selected students were then used to form twelve groups each consisting of one high ability, two medium ability and one low ability student. The composition of the twelve groups was described in Table 2.

Table 2: Sample distribution by ability and groups

Ability	Groups												
	A	B	C	D	E	F	G	H	I	J	K	L	TOTAL
High	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Medium	2	2	2	2	2	2	2	2	2	2	2	2	**24**
Low	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Total	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**48**

Table 2 shows how the students from each stream were assigned to the twelve groups according to their ability level. The names of the twelve students were put in four different boxes each representing the high, medium and low ability strata. A name was randomly picked from each box and assigned to a group. This was done to ensure that a group had one high ability student, two medium ability students and one low ability student. These groups were used in the group learning settings.

Instrumentation

Instructional booklets, answer booklets a package of complex questions and a package of stepwise solutions to the complex questions prepared by the instructor and a mathematics achievement test were used in the study. The test consisted of complex questions on Probability. The test was scored on a 0-10 point scale, with the minimum possible error score of 0 and the maximum possible error score of 10. The test was pretested with similar students from a parallel school. An internal consistency reliability coefficient (Cronbach’s alpha) of 0.75 was obtained.

ISSN: 2582-0745
Vol. 3, No. 03; 2020

In addition an observation checklist was used to collect data on group interaction. The observation categories were related to algorithmic errors and to computational errors. Trained research assistants familiar with the mathematics concepts were used as observers. The observation checklist was pretested with students from a parallel school to enhance its validity. The instruments were also assessed by research experts from the department of Educational Psychology at Maseno University to ensure they had face validity.

Data Collection Procedure

The instructor gave the students in the study some learning materials which consisted of instructional booklets and their answer booklets; some complex questions and a package of stepwise solutions to the complex questions on probability. The students were shown how to use them to solve basic problems. They worked alone and consulted with the instructor after studying all the hints. They thereafter worked through the complex questions. This was done on some particular concepts on probability which were learnt individually.

The students were then put in groups of four and used learning materials which were different from those used individually. Each group consisted of one high ability student, two medium ability students and one low ability student. The students were shown how to help each other in solving problems and solicit for explanations from each other in case of difficulties. Thereafter the students worked through the complex questions while working in groups. An observer in each group noted the nature of interaction initiated by each student. The concepts learnt were new to the students and it was assumed that the performance was due to experimental conditions.

After the learning sessions the students were given a mathematics test which was administered under power conditions. The test consisted of complex items which tested the concepts learnt in the individual learning setting and the group learning setting. The test was administered under the supervision of the instructor while strictly observing the examination ethics. They sat for the tests alone and no consultations were allowed. The tests were scored, coded and entered for further analysis.

Methods of Data Analysis

Analysis was done using the Statistical Package for Social Sciences, IBM SPSS Version 20 (Nie et al, 2019) computer software. Descriptive statistics such as percentages and measures of central tendency such as mean were used to describe the incidence of errors in the individual and group setting and also the mean error scores for ability and the learning setting.

Two way analysis of variance was used to test the main and interaction effects of ability and learning setting on the error scores on a mathematics test. The level of significance was 0.05 with 1,42 degrees of freedom for the learning setting alone, 2,42 degrees of freedom for ability alone and 1,42 degrees of freedom for the interaction of ability and learning setting. Post-Hoc Tukey statistic was used to compare the difference among the means where the difference was statistically significant.

ISSN: 2582-0745
Vol. 3, No. 03; 2020

4. RESULTS

Error scores for each ability level in the learning settings

The error scores at each ability level were determined at both the individual and group settings. Since the number of errors of the two categories differed across items, percentages were used to allow direct comparisons across the categories.

Table 3 shows the percentage error scores for each ability level in the individual learning setting.

Table 3: Percentage error scores for each ability level in the individual learning setting

Ability	Percentage Error Score		
	Algorithmic	Computational	Total
High	23.3	30.0	26.7
Medium	46.7	75.0	60.8
Low	73.3	66.7	70.0
Total	**47.5**	**61.7**	**54.6**

Table 3 shows that in the individual learning setting, the high ability students made the least total error scores (26.7%). The medium ability students made more total errors (60.8%) while the low ability students made most of the total error scores (70.0%). This indicates that the number of total errors made by the students depended on their ability level. The difference between the error scores of the high and the medium ability students was considerably high compared to the difference between the medium and low ability students. The individual learning setting did not seem to reduce the total error scores of the low ability students.

When the error types were distinguished, it was noted that high ability students made more computational errors (30.0%) than algorithmic errors (23.3%). The medium ability students made more computational errors (75.0%) than algorithmic errors (46.7%). The low ability students however made more algorithmic errors (73.3%) than computational errors (66.7%). This indicated that low ability students had difficulties in setting up algorithms when they were working alone. The high and medium ability students could set up algorithms but could not perform computational manipulations. The individual learning setting was not useful in helping the low ability students set up and manipulate the algorithms.

ISSN: 2582-0745
Vol. 3, No. 03; 2020

Table 4: Percentage error scores for each ability level in the group learning setting

Ability	Percentage Error Score		
	Algorithmic	Computational	Total
High	13.3	23.2.	18.3
Medium	43.3	70.0	60.0
Low	50.0	83.3	63.3
Total	**37.5**	**65.0**	**51.25**

Table 4 shows that in the group learning setting, the high ability students made the least total errors (18.3%). The medium ability students made more total errors (60.0%) while the low ability students made most of the total error scores (63.3%). This indicated that ability played a major role in the error scores made by the students. However the difference between the error scores made by high and the medium ability students was considerably large. That between the medium and low ability students was quite small. This indicated that the group setting was significant in the learning opportunities of the low ability students.

When the error types were distinguished, it was noted that high ability students made more computational errors (23.2%) than algorithmic errors (13.3%). The medium ability students made more computational errors (70.0%) than algorithmic errors (43.3%) while the low ability students made more computational errors (83.3%) than algorithmic errors (50.0%). Generally more computational errors (65.0%) were made by all the students than algorithmic errors (37.5%). The group learning setting therefore helped all students to learn how to set up and manipulate algorithms.

When the learning settings were compared, it was noted that the number of errors made by the high ability students in the individual setting (18.3%) was less than that in the group setting (26.7%). This indicated that the group setting was more beneficial to the learning opportunities of the high ability students than the group setting. The performance of the medium ability students was almost similar in the individual setting (60.0%) and in the group setting (60.8%). The learning setting did not have an effect on the learning opportunities of the medium ability students. The number of errors made by the low ability students in the group setting (63.3%) was lower than that in the individual setting (70.0%). The group setting therefore increased the learning opportunities of the low ability students. Considering all the students, it was noted that the performance in the group setting (51.25%) was better than that of the individual setting (54.6%).

Nature of group interaction

ISSN: 2582-0745
Vol. 3, No. 03; 2020

An analysis of the nature of interaction initiated by each student in the groups helped to explain the performance by error type at each ability level in the group learning setting. The nature of interaction was analyzed separately for content related to algorithms and to computational manipulations. Table 5 shows results of group interaction analysis.

Table 5: Instances of free interaction initiated by each student.

Interaction Variable	Ability		
	High	Medium	Low
Describing Algorithms	45	34	8
Explaining Algorithms	45	14	5
Receiving Algorithmic explanations	9	20	52
Describing Calculations	35	17	7
Explaining Calculations	39	14	2
Receiving Calculation explanations	18	14	33

Table 5 shows that high ability students quite often described and explained specific featutrs of algorithms but rarely received explanations of algorithms. It was also noted that high ability students in nearly every group directed the group work, stated overall objectives and delegated work to other members of the group. The high ability students spent most of the time describing or explaining the algorithms than calculating or explaining how to perform calculations.

The medium ability students on the other hand quite often explained how to carry out algorithms to other members of the group. They rarely explained how to carry them out. They also received explanations of the algorithms. The medium ability students participated in doing calculations but rarely explained how to carry them out. They also received explanations about the calculations. Medium ability students often failed to detect errors made by other members. Some medium ability students often failed to detect errors made by other members. Some medium ability students expressed lack of confidence in their ability to perform calculations and asked other members for answers to simple calculations. Some medium ability students did not even attempt calculations.

Low ability students rarely participated in setting up or explaining algorithms but often solocited and received explanations from other members. In explaining to the low ability students, other members of the group made certain that the low ability member understood how to carry out the algorithms. The low ability students performed some calculations but often received explanations about how to perform calculations especially when they made errors. Low ability students quite often received explanations about the algorithms and about calculations. Describing the

ISSN: 2582-0745
Vol. 3, No. 03; 2020

algorithms may have helped students to understand and to solidify their memory on how to carry out the algorithm. Students were able to locate their own areas of difficulty by describing rather than listening to others describe it. Being the target of explanations may have helped the students to understand the algorithms more than merely reading text materials. The other members of the group may have understood a particular member's difficulty and was able to help the student experiencing difficulty to understand the algorithms. The group sessions were too brief to remedy deficiencies in computations that months of classroom instruction could not remedy.

Relationship between learning setting, ability and the total error scores

The following null hypotheses were tested in order to investigate the main and interaction effects of ability and leaning setting on the error scores on probability.

a) There was no significant relationship between learning setting and total error scores.

b) There was no significant relationship between the ability and total error scores.

c) There was no significant combined relationship between ability, learning setting and total error scores.

These hypotheses were tested using two way analysis of variance. The independent variables were ability level and learning setting. The dependent variable was the total error scores on a mathematics achievement test. The level of significance was 0.05. Table 6 shows results of two way analysis of variance at a level of significance of 0.05.

Table 6: Two way Analysis of Variance for error scores on a mathematics test

Source of Variation	Sum of Squares	df	Variance Estimate	F Ratio	Sig
Learning Setting	0.75	1	0.75	0.13	0.822
Ability	156.75	2	78.375	13.58*	0.023
Ability × Learning setting	1.417	2	0.736	0.128	0.935
Within Group error	242.33	42			
Total	401.25	47			

*0.05 level of significance

Statistically significant differences in the mean error scores were noted for ability only (F = 13.58, df 2, 42, P=0.023) and not for learning setting (F=0.13, df 1, 42 P=0.822) and the interaction between ability and learning setting (F= 0.128, df 1, 42, P=0.935).

ISSN: 2582-0745
Vol. 3, No. 03; 2020

The findings failed to reject the Null hypothesis of no significant effect of the learning setting and no significant combined effect of the learning setting and ability on the total error scores at a level of significance of 0.05. However the null hypothesis of no significant effect of ability on the total error scores was rejected at 0.05 level of significance. The alternative hypothesis of a significant relationship between ability and the total error scores was accepted at 0.05 level of significance.

From the findings it was evident that whether the students were in the individual or group learning setting, it did not have a significant effect on the error scores on a mathematics test. However ability did have a significant effect on the error scores on mathematics achievement test and the interaction between ability and the learning setting was not significant at 0.05 level of significance. Table 7 shows results of Post-Hoc Tukey comparison of the ability levels.

Table 7: Post-Hoc Tukey comparison for the ability levels.

Ability	Mean Score	Difference	Tukey Value	Sig
High	2.250	4.080*	1.982	0.035
Medium	6.330	4.335*	1.982	0.029
low	6.585	0.255	1.982	0.342

*0.05 level of significance

From Table 7 it can be seen that the difference between the High and Medium ability levels was significant (P<0.5). The difference between the medium and low ability students was not significant (P>0.5).

From the result ability accounted for 35.7% of the variance in the total error scores while learning setting alone and the combination of both the learning setting and ability accounted to a negligible extend of the variance in the total error scores. A strong association existed between ability and the total error scores. The association was quite sizable in a predictive sense for any population corresponding to the current study. The other proportion of error scores could have been accounted for by other factors. The possible factors that could have contributed to the unexplained variance were suggested to be;

i) The level of interest and attitude towards mathematics.

ii) The student's personality in the group setting.

iii) The levels of motivation.

5. DISCUSSION OF FINDINGS

The findings from descriptive statistics indicated that individual leaning setting was more effective in learning mathematics for the high ability students than the group setting. The learning setting did not affect the error scores of the medium ability students. It did not therefore matter whether they were in the individual or the group setting. The group setting seemed to greatly improve the performance of the low ability students over the individual setting. When all students were considered, the performance in the group setting was better than that of the individual setting. The findings also indicated that being the target of explanations may have helped the students to understand the algorithms more than merely reading text materials. These findings are inconsistent with a study by Peterson and Janicki (1979) who found out that receiving explanation was not related to achievement. Kaya (2015) found that there were no significant differences between the heterogeneous and homogeneous classrooms on the amount or type of questions generated. Webb (1980) found out that merely participating in a teacher learner relationship was not sufficient for high achievement.

The finding of no significant effect of the learning setting on the error scores was consistent with previous research. Brulles et al (2012) found insignificant effects, neither positively nor negatively of between class ability grouping on student achievement in mathematics. Mathews et al (2013) found out that gifted students showed an increase in reading ability at the same rate over time as students not identified as gifted. They found no evidence that ability grouping benefited or harmed academic achievement in the area of reading. Nomi (2010) found no difference among students in low, middle and high achievement levels at ability grouped and ungrouped schools. Leonard (2001) and Kumar (2004) found that multi level classes do not have an effect on students' academic achievement when compared to students in mixed ability classrooms.

Ability was seen to have a significant effect on the student total error scores on a mathematics test. These findings were in agreement with research by Liem, et al (2013). They noted that the intellectual dimension of the students was the strongest variable that predicted high academic achievement. Kaya (2015) found out that high achieving students performed well regardless of how they were grouped and showed more positive effects from ability grouping than their lower performing peers.

The findings of no significant interaction effects of the learning setting and ability are not consistent with previous research by Macqueen (2013) who revealed that low ability students did better in the group setting than the individual setting. The medium ability students' performance was the same regardless of the learning settings. Macqueen (2013) also found out that helping each other was positively related to achievement. Smith (2011) found out from his study that the composition of groups according to ability positively contributed to the learning of mathematics. The study found out that the effect of the learning setting depended on the ability levels of the students. Vogl and Preckel (2014) found out that grouping between classes by ability had insignificant results on students' self concept and school related attitudes. Naomi (2010) found out that the style of ability grouping, paired with the level of student participants and subject area

ISSN: 2582-0745
Vol. 3, No. 03; 2020

studied, had neither improved nor decreased academic achievement. Leonard (2001) found significant effects between scores of students in heterogeneous and homogeneous groups.

6. CONCLUSION

From the findings of the study it was concluded that being the target of explanations may have helped the students to understand the algorithms better. The learning setting had no significant effect on the performance of the students. Ability had an effect on the performance of the students regardless of the learning setting. The interaction effect of learning setting and ability on the total scores was not significant.

7. RECOMMENDATIONS

The following recommendations were based on the findings of the study.

i) Mixed ability group settings should be established in most secondary schools since they were conducive to better learning in all the three ability levels.

ii) Educational policy makers in Kenya should consider the relationship of ability and learning setting when establishing learning units in secondary schools.

8. SUGGESTIONS FOR FURTHER RESEARCH

The following were suggestions for further research;

i) Research on Ability grouping focusing on a larger sample of students.

ii) Research on ability grouping and learning settings at other levels of education like Primary schools colleges and the University.

iii) Research on ability grouping and learning settings using other subjects.

iv) Research using a true experimental design and the use of a control group.

v) Research on ability grouping and learning settings using a population consisting of Girls only and also a sample consisting of mixed gender.

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Vol. 3, No. 03; 2020

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