International Journal of Humanities and Social Science Invention (IJHSSI)
ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714
www.ijhssi.org ||Volume 11 Issue 4 Ser. II || April, 2022 || PP. 46-50

Computer Assisted Learning (CAL) and learner achievement in probability in mathematics in public secondary schools in KISII County, Kenya

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ABSTRACT
The Mathematics National performance of students in Kenya Certificate of Secondary examinations (KCSE) from 2012 to present has been consistently low. Probability was identified as one of the areas in Mathematics that posed difficulty to the majority of students in the KNEC, KCSE Examination reports of 2012 to present. To address the problem, a new strategy was presented that argues for the inclusion of Computer Assisted Learning techniques such as simulation. The study sought to determine the difference in achievement in Probability between students using computer simulation and those taught using conventional method. To collect data, a Solomon's four group type quasi-experimental research design was devised. Though, both control group and experimental group had similar results in the pre-test. Results were analyzed using mean, standard deviation and ANOVA. It was found that in general the experimental group performed significantly above the control group. Specifically, the experimental group performed better in probability achievement than the control group.
KEY WORDS*: Computer assisted learning (CAL), Computer simulation (CBS), Probability.*

Date of Submission: 07-04-2022 Date of Acceptance: 22-04-2022

I. INTRODUCTION

Mathematics as a subject form a key component of the school curriculum in most countries worldwide. This is due to the perceived role the subject plays in preparing learners for future career prospects. In particular, the subject has been shown to aid in sharpening human mind, aid in the development of logical thinking and enhancement of learners' reasoning ability as well as their spatial power (Nur, 2010; Wanjiru, Miheso & Ndethiu, 2015). Additionally, mathematics is seen as important in supporting the learning of science and technical based subjects (Adesoji & Oginni, 2012; Ajewole, Oginni, & Okedeyi, 2006; Ogembo, 2012; Peters, 2000; Salau, 2000; Tella, 2007). Also, for personal development and use of Mathematics in daily life. Consequently, the subject is very popular with educational policy planners as well as curriculum specialists in all countries, Kenya included. In these countries, mathematics has been made compulsory to all learners at the basic levels of education, that for Kenya include the Pre-primary, Primary and Secondary levels.

From the KNEC reports, probability as a topic is poorly done in section A and in most instances skipped, if set in section B of KNEC exams. This is illustrated in Table 1.1 and 1.2 respectively.

Table 1.1: ***Mean scores in KCSE Mathematics in Kisii by Sub- County, 2014-2018***

	Sub-county	2014	2015	2016	2017	2018
1.	Marani	2.151	2.016	2.215	3.432	2.631
2.	Sameta	1.782	1.601	1.512	2.114	2.151
3.	Kisii Central	2.152	2.201	3.014	3.156	2.871
4.	Kisii South	2.415	2.103	2.012	3.012	2.602
5.	Nyamache	2.321	2.002	2.211	2.934	2.023
6.	Gucha	1.872	1.612	2.042	2.678	2.321
7.	Gucha South	2.015	2.123	1.478	2.842	1.827
8.	Kenyenya	1.791	2.017	1.787	2.785	2.783
9.	Masaba South	1.982	2.111	2.124	3.012	2.033
	Mean	**2.053**	**1.976**	**2.044**	**2.885**	**2.360**

Source; Ministry of education, Kisii County (2018)

Information contained in Table 1.1 showed that the mean achievement in Mathematics for candidates transiting secondary schooling in Kisii County stood at 2.264 out of 12 between 2014 and 2018. This means that

for the five consecutive years, the mean achievement stood at D- way below the C+ aggregate recommended for minimum university entry. A similar trend in achievement was observed for the subject, PP1 and PP2 at the national level as in Table 1.2.

Table 1.2: ***KCSE National Mathematics performance 2011 – 2018*** **(%)**

Year	2011	2012	2013	2014	2015	2016	2017	2018
PP1	22.71	19.55	22.76	22.37	26.21	21.36	29.46	28.12
PP2	15.36	19.91	19.82	19.87	19.92	28.22	27.86	27.03
Mean	**19.04**	**19.73**	**21.29**	**21.12**	**23.07**	**24.79**	**28.66**	**27.58**

Source: KNEC Reports 2011 - 2018

According to the data in Table 1.2, the national mean achievement of learners in Mathematics was 23.16%, which was significantly lower than the expected C+ accepted aggregate. This observation supports the findings of a number of researchers who have examined students' poor performance in mathematics across Africa and Kenya. For Nigeria, there are Umoinyang (1999) and Tella (2007); Somalia, Nur (2010); and for Kenya, there are Benson and Jones (1999), Miheso (2002). Among the topic that was seen to pose a challenge to a majority of learners in Mathematics is Probability. This topic constitutes Mathematics content learners are exposed to at the basic levels of education (ROK, 2002). It greatly contributes in enabling learners develop skills and abilities that they require to cope with life expectations (Chiesi & Primi, 2010). Specifically, a number of studies link students' positive conception of probability with better learning outcomes (Kazima, 2006; Watson, 2006). Empirical evidence indicated that the importance of probability in everyday life and the workplace had led to the call for an increased attention on it (NCTM, 2000; Shaughnessy, 2007; Watson, 2006).

In an attempt to mitigate pedagogical approach to the teaching and learning of probability, a number of interventions were proposed. Among the proposals was the concept of inclusion of introductory topics related to probability at elementary levels of education to provide a stronger foundation for further study in high school (MSEB, 1990; NCTM, 2000). It was argued that since probability was not always intuitive, it may not be developed in young children if it was not included in the curriculum early (NCTM, 2000). Earlier, Garfield and Ahlgren (1988) had observed that many middle and high school students had challenges with probability which could be attributed to inadequacies in prerequisite Mathematics skills and abstract reasoning. The researchers opined that the main cause of such were the little or no curriculum instruction in Probability given to learners at the elementary school level. It was noted that since Probability literacy took a long time to develop, it was necessary for its instruction to begin in the earliest years of schooling (Franklin & Garfield, 2006; Shaughnessey, 2006).

At the same time, researchers had proposed adoption of Computer Based Instruction (CBI) in the teaching and learning of Mathematics generally and probability in particular. This would entail integration of Computer Assisted Learning (CAL) tools such as simulation in the teaching and learning of probability in particular with the aim of enhancing learning outcome. Unlike the conventional approaches which primarily focuses on Mathematical presentation of the underlying theory, supported by theoretical and numerical exercises of the individual topics separately (Manuguerra & Petocz, 2014), CAL approaches such as computer-based simulation calls for use of concurrent and consolidated practical approach to the instruction of Probability.

II. Statement of the problem

In most nations around the world, mathematics is an important part of the school curriculum. This was owing to the subject's recognized importance in preparing students for future employment opportunities. Despite the importance of the subject, research showed that there has been low achievement of learners in Mathematics from the year 2011 to 2018 both in Kisii County and nationally (KNEC Reports, 2011 - 2018). This low performance of students in mathematics has been attributed to a recurring low performance in probability among the topics tested since 2011 to 2018. This recurring low performance of students in probability calls for a concerted effort by both mathematics educators and policy designers in adopting teaching and learning strategies that will improve specifically the performance of students in probability and mathematics in general. Probability is a crucial topic in mathematics that aims to prepare students for their future careers. To address the problem, a new strategy was devised and implemented mostly in Western countries, which pushed for the incorporation of CAL techniques like computer-based simulation (CBS) in probability teaching and learning.

Because there is a scarcity of empirical evidence on the efficacy of the existing pedagogical approach, which is focused mostly on traditional teaching methods, research comparing current approaches to best practices, such as the integration of computer-based simulation, are urgently needed. In order to contribute to closing the knowledge gap, on proposed outcome, the study sought to assess the effects of integrating computer-based simulation (CBS) in classroom instruction of probability in Kenya and its impact on learner achievement in probability in particular and Mathematics in general in public secondary schools in Kisii County, Kenya.

III. Research Methodology

Methodology is a formal plan of action for a research project. A mixed method design comprising both quantitative and qualitative research designs was used for this study. According to Creswell (2009), the problems addressed by social and health science researchers are complex and use of either quantitative or qualitative approaches by themselves is inadequate to address this complexity. (Cohen, Marrison, 2004; Greene, Caracelli & Graham, 1989; Strauss & Corbin, 1990) argue that the use of both quantitative and qualitative data and data analysis allow researchers to simultaneously make generalization about a population from the results of a sample and to gain a deeper understanding of the phenomena of interest.

The study's main objective was to assess the effects of computer-assisted learning (CAL) on secondary school students' achievement in probability and mathematics in general. The researcher employed a Solomon's four group type quasi-experimental design to accomplish this. In this study, the participants were placed into four groups, two of which were experimental and two of which were control. The first group consisted of students who were open to new experiences. It was assessed both before and after treatment, whereas the control group was assessed both before and after no treatment. The third group was also a test group. This cohort was only examined once after getting therapy. Finally, the fourth group (a different control group) was examined only once, with no treatment or pre-testing. The Solomon's four-group model can be expressed visually as follows:

Group	**Pre-test**	**Treatment**	**Post-test**
$\mathbf{E_1}$	O_1	X	O_2
$\mathbf{C_1}$	O_3		O_4
$\mathbf{E_2}$		X	O_5
$\mathbf{C_2}$			O_6

KEY: E_1: Experimental group 1, C_1: Control group 1, X: Treatment, O: Testing

This approach, according to Johnson and Onwuegbuzie (2004), provided considerable evidence for intervention while also allowing for the evaluation of both testing effects and confounding variables.

This was not possible with either the two-group pre-test-treatment post-test or the two-group treatment-post-test models. Solomon's four-group model combines the advantages of two-group pre-test-treatment-post-test and two-group treatment-post-test models while eliminating their disadvantages. Solomon's four-group model combined the two methodologies. In addition to the quantitative procedures, qualitative design was used to provide a deeper understanding and multiple realities of the phenomenon to be studied (Gosling & Edwards,1995; Strauss & Corbin,1992). Questionnaires for learners as well as interview schedule for teachers were utilized to gather multiple perspectives as they emerged (Ely, Anzul, Friedman, Garner & Steinmetz,1991).

IV. Results and Discussions

CBS and Students' Achievement in Probability

The objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability. To achieve this, a group of students in experimental and control groups were pre-tested, exposed to intervention and then post-tested. Descriptive findings illustrated that students' achievement in both pre-test and post-test were poor. This observation is consistent with previous finding that have illustrated that a majority of learners generally perform poorly in mathematics generally thus returning either below average and average achievement in the subject. For instance, Tella (2007) and Nur (2010) established learner's poor achievement in Mathematics in their respective studies. Similarly, Kiwanuka et al. (2015), Ramani and Patadai (2012), Wanyonyi (2013) as well as Yadavalli and Swarna (2014) observed low achievement of a majority of learners in their respective studies and attributed it to the abstract nature of mathematical concepts leading to academic difficulties in many areas of the subject as well as other academic disciplines.

Descriptive data obtained from the pre-test illustrated that student from the control group C_1 performed better in the examination as compared to their counterparts from experimental group E_1 thus a comparatively higher mean for the control group (M=17.58. SD=11.07 for control and M=14.63, SD=11.39 for experimental group). However, on exposure to intervention (CBS for experimental group and conventional method for control group) resulted in students in the experimental group posting achievement level greater than their counterparts from control group (M=43.59, SD=16.73 for experimental and M=24.24, SD=14.04 for control respectively). This can be interpreted to imply that CBS teaching strategy is a better teaching strategy compared to conventional methods thus the higher achievement of learners exposed to the method. This observation is consistent with findings by Ben Ouahi et al. (2021) in a study on the effect of using computer simulation on students' performance in teaching and learning Physics in which they established higher mean achievement for students exposed to computer-based simulation compared to those exposed to conventional methods. Corroborating findings are attributed to Ojo (2020) in a study designed to determine the effect of computer

simulation instructional strategy on primary school pupils' achievement in basic science in Akure township in Ondo state, Nigeria. Findings illustrated a mean difference of 7.35 in the post test results in favour of the experimental group, the mean score of pupils in the experimental group being 19.92, while that of their counterparts in the control group was 12.57. Other researchers with similar findings include Aoude (2015), Bozkurt and Ilik (2010) as well as Mihindo, Wachanga and Anditi (2017).

ANOVA results showed that the observed mean difference was significant at 0.05 level of significance, mean difference being significantly greater in favour of the experimental group implying that CBS is a better teaching strategy for probability compared to conventional teaching methods. This observation is similar to that of Dhamija (2016) who in an experimental study aimed at comparing the effect of Computer Assisted Instructional (CAI) and Lecture Method of teaching on the performance of IX class students in mathematics observed significant differences between the experimental and control groups. In particular, findings from the study showed that achievement of experimental group was significantly higher than the control group. It is also consistent with findings by Fakomogbon et al. (2014) who in a study aimed at determining the effect of computer assisted instructional package on the performance of students in Mathematics in Ilorin metropolis reported significant difference between achievement scores of students taught Mathematics with CAI package and those taught using conventional method. Other researchers with similar observations include De Witte and Rogge (2014), Oginni and Popoola (2013) as well as Panthi and Belbase (2017).

On the whole, data obtained showed that CBS is a better teaching strategy as compared to conventional methods due the better performance of students exposed to CBS when compared to those exposed to conventional method. De Witte and Rogge (2014) in a study on effectiveness of a computer-assisted math learning program concluded that Computer-assisted instruction (CAI) programs are a way to improve learning outcomes of students. Pratt and Ainley (2014), in their findings in Italian schools to help students use probability to model real world phenomena is to engage learners through a model using technology and how technology could advance learning and teaching probability through sampling, storing, organizing and analysing data generated from a probabilistic model were facilitated tremendously by technology. Specific to CBS, it had been illustrated the strategy with its animated colour graphic images is capable of presenting the dynamic nature of abstract concepts that lacks in regular teaching methods (Smetana & Bell, 2012). Lindgren and Schwartz (2009) emphasized that the visual forms of learning encourage students to develop an understanding of learnt concepts and support their memory retention which improves their achievement. Ali and Zamzuri (2007) established that simulation as an instructional strategy aided learning of concepts and facts and through visualization enables learners build their own mental model based on the observations which are then recorded in the form of schemas in their long-term memory. Teachers participating in the study by helping implement intervention were interviewed. Extent of integration of CAL tools in teaching and learning mathematics was indicated by the respondents to range from below average to average extent. An interviewee complained about prevailing poor conditions" in his school which had forced him to turn to "old ways of teaching mathematics such as lecture method. Specific challenges of implementation of CBS included "limited CAL tools" and "over enrolment of students" leading to large class sizes. Other factors include "limited physical infrastructure" and "lack of constant power supply" to use CAL tools.

V. Conclusion

The objective sought to compare the effect of CBS teaching strategy and conventional methods on students' achievement in Probability. Descriptive findings illustrated that achievement of students in the experimental group was higher than those from control group. The observed mean difference was significant in favour of experimental group. It can therefore be concluded that CBS is a better teaching strategy compared to conventional methods.

VI. Recommendations

It is suggested that further research be undertaken in the following areas:

i. A longitudinal study of the effectiveness of CAL-CBS on teaching and learning other topics in mathematics in secondary schools in Kisii County, Kenya.
ii. A comparison of primary school pupils' achievement in mathematics using CAL-CBS driven curriculum, a traditional driven curriculum and a blend of CAL-CBS and traditional approach curriculum in public and private schools in Kisii County, Kenya.
iii. Investigation of how CAL-CBS approach can be used to change the perceptions of mathematics teachers about teaching and learning probability (Mathematics).

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Monyoro Wilfred Mogire, et. al. "Computer Assisted Learning (CAL) and learner achievement in probability in mathematics in public secondary schools in KISII County, Kenya." *International Journal of Humanities and Social Science Invention (IJHSSI)*, vol. 11(04), 2022, pp 46-50. Journal DOI- 10.35629/7722