COMPUTER SIMULATION EFFECT ON LEARNER ACHIEVEMENT IN PROBABILITY IN MATHEMATICS IN SECONDARY SCHOOLS IN KISII COUNTY, KENYA

[1]Monyoro Wilfred Mogire, PhD, [2]Dr. Miheso Marguerite O'connor PhD, [3]Prof. Ondigi Samson Rosana.

Department of Educational Communication and Technology
School of Education
Kenyatta University, Kenya.

***Abstract*- From 2012 to 2018, pupils taking the Kenya Certificate of Secondary Education (KCSE) routinely performed poorly in mathematics on a national level. In KCSE Test data from 2012 to 2018, it was noted that probability was one of the mathematical concepts that the majority of pupils found challenging. A novel approach that advocates for the incorporation of computer assisted learning methods like simulation has been put out to address the issue. In this study, learner achievement in probability in mathematics was compared to computer-based simulation (CBS) effect in public secondary schools in Kisii County. The study sought to establish the effect of computer simulation on achievement of high-ability (HA) and low-ability (LA) students in Probability. 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 Simulation (CS), Probability.**

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 was identified as a topic in Mathematics that posed a challenge to the majority of students during national examinations (KNEC reports, 2011-2018) illustrated in table 1

Table 1 KCSE National probability marks & Performance report (2011-2018)

Year	2011	2012	2013	2014	2015	2016	2017	2018
SEC A	2	0	0	0	2	0	4	0
SEC B	0	10	0	10	10	0	0	10
Weakness	**No score**	**No score**	**Not set**	**No score**	**No score**	**Not set**	**No score**	**No score**
Popularity	**Unpopular**	**Unpopular**		**Unpopular**	**Unpopular**		**Unpopular**	**Unpopular**
Advise To Teachers	**Practice**	**Practice**		**Practice**	**Practice**		**Practice**	**Practice**
Mean	**declined**	**declined**	**improved**	**declined**	**declined**	**improved**	**declined**	**declined**

Source: KNEC Reports 2011 - 2018

Table 1indicates the marks awarded to the probability question in compulsory section A with a maximum score of 4 marks and sec B with a maximum score of 10 marks and how it was reported with weakness, popularity to students attempting the question, and advice to teachers on how to improve. Weakness on the part of learners indicated no score, unpopular with students, meaning it was not attempted by students and the report went ahead to advise teachers to do more practice with students to attempt probability questions in subsequent examinations. In the years 2013 and 2016 for instance, the mean for Mathematics improved, because Probability was not examined in the compulsory section, and section B posed a challenge to the learners. The overall report showed that Probability was very unpopular with students, because most students could not identify an occurrence of two independent events and lack of knowledge of the laws of probability (KCSE, 2014). Students were unable to obtain the required Probabilities without replacement and the majority never attempted Probability at all examined in both sections of A and B (KCSE, 2014).

Probability is part of the Mathematics content that students are exposed to at the secondary school level (ROK, 2002). However, Chiesi and Primi (2010) found that many students struggled with Probability, with the problem persisting even among graduate students. It is on this basis that the researcher identified the performance gap at the secondary level of learning Probability and the poor performance of Probability at the secondary level. Probability contributes significantly to students' ability to develop the skills and capacities they need to face life's problems (Chiesi & Primi, 2010). Students that have a positive attitude toward Probability perform better in school, according to several studies (Kazima, 2006; Watson, 2006). The importance of Probability in everyday life and business entrepreneurship, according to empirical study, necessitates a greater focus on it (NCTM, 2000; Shaughnessy, 2007; Watson, 2006). Yadavalli and Swarna (2014) ascribed learners' low performance in Probability to the use of traditional Mathematical procedural learning methods, which were completely unfriendly to learners' ability to create their concepts and schema. The most significant psychological obstacle to understanding Probability principles was the difficulty of using deductive reasoning to comprehend chance situations. Traditional methods of instruction, which emphasize Mathematics teachers' communication of facts, principles, laws, and theories to students who are passive recipients of the concepts (Ben-Zvi & Garfield, (2008), are said to be insufficient in providing learners with the necessary skills in the subject. Students were relegated to becoming passive consumers of knowledge for the goal of storing and occasionally maintaining thoughts, rather than being equipped with critical thinking and problem-solving skills. Such traditional Mathematical procedural learning approaches were proven to be unfavorable for learners to create their thoughts and schema because no creative learning circumstances were supplied to them (Yadavalli & Swarna, 2014). It was suggested that higher performance could only be achieved if learners developed critical and analytical skills in phenomena. Moore (1997), NCTM (2000), Shaughnessy (2007), and Watson (2006) are some of the other proponents of this school of thinking. As a result, the adoption of CBS helped to close the gap in memorization of Probability chances such as tossing a die and how many times six appear in two tosses to practical computer simulation of chance and outcomes of tosses.

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.

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 sought to determine the impact of CBS on students' ability-based achievement. The study's second hypothesis, Ho_2, intended to observe if there was a statistically significant difference in accomplishment between LA (Low Ability) and HA (High Ability) exposed to (CBS) Computer Based Simulation. 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**
E_1	O_1	X	O_2
C_1	O_3		O_4
E_2		X	O_5
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).

Results and Discussions

CBS and Students' achievement in Probability based on their ability

The study sought to determine the impact of CBS on students' ability-based achievement. The study's second hypothesis, Ho_2, intended to observe if there was a statistically significant difference in accomplishment between LA and HA exposed to CBS. Based on the results of the Pre-test Student Mathematics Test (PRESMT) given to the two groups at the start of the procedure, students were classified as low ability (LA) or high ability (HA) students in Probability achievement. Those who performed below average on the test were labeled LA, while those who performed above average were labeled HA in Probability achievement. Students were classified as LA or HA based on their performance on the PRESMT test, resulting in the group makeup shown in Table 2.

Table 2: ***Students' Ability in Mathematics***

Ability level	E1		C1		Total	
	f	%	f	%	f	%
Low ability(LA)	41	41.4	40	40.4	81	81.8
High ability(HA)	8	8.1	10	10.1	18	18.2
Total	49	49.5	50	50.5	99	100.0

According to the data, the bulk of the students (81.8%) were classified as LA. There were somewhat more E1 students (41.4%) than C1 students among these (40.4%). When it came to those classified as HA (18.2%), significantly more students (10.1%) came from C1 than from E1 (8.1%), showing that there were more LA students in E1 than C1 and more HA students in C1 than E1.
To determine homogeneity or otherwise in the makeup of the groups by students based on ability, an independent sample t-test was used. Table 4.10 summarizes the findings.

Table 3: ***Independent Sample Test Group Composition based on Ability***

Test Groups	N	Mean	Std. Dev	df	t– value	p – value
E_1	49	1.16	.373	97	0.470	.640
C_1	50	1.20	.404		0.888	.348

Insignificant differences in variances in the composition of E1 and C1 with students classified as LA and HA were found using Levene's test for equality of variance, F=0.888, p =0.348. This signifies that the data acquired conforms to the homogeneity of variance assumptions for the combination of groups in terms of student aptitude in the experimental and control groups. An equal variance analysis of test results revealed no significant mean difference between the experimental (M=1.16) and control (M=1.20) groups, t (97) =0.470, p= 0.640. This suggests that the groups had similar mean values and had learners with similar critical study characteristics.
The study's second hypothesis, Ho_2, was to observe if there was a statistically significant difference in achievement between low-ability (LA) and high-ability (HA) students exposed to CBS. The results of the Post-test Students' Mathematics Test (POSMT) were subjected to a two-way analysis of variance to examine the effects of the CBS teaching strategy on students' achievement in the subject. As seen in Table 4.11, the findings were as follows.

Table 4: ***Effect of CBS on Low and High-Ability students***

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11469.602[a]	3	3823.201	17.387	.000	.354
Intercept	82629.202	1	82629.202	375.783	.000	.798
Gp	4915.192	1	4915.192	22.353	.000	.190
Ability	2042.837	1	2042.837	9.290	.003	.089
Gp * Ability	72.962	1	72.962	.332	.566	.003
Error	20889.126	95	219.886			
Total	145582.000	99				
Corrected Total	32358.727	98				

a. R Squared = .354 (Adjusted R Squared = .334)
According to table 4.11, ability accounts for 35.4% of the overall variance in achievement. As a result, ability accounts for around a third of the entire variation in achievement. Ability and groups are important, according to the research. The interaction effect,

however, is not significant (F (1,99) =0.332, p =.566, p2 =0.003). F (1,99) =9.29, p =.003, p2 =0.089, F (1,99) =9.29, p =.003, p2 =0.089, F (1,99) =9.29, p =.003, p2 =0.089, F (1,99) =9.29, p = F (1,99) =22.35, p.001, p2 =0.190, F (1,99) =22.35, p.001, F (1,99) =22.35, p.001, F (1,99) =22.35, p.001, F (1,99) =22.35, p.001, F (1,99) =22

It was also discovered that HA students' achievement levels (M=43.56, SE=3.52) were significantly different from LA students' achievement levels (M=31.73, SE=1.65) and that students in the experimental group E1's achievement levels (M=46.83, SE=2.87) were significantly different from students in the control group C1's (M=28.46, SE=2.62). The effect was substantially bigger for LA in the experimental group E1 (M=42.02, SE=2.32) than in the control group (M=21.43, SE=2.33), according to a pairwise comparison. F (1,99) =9.29, p =.003, p2 =0.089, and test groups, F (1,99) =22.35, p.001, p2 =0.19. Univariate test results were likewise significant for ability, F (1,99) =22.35, p.001, p2 =0.19. This might be construed to mean that using CBS in Probability teaching has a greater influence on low-ability students than on high-ability students. As a result, hypothesis $H0_2$, which indicated that when teaching Probability using CBS there is no significant difference in accomplishment between low and high-ability students, was rejected.

In summary, descriptive data explained the similarity of distribution of students with LA and HA across control and experimental groups of the study important for consideration. Findings from ANOVA showed a significant effect of CBS on the ability of students, with 35.4% of the total variance being attributed to the effect of teaching strategy consistent with (Scardamalia, & Bereiter, 1994) who found out that students' cognitive abilities predicted their academic achievement, particularly in disciplines like Mathematics. Similarly, Bartels, Rietveld, Van Vaal, & Boomsma, (2002) found relationships between cognitive test scores and educational outcomes ranging from 0.40 to 0.63 in IQ scores and school performance grades in an analysis of eight samples from six longitudinal studies. Specifically for Mathematics, Taub, Floyd, Keith, and McGrew (2008) found a statistically significant direct link between students' general cognitive aptitude and their Mathematics achievement.

Results specifically indicated the greater effect of CBS for LA as compared to HA students as was seen from the mean posted by this category of learners. This implies that the use of CBS in teaching and learning Probability significantly improves the achievement of LA students compared to HA students. These finding partly agree with that of Garfield and Delmas (1989) who found out that when CBS is employed to toss a coin with mixed results, some students change their minds on variability for better performance after utilizing the CBS software and others stick to their old attitudes.

The significant effect of CBS on achievement levels of both HA and LA students is demonstrated by the significantly higher achievement levels in the experimental groups compared to those from the control groups, with each learner in the experimental groups posting significantly higher mean scores than their counterparts in the control groups. This result is congruent with those of Wanjala (2005) and Liao (2007), who discovered that students performed better when they learnt in cooperative groups with CBS than when they learned independently without using CBS. This aids in bridging the gap between traditional approaches and the more sophisticated CBS visualization methods employed by scientists.

In general, the study found that the CBS teaching style is a more effective way to teach probability because it improves education for low-ability students by giving them more hands-on experiences that engage their thinking, increasing their retention and raising their performance levels. This finding supports that made by Feyzioglu (2009), who discovered that computer-based instructional methods that encourage active student participation in the learning process frequently result in greater academic achievement than those that do not.

V. CONCLUSION

In general, the study found that the CBS teaching style is a more effective way to teach probability because it improves education for low-ability students by giving them more hands-on experiences that engage their thinking, increasing their retention and raising their performance levels. This finding supports that made by Feyzioglu (2009), who discovered that computer-based instructional methods that encourage active student participation in the learning process frequently result in greater academic achievement than those that do not.

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).

REFERENCES:

1. Ahlgren, A., Garfield, J. (1991). Analysis of the probability curriculum. In Chance encounters: Probability in education, Dordrecht, The Netherlands: Springer. *Computer Assisted Learning (CAL) and learner achievement in probability in mathematics in* .DOI: 10.35629/7722-1104024650 www.ijhssi.org 50 | Page

2. Ajewole, G. A., Oginni, A. M., & Okedeyi, A. S. (2006). Management of resources for science,technology and mathematics education: Problems and way forward. In *Science Teachers Association of Nigeria Annual Conference Proceedings* (p. 67). Science Teachers Association of Nigeria.
3. Akala, J. (2000). The agony of teaching mathematics. *Kenya Times*, *16*(1).
4. Alessi, S. M., & Trollip, S. R. (2001). Simulations. *Multimedia for Learning (Methods and Development)*, 213-269.
5. Ali, M., & Zamzuri, A. (2007). Kesan koswer strategi animasi pelbagai kawalan penggunaan terhadap prestasi kognitif dan ketekalan pelajar. Tesis ijazah Doktor Falsafah, Universiti Sains Malaysia, Pulau Pinang.
6. Allport, G. W. (1935). *Handbook of Social Psychology*. Worcester, MA: Clark University Press.
7. Ash, J. E. (2005). *The effects of computer-assisted instruction on middle school mathematics achievement* (Unpublished doctoral dissertation).Tennessee State University.Nashville, TN.
8. Aunola, K. E., Leskinen, E., Lerkkanen, M.-K., & Nurmi, J.-E. (2008). Developmental dynamics of math performance from preschool to grade 2. Journal of Educational Psychology, 84,261–271.
9. Ayalon H., Livnah I. (2013). Educational Standardization and Gender Diff erences in Mathematics Achievement: A Comparative Study. „Social Science" 42, s. 432–445
10. Bachar S. (2012). Gender and Gender Equality in Education, To Study Scientifi c and Technological Subjects in Gender Segregation.
11. Benson, C. T., & Jones, G. A. (1999). Assessing students' thinking in modelling probability contexts. *The Mathematics Educator*, *4*(2), 1-21.
12. Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics Education Research Journal*, *9*(1), 6-26.
13. Cohen, S. (2003). *Report on the Use of ICTs in Schools Research Project*. Johannesburg: South African Institute for Distance Education (SAIDE).
14. De Witte, K., & Rogge, N. (2014). Does ICT matter for effectiveness and efficiency in mathematics education? *Computers & Education*, *75*, 173-
15. Fakomogbon, M. A., Omiola, M. A., Awoyemi, S. O., & Mohammed, R. E. (2014). Effect of computer assisted instructional package on the performance of students in mathematics in Ilorin metropolis. *European Scientific Journal, ESJ*, *10*(25), 196-206.
16. Kiwanuka, H. N., Van Damme, J., Anumendem, D. N., Van Den Noortgate, W., & Namusisi, S. (2015). Factors affecting Mathematics achievement of first-year secondary school students in Central Uganda. *South African Journal of Education*, *35*(3), 1-16.
17. KNEC Reports (2012). Kenya national examinations council.
18. Lindgren, R., & Schwartz, D. L. (2009). Spatial learning and computer simulations in science. *International Journal of Science Education*, *31*(3),
19. Manuguerra, M., & Petocz, P. (2014). Learning and teaching probability in the 21st Century. *Macquarie University, NSW Australia. ICOTS9*.
20. Miheso, M. (2002). Factors Affecting Mathematics Performance Among Secondary Schools Learners, In Nairobi Province, Kenya. *Unpublished). M. Ed. Thesis. Kenyatta University, Nairobi*.
21. Mihindo, W. J., Wachanga, S. W., & Anditi, Z. O. (2017). Effects of Computer-Based Simulations Teaching Approach on Students' Achievement in the Learning of Chemistry among Secondary School Students in Nakuru Sub County, Kenya. *Journal of Education and Practice*, *8*(5), 65-75.
22. National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston, VA: Author
23. Nur, M. A. (2010). Factors that Influence Secondary School Students Performance in Mathematics in Banadir Region, Somalia. Unpublished Master 's thesis, Kenyatta University, Nairobi, Kenya.
24. Ogembo, J. O. (2012). Determinants of Students' Poor Performance in Chemistry in Public Schools of Kwale County, Kenya. Unpublished MED thesis in the School of Education of Kenyatta University, Nairobi.
25. Oginni, O. I., & Popoola, A. A. (2013). Effects of Mathematics Innovation and Technology on Students Academic Performance in Open and Distance Learning (ODL). oasis.col.org
26. Shaughnessy, J. M. (2007). Research on statistics learning and reasoning. *Second handbook of research on mathematics teaching and learning*, *2*, 957-1010.
27. Tella, A. (2007). The Impact of Motivation on Student's Academic Achievement and Learning Outcomes in Mathematics among Secondary School Students in Nigeria. *Eurasia Journal of Mathematics, Science & Technology Education*, *3*(2), 149-156.
28. Umoinyang, I. E. (1999). Student Socio-Psychological Factors as determinants of achievement in senior secondary mathematics. Unpublished Ph. D. Thesis, University of Ibadan, Ibadan.
29. Wanyonyi, P. W. (2013). *An Assessment of Factors Affecting Students' Performance in Mathematics at KCSE Level in Secondary Schools in Kakamega County, Kenya* (Doctoral dissertation).
30. Yadavalli, R., & Manda, M. S. L. (2014). The Effect of Gender, Medium of instruction, Parent's Educational and Socio-Economic background on Children's Conceptions and Abilities in Graphical Representation and Interpretation of Geometrical Concepts.