Scholars Journal of Physics, Mathematics and Statistics OPEN ACCESS
Abbreviated Key Title: Sch J Phys Math Stat
ISSN 2393-8056 (Print) | ISSN 2393-8064 (Online)
Journal homepage: http://saspjournals.com/sjpms

The Mathematics Laboratory and Its Effect on Secondary School Students Performance in Mathematics

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DOI: 10.36347/SJPMS.2019.v06i11.001 | **Received:** 07.11.2019 | **Accepted:** 14.11.2019 | **Published:** 16.11.2019

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Abstract **Review Article**

Mathematics as a subject has defined axioms, theories, principles and structures that can be manipulated according to a formal system. It has its own language, and helps to develop the power of logical thinking and accuracy. However, according to Piaget (1936), cognitive development in children occurs as a result of the experience with the environment. A mathematics laboratory would provide such concrete objects to be used as teaching aids. This study followed up records of fifteen students from the same primary school that joint different secondary schools. Performance in mathematics for these fifteen students was recorded and analyzed. Results show that of the fifteen students, those who joint secondary schools that had a mathematics laboratory performed better on average than those students who joint schools that had no mathematics laboratory. Further analysis of the results using ANOVA revealed that the difference in performance between the two sets of students was significant at 0.001. It is therefore recommended that all secondary schools in Kenya provide a mathematics laboratory for its learners.

Keywords: Mathematics Laboratory School Students.

INTRODUCTION

As children start to learn arithmetic in baby class, they have no idea of the meaning of numbers; 1, 2, 3, 4, etc. However, by using song and dance, and by using teaching aids, they begin to understand the meaning of the number one, then the number two, then eventually they are able to count up to ten and more. With time they are able to tell the difference between one and two, between putting together and taking away, then multiplication and division. In most infant schools in Kenya today, you will find cards with numbers, bottle tops, straws, sticks etc. for counting. Children therefore learn with hands on. They sing songs like;

'1, 2, I wake up in the morning and wash my face
3, 4, I take a cup of tea, I say bye to mummy and run to school
5, 6, its time for parade! We sing and pray
7, 8, time for class, we learn and learn and learn.
9, 10, time for lunch, I say bye to teacher and home I go.'

The nursery school children are made to look at the number cards daily and the learning of arithmetic is made simple and enjoyable. However, as these nursery school children move to primary school, it is observed that the teaching aids, song and dance, are still available in the lower primary schools; thus class one to class four. From class 5 to 8, teaching aids seem to simply disappear. There is no more song and dance as they learn mathematics, and suddenly the pupils start finding mathematics difficult [1]. Teachers rely on text books and try to draw diagrams on the board thus depending on how well a teacher is able to draw; the learners may or may not understand the concept being taught.

Purpose of the Study

This study is to find out if availability of a mathematics laboratory in secondary schools affects student performance in mathematics.

RESEARCH DESIGN

This is an Ex Post Facto Research Design, where records in various schools were used. In particular, some students' records were followed for over a period of ten years.

Statement of the Problem

Mathematics is a subject with a system of defined axioms, theories, principles and structures that can be manipulated according to a formal system. It is a philosophy of numbers. Mathematics has its own language, and therefore it is a powerful means of communication. It can be used to present information through tables, charts, diagrams and graphs. It helps to

develop the power of logical thinking and accuracy. It is therefore imperative that all learners in Kenya and beyond be taught to understand concepts of this subject. However, according to Piaget [2], cognitive development in children occurs as a result of the experience with the environment. Piaget advices that children be exposed to concrete objects and teaching aids are used at all times and at all levels when teaching mathematics. A mathematics laboratory would provide such concrete objects and teaching aids.

Availability of Teaching/Learning Aids in Primary Schools in Kakamega County

A survey on thirty primary schools in Kakamega County to establish availability of teaching/learning aids at the lower primary section and the upper primary section revealed that most schools had teaching aids only at the lower primary section. Teachers at the upper primary section only had the chalk board geometrical sets like the chalk board ruler, protractor and pair of compasses. They mostly relied on the text books to teach thereby making mathematics more and more abstract. Table 1 shows the teaching aids available in the 30 public primary schools selected randomly from Kakamega County.

Table-1: Availability of Teaching Learning Aids in Primary Schools

	Lower Primary Section				**Upper Primary Section**				
Teaching aids	Maths shop corner	Maths songs	Number cards	Multiplication tables	Maths shop corner	Maths songs	Cards	Geometrical set items	Wall charts
Number of Schools	30	22	30	30	0	0	0	25	21

From Table 1, all thirty schools had a mathematics shop corner with shop items, a price list, and different denominations of money. They also had number cards and multiplication tables. In 22 schools, there were written songs, such that each number represented a different item. One of the songs was;

1, 2; these are my shoes
3, 4; that is the door
5, 6; a big blue book
7, 8; teachers table
9, 10; say it again

In the same schools, at the upper primary section, none of the schools had either the mathematics corner shop, mathematics counting cards or any type of a mathematics song. Instead a few schools had chalk board geometrical instruments, some charts on the classroom walls and some text books. An observation of pupil performance in mathematics in these schools, revealed that the marks scored by individual pupils steadily dropped from 95 marks average to 80 marks average. By the time they get to standard 8, most of them were on average scoring 70 marks and below.

As these pupils move to secondary schools, some will have developed a poor attitude towards mathematics. Things get worse, since in some secondary schools there is neither a mathematics corner nor a mathematics laboratory.

Table 2 shows a list of 15 students from the same primary school who went to different secondary schools. Some of the secondary schools had mathematics laboratories while others did not have mathematics laboratories. The average marks of these pupils from class one to class 8, were found in the records at the primary school. The records also showed the secondary schools to which these 15 students went to. It was therefore easy to follow up and find the average marks scored by the same students at the various secondary schools. The primary school in question was known to the researcher, and it was the schools tradition to follow up on its pupils as they pursued secondary education and beyond. At the different secondary schools, it was also easy to pick the mean marks scored by each of the fifteen students from the records kept in the office of the Head of Mathematics Department.

Table-2: Average Marks Scored by Individual students From Class 3 to Form 4

Class	**3**	**4**	**5**	**6**	**7**	**8**	**F1**	**F2**	**F3**	**F4**
Yr	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	95	91	89	85	78	75	80	75	65	60
2	93	92	87	85	80	76	70	67	61	52
3	96	90	86	83	80	71	65	55	50	43
4	89	90	88	82	79	75	72	61	56	48
5	92	85	82	79	75	71	75	64	53	45
6	90	83	79	75	70	66	65	55	45	37
7	95	91	85	80	71	70	67	58	46	35
8	88	85	79	74	73	69	65	60	55	31
9	91	91	89	87	85	80	88	84	78	73
10	93	90	90	89	85	80	85	81	80	75
11	95	89	85	84	81	78	80	71	64	56
12	90	91	90	85	85	82	83	80	78	72
13	91	87	82	80	76	71	75	70	66	52
14	89	85	80	80	80	80	85	80	76	75
15	94	91	90	88	85	84	88	82	80	78

From Table 2, students; 9, 10, 12, 14 and 15, were admitted in secondary schools that had a mathematics laboratory. Students; 1, 2, 4, 11 and 13, were in secondary schools that had only a mathematics room, but not a mathematics laboratory. The remaining 5 students were in secondary schools that had neither a mathematics laboratory nor a mathematics room. The few teaching/learning aids in the school were stored in the mathematics Head of departments' office or in the science laboratory. This is shown in table 3

Table-3: Mean Marks per Category of School

Sch Type	**Schools with a maths lab (group 1)**	**Schools with a maths room (group 2)**	**Schools with neither a maths lab nor a maths room (group 3)**
1	73	60	43
2	75	52	45
3	72	48	37
4	75	52	35
5	78	56	31

From table 3, students in group 1 category of schools seem to have performed better than their counter parts in group 2 and group 3 categories of schools. However, to find out if the difference in performance is significant, the data was subjected to a one way analysis of variance ANOVA. The results are shown in table 4.

Table-4: ANOVA

marks					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2516.933	2	1258.467	14.263	.001
Within Groups	1058.800	12	88.233		
Total	3575.733	14			

From table 4, there is a significant difference in performance between the three categories of schools. According to Kothari [3], a value of 0.05 indicates a significant difference in variables. Table 4 shows a significance of 0.001, which confirms that there is a significant difference in performance between schools with mathematics laboratories, and those with just a mathematics room, or with neither a mathematics laboratory or a mathematics room. Furthermore, Table 5 shows multiple comparisons between the three categories of schools.

Post Hoc Tests

Table-5: Multiple Comparisons

Dependent Variable: marks						
Bonferroni						
(I) mathematics resource center	(J) mathematics resource center	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1 schools with a mathematics laboratory	schools with a mathematics room	10.60000	5.94082	.299	-5.9123	27.1123
	schools with neither a mathematics lab nor mathematics room	31.20000*	5.94082	.001	14.6877	47.7123
schools with a mathematics room	1 schools with a mathematics laboratory	-10.60000	5.94082	.299	-27.1123	5.9123
	schools with neither a mathematics lab nor mathematics room	20.60000*	5.94082	.014	4.0877	37.1123
schools with neither a mathematics lab nor mathematics room	1 schools with a mathematics laboratory	-31.20000*	5.94082	.001	-47.7123	-14.6877
	schools with a mathematics room	-20.60000*	5.94082	.014	-37.1123	-4.0877
*. The mean difference is significant at the 0.05 level.						

LITERATURE REVIEW

The Mathematics Room

According to Adenegan [4], Mathematics involves thinking logically and reasonably so as to understand how formulae are derived and how they are applied. In order to enhance learners' mastery and meaningful learning of mathematics, it is necessary to reduce to the bearable minimum its level of abstraction with the use of instructional materials. Adenegan [5] testified to this that instructional materials, when properly used in the teaching and learning situation, can supply concrete bases for conceptual thinking, high degree of interest for students in making learning more permanent. Thus the need for a mathematics room, or more importantly, the need for a mathematics laboratory.

From the researchers' experience, a mathematics room is that room that houses mathematics teaching aids or equipment. These include models of three dimension geometry, geometrical set instruments like the ruler, pair of compasses, protractor, Set Square and pencils. The globe showing longitude and latitude lines will also be found in this room. The room is usually small and cannot be used as a class room for teaching a mathematics lesson. Mathematics teachers pick the items from this room to be used for teaching in the normal classroom then return them in the mathematics room after use. It can be equated to a store of mathematics teaching aid. However, sometimes the room also serves as an office for the Head of Mathematics Department.

According to Oyekan [6], "instructional materials are those things that can facilitate effective teaching and pleasant learning that is teaching aids through which learning process may be encouraged and motivated under the classroom situation". These enhance the teaching learning process when adequately and appropriately used. Some of the instructional materials are shown in figure 1.

Fig-1: Some of the Items in a mathematics room

The instructional materials shown in figure 1 can only be carried by mathematics teachers to be used in the teaching of mathematics in a normal classroom. As seen in the figure, it is not possible to have a lesson in this room. This calls for a better room, which can serve both as a store and a classroom. The mathematics laboratory is one such room.

The Mathematics Laboratory

A mathematics laboratory is an improvement of a mathematics room. It is big enough to be used as a classroom and therefore has tables and chairs, or desks where students may sit to learn mathematics. Along the walls at the bottom of the room, are cupboards in which the instructional materials are kept. Apart from those materials found in the mathematics room, in the mathematics laboratory more items are available. These include; the computers, calculators, slide rules, the spike abacus, dice, playing cards, coins, tape measures, mirrors, and even thermometers. On the upper part of the walls in the mathematics laboratory are charts displaying concepts of different topics. Some of the charts are shown in figure 2.

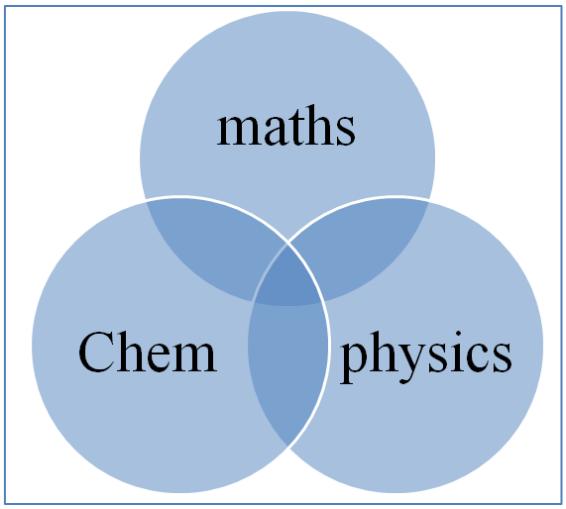

Fig-2: Sets Theory

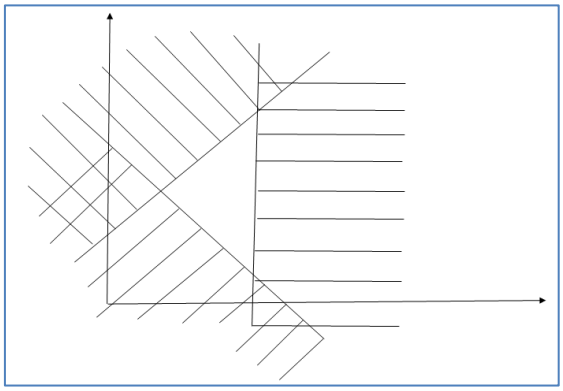

Fig-3: Linear Programmimng

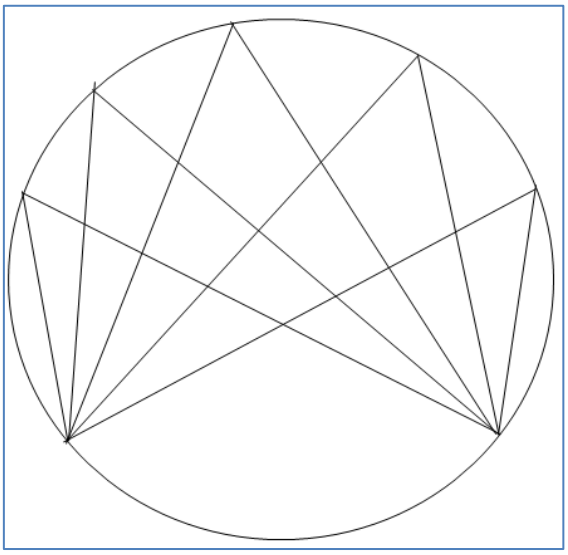

Fig-4: Angles in the same segment

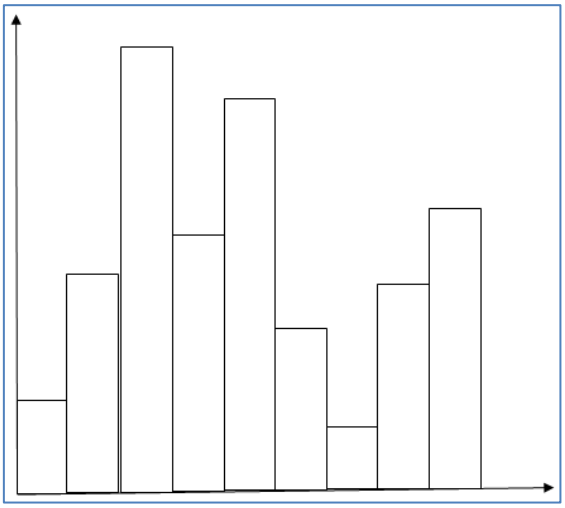

Fig-5: Bar Chart

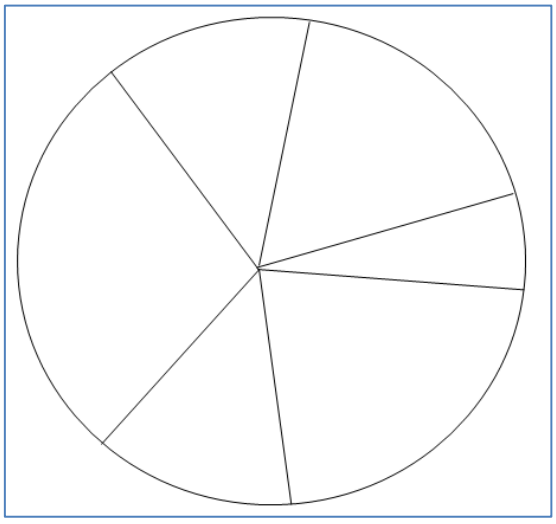

Fig-6: Pie Chart

From the six figures, it is clear that during a mathematics lesson, students are able to observe the figures, and then draw their own figures, and with the

teachers' help able to follow the given concept. In most of the mathematics laboratories visited, the labs had teaching aids for almost all topics taught in the mathematics syllabus. When teaching the frequency distribution table for example, learners are able to follow the example in table 3, then make their own table and use it to calculate the mean, median, mode variance and standard deviation.

Table-3: Example of a Frequency Distribution Table

Number of Pets (x)	Tally	Frequency (f)
0	IIII	4
1	𝍸 I	6
2	𝍸	5
3	III	3
4	II	2

With such information, learners should be able to handle questions like:

A farm wished to employ a computer expert whose age was to be between 30 and 50 years. The ages of the following 40 applicants were recorded.

37	40	42	40	41	40	39	40	39	43
39	43	40	39	37	41	41	38	42	38
44	40	37	36	39	37	45	40	43	41
38	41	36	40	42	38	37	41	42	37

i) Make a frequency distribution table using class intervals 35 – 37, 38 – 40… ii) Calculate the mean age. iii) Calculate the medium age. iv)Calculate the standard deviation.

According to teachers in the five schools with mathematics laboratories, the charts on the walls help them to teach this concept easily and learners enjoy learning the topic.

When teaching graphs and especially bar charts, figurer 7, also found in the mathematics laboratory makes mathematics look nice, simple and enjoyable.

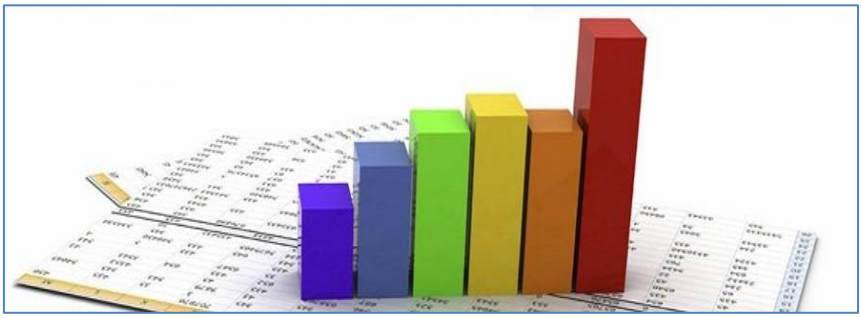

Fig-7: Example of a Bar Chart

On the other hand, when teaching longitudes and latitudes, a teacher may draw a diagram as in figure 8, but learners will understand the concept better, if they see and touch such a globe in the mathematics laboratory. In figure 8, the latitude showing zero degrees is actually the equator. It is a circle whose circumference can be culculated and the length of any arc can be found. However, looking at the diagram learners may not be able to connect the two. It is only when they see the actuall globe that they realise it is a circle. Things become even more complicated, when trying to find the distance between a point on latitude twenty degrees north, longitude sixty degrees west and a point on latitude eighty degrees north, longitude thirty degrees east. Most learners will not be able to visualise this information on a diagram, but will be able to follow the latitude and longitude very easily on the actual globe in the mathematics laboratory. It is for this reason that all schools in Kenya are encouraged to have a mathematics laboratory to enable learners understant such concepts better.

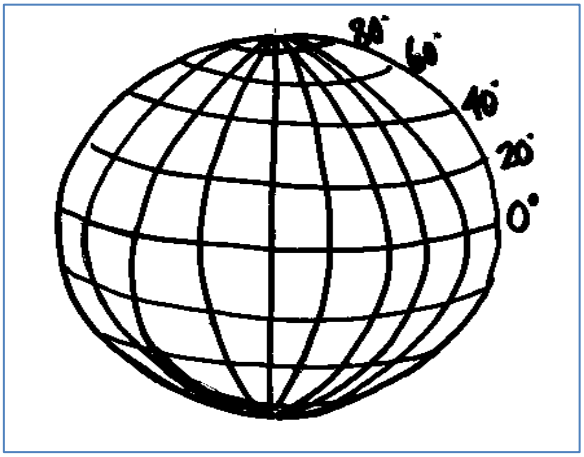

Fig-8: The globe showing latitudes and longitudes

CONCLUSION AND RECOMENDATION

Shikuku [1], found that some topics in the mathematics syllabus are left untaught by a majority of secondary schools in Kakamega County in Kenya. Such topics include; Linear Programming, Three Dimension

Geometry, Vectors and Locus. However, an inspection of schools in this study shows that the five schools with the mathematics laboratories had taught these topics with ease, while the ten schools without mathematics laboratories had either found it difficult to teach these topics or left them untaught. These imply that a mathematics laboratory is important and necessary in every school in Kenya. It will make the teaching easier, all topics will be taught, it will make mathematics simple to understand, and performance in mathematics should improve. It is therefore recommended that all schools in Kenya be encouraged to have a mathematics laboratory. In fact, the ministry of education should insist that all secondary schools have a mathematics laboratory.

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