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Computer Based Instruction: A Springboard to Students Performance in Mathematics

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Abstract:
Mathematics is regarded by most people as an essential subject in the curriculum. Its usefulness range from social, aesthetic, utility and communication. Mathematics plays a pivotal role in providing means of studying other disciplines and is designed to enable the learners to acquire attitudes and knowledge that will be relevant to their life after school. Great emphasis is thus placed on the application to real life situations and practical approaches to the teaching and learning of the subject. However, the formidable problem currently facing mathematics education in Kenya is the need to improve the student's performance in mathematics. The literature is replete with studies indicating that Computer Based Instructional programs enhance students learning outcomes. With the introduction of e-learning in Kenyan schools, there is need to develop and explore the effects of computer-based programs in the area of mathematics for instructional purposes. This paper examines a Computer Based Instructional program that can be used to enhance students learning of mathematical probability concepts in secondary schools in Kenya.

Keywords: *Computer Based Instruction, achievement, attitude, motivation and perception*

1. Introduction

The pace of technological development in educational setting is on the increase in Kenya. The literature is replete with studies indicating that Computer Based Instructional (CBI) programs enhance students learning outcomes (Kiboss, 1997; Makau, 1999: Tanui, 2003; Wanjala, 2005; Wati, 2011; Wekesa, 2003; Wasike, 2013; Wekulo, 2014). With the introduction of e-learning in Kenyan primary schools, there is need to develop and explore the effects of computer-based programs in the area of mathematics where little or no studies have been done.

Literature suggest that one problem facing the instruction process in Kenya is the need to improve students' learning outcomes in a subject that impacts poorly on students learning especially in science-based subjects (Kenya National Examinations Council (KNEC), 2006; 2008). It is not immediately clear if poor performance in mathematics is related to lack of teaching resources, poor teaching strategies, and the abstractness of the mathematical concepts or other such related factors. However, systematic studies have been undertaken to examine whether CBI can have any significant impact on learners' performance in secondary school learning in Kenya. In this regard, computer based interventions have shown great potential for those areas of science and mathematics that are difficult to teach by traditional methods or where students interest is lacking (Allessi and Trollip, 1991; Kiboss, 1997; Makau, 1999; Ndirangu, 2000; Tanui, 2003; Wanjala, 2005; Wati, 2011; Wekesa, 2003; Wasike, 2013; Wekulo, 2014). As such, there is need to investigate the effectiveness of a computer-based instruction in improving secondary schools students learning outcomes in mathematics.

The Computer-Based Instruction (CBI) is an area that has been recently lauded for its capability to foster the teaching of concepts and skills that are otherwise difficult to teach using the regular techniques (Kiboss, 2002; Tanui, 2003; Wanjala, 2005; Wati, 2011; Wekesa, 2003; Wasike, 2013; Wekulo, 2014). The use of CBI is perceived to enhance students understanding of mathematical concepts. The computer can be a good instrument in fostering interpersonal relationships as well as creativity in students and in assisting teachers to effectively teach in a more successful manner. Computers can play a vital role in making the subject matter real, dynamic, and engaging for students. They can offer students a collaborative environment and the opportunity to explore and try out alternatives in problem solving. This study was therefore designed to explore the instructional potential of the CBI in mathematics instructional process.

1.1. Significance of CBI

Several aspects make the CBI significant and distinct. The results of CBI would add value to both theory and practice of the mathematics instructional process. In terms of its theoretical value, the findings would make systematic attempts to explore the effect of the CBI in terms of students understanding, their perception of the learning environment and their attitudinal and motivational aspects. More specifically, the findings would shed more light on the new pedagogy characterized by concepts such as scaffolding and affordances that epitomize opportunities given by computers in education (Wasike, 2013; Wekulo, 2014). To this end, the CBI program was used to scaffold learning to meet the demands of students who were able to manipulate the tasks and materials in an effort to analyze and internalize the knowledge of probability.

The CBI program provides flexibility in terms of performing tasks in probability and encouraging internalization of the knowledge in a systematic and active manner. This would help explain the affordances provided by the program. Moreover, the findings would indicate the role of the teacher in the computer based instruction in classroom discourse when teaching concepts with high cognitive demands. This would validate the current trends and innovations in the area of computers and education as epitomized by e-learning and use of multimedia digital devices such as SMART boards. Additionally, the findings would form the basis of the dynamic and creative intellectual learning tasks that promote the learners' intelligence and skills that would be modeled and the optimal instructional strategies that lead to such outcomes.

The findings of this study would also contribute to practice in terms of the extent to which learners benefit from the researched instructional techniques. Such techniques are expected to promote creativity and self-pacing in the learning of mathematical concepts with high cognitive demand. Moreover, the results would be beneficial to the entire educational system for the purpose of improving performance in the teaching and learning of mathematics in Kenyan secondary schools. These contributions are based on the observation that the instructional program accompanying the computers received through donations are commercially produced and are usually not suited to the existing curriculum because they were designed for different environments from those commonly found in the third world.

The instructional program for this study was specifically tailored to enable the teacher to use the CBI to augment conventional teaching. For instance, the content of the CBI program developed was based on the current approved Kenya Institute of Curriculum Development secondary school mathematics syllabus (Kenya Institute of Education (KIE), 2002; KNEC, 2000). It was developed and empirically tested using comparable learners before it was used in actual classroom and specially tailored to suit the existing syllabi. Unlike the commercially produced CBI programs, the CBI program developed for this study is domain-specific to the groups to be investigated. Therefore, the CBI program is suited to the existing mathematics curriculum as recommended by several authors' (Allesssi and Trollip, 1991; Ragsdale, 1991; Wekesa, 2003; Wasike, 2013; Wekulo, 2014). This study is therefore envisaged to contribute towards greater realization of the need to resolve the perennial problems inherent in mathematics instructional process as reflected by the poor performance in the subject.

1.2. Theoretical Basis of CBI

The use of technology in instructional context takes into consideration different learning philosophies and paradigms that hierarchically reinforce each other. For example the behaviouristic paradigm emphasizes the principle of associative and conceptual learning. This paradigm assumes that learning requires only association by contiguity and that most associations are mediated by perceptual and/or verbal responses (Schar and Krueger, 2001). But learning is a dynamic and more complex process than mere associations with external stimuli.

The cognitive paradigm is also another theory that seems to influence the use of technology in instruction today. It addresses the mental structures and process for explaining the network of verbal and visual representations (Dabbagh, 1999). The human cognition is specialized to deal with the linguistic input and output. At the same time it serves the symbolic function with reference to non-verbal objects, events and behaviours (Park and Hopkins, 1993). The non-verbal system deals with specific languages for shapes, environmental sounds, actions, skeletal or visceral sensations that are related to emotion and other non-linguistic objects and events (Kiboss, 1997; Wekesa, 2003; Wasike, 2013; Wekulo, 2014). However, in the last two decades it has been found that the mental structures are not a product of mere acculation of verbal and visual presentations in the brain. Instead these are proactive constructions by the learners, hence the constructivist theory of learning.

Currently, the constructivist philosophy seems to influence the design and application of instructional media than any other (Herrington and Standen, 1999). Unlike the objectivistic philosophy where information content should be presented as structured and/or unquestionable truth, the constructivist view incorporates dynamic media that enables user initiated integration and individually structured information flow (Schar and Krueger, 2001).The CBI program used in this study is a product of constructivist thinking based on dual-coding theory. The dual-coding theory of the cognitive paradigm postulates that information in memory is represented by images and verbal codes. Park and Hokins (1993) argue that there is a referential connection that links verbal and non-verbal cue into a complete associative network to potentially allow such operations as imaging to words. The connection has a complementary function that serves to activate one another in a different or the same subsystem. Therefore, something is more likely to be remembered if coded both verbally and visually because representatives of one form reinforce the other (Wekesa, 2003; Wasike, 2013; Wekulo, 2014). This was conceptualized as a model shown in Figure 1.

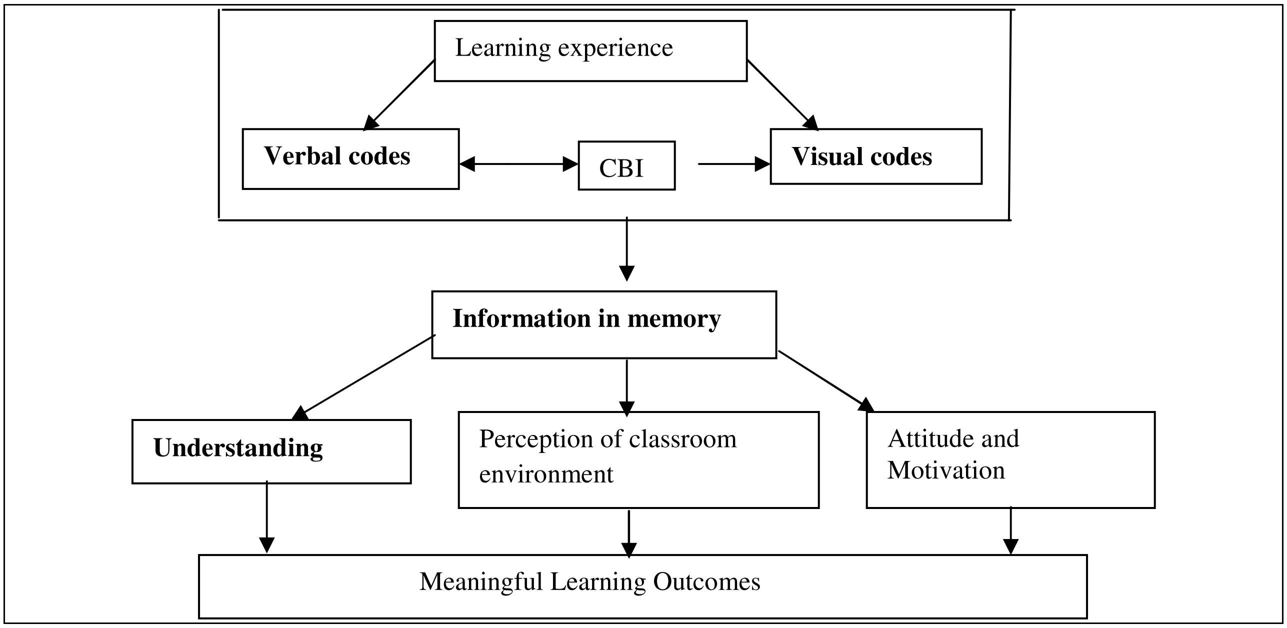

Figure 1

In this model, the interactive attributes of the CBI combine simple language to explain concept (verbal codes) with graphical illustrations and animation (visual codes) to give the learner not only a wider range of learning activities and tasks within the concept of probability but also provide the option to interact more overtly with the instructional material and hence engender more active processing of information and creation of meaning (Gavora and Hannafin, 1995; Kiboss, 1997;Wekesa,2003; Wasike, 2013; Wekulo, 2014).

The design of the CBI learning environment was based on two major assumptions that persist in achieving the above goals not available in the regular instructional technique. Firstly the CBI brings out the dynamic nature of the process of learning probability that is otherwise not available. Secondly, improvement in cognition occurs when students experience and interact with the learning materials unlike in regular instruction where students are passive. In this regard, this model has major implication for the study because the CBI illustrations are capable of improving the students' acquisition of the concept of probability and prolong retention time of the otherwise abstract information as the illustrations complement the verbal codes in the memory subsystems.This framework is suitable because it would help depict the interaction of dependent, independent, intervening and control variables.

1.3. The Design of the CBI Software

In order to unravel the relative effects of the CBI, two methods of teaching were employed in the study namely; the CBI augmented instruction and the regular teacher instruction. The design of the CBI was adapted from Wanjala (2005) and modified as per the current KIE (2002) approved mathematics syllabus, the teachers' guide, students' textbook and other relevant materials for secondary school mathematics. This utilized the Visual Basic authoring language that is capable of creating, presenting and managing computer-based learning courseware (Park and Hopkins, 1993). It allows the use of automatic completion list that guide the user when writing the code. Its interactive language called the Compiler can easily locate semantic and syntax errors and correct them. This makes it easy to compile, execute, package, and deploy the CBI program (see appendix A for the main menu layout).

The lessons contained in the CBI program employed dynamic visual displays (DVD) of verbal and nonverbal information which were relayed by the computer. A DVD is the presentation of any type of pictorial and graphical movement during instruction (Park and Hopkins, 1993).The essence of this DVD verbal and nonverbal information was to facilitate the learners encoding and decoding (retrieval) of information during the instructional process (Wekesa, 2003; Wasike, 2013; Wekulo, 2014). The materials in the program were organized in a format that renders the learning of complex factual information on probability easier and interesting. This exploited computer attributes, making the program distinguishable from the ordinary textbook. The materials were presented in form of short notes, examples and exercise that allow key concepts to be learnt as a coherent whole rather than in isolation from one another.

1.4. Validation of the CBI Program

The CBI program used in this study underwent several reviews during its adaptation. This involved two computer education experts and four high school teachers knowledgeable in mathematics education who assessed the content validity in terms of the general design format, sequencing, language level and grammar, subject content and pedagogical issues. The comments and/or suggestions from the experts were incorporated into the revised CBI program before the pilot test stage using Allessi's and Trollip's (1991) seven-step CBI evaluation model. This model was used because it is more convenient and easy to use as it follows ordered steps as outlined below.

The first step entailed the involvement of six student-helpers from all ability of levels (i.e. those with high, middle and low ability levels). Such a combination was deemed necessary because it could provide a spread of capabilities necessary to informally test the suitability of the CBI program to the needs of the population. In the second step, the student-helpers were oriented to the CBI system. This was done in order to familiarize them with the basic operation skills necessary for them to follow the CBI program. After the brief operation training, the student-helpers were pre-tested in order to determine their knowledge and attitudes prior to the treatment. At the fourth step, the students were exposed to the treatment. In addition, their feelings, difficulties and/or experiences as they interacted with the CBI lesson material were closely monitored. Step five involved an informal interview of the students to get their views regarding the course content and CBI. In the sixth step, the students were post-tested on the exposure to the CBI program. Finally, the problems and/or errors that were detected were used in further revision before the CBI program was actually implemented in a real classroom setting for the study.

2. Methodology

A quasi-experimental approach adapted from the Solomon Four-group experimental design was employed for this study. This design is considered appropriate for quasi-experimental studies because it provides the most effective and efficient tools available for determining cause and effect relationship (Ary et al, 1972; Borg, 1987; Koul, 1992; Ogunninyi, 1992). Besides, the design is robust in eliminating variations that might arise due to difference of experiences and that may contaminate the internal validity of the study. The design involves a random assignment of intact classes of subjects to four groups with two groups being experimental i.e. the Experimental Group One (E_1), the Experimental Group Two (E_2), and the other two as controls i.e. the Control Group One (C_1) and the Control Group Two (C_2). Groups E_1 and C_1 received a pre-test to ascertain whether the two groups differed significantly before exposure while E_1 and E_2 got treatment that is an exposure to the probability content by the CBI mode (see appendix A). Groups C_1 and C_2 were taught by the conventional method. All groups received a post-test on all the dependent measures for comparisons between the groups.

However, to avoid interaction of subjects from different groups that may contaminate the results of the study, one class from a school for two schools were taken to constitute one group of subjects, hence eight schools were required for this study. It is noteworthy that there was random assignment of selected classes to both groups because schools chosen for the study could not allow intact classes to be split. This is because established ambiance of the existing class streams are seldom considered whereby school authorities do not permit random selection of individual students to be broken up and re-constituted for research purpose once they have been assigned to a class stream.

3. Results

Prior to the commencement of lessons in probability, data were collected from groups E_1 and C_1 using four testing instruments namely the Students' Perception Questionnaire (SPQ), the Mathematics Achievement Test (MAT), the Students' Motivation Questionnaire (SMQ) and the Students' Attitude Questionnaire (SAQ) to ascertain whether the students had similar and comparable entry characteristics. The pre-test results obtained are presented in Table 1.

TEST	Group E_1 (N = 76)		Group C_1 (N = 78)	
	Mean	S.D	Mean	S.D
MAT	22.91a	10.89	22.42a	10.47
SAQ	54.82b	12.68	54.24b	12.63
SPQ	52.46c	11.98	52.50c	10.42
SMQ	59.25d	12.12	60.01d	12.99

Table 1: Comparison of Pre-test Mean Scores on the MAT, SAQ, SMQ and SPQ.
a,b,c,d respectively is identical

The results shown in Table 1 indicate that the mean scores of groups E_1 and C_1 on all the four measures seem not any between the groups. It is however important to establish whether the results are statistically different. As such a further analysis of these results was performed at $\alpha = 0.05$ level using a one-way Analysis of Variance (ANOVA) and results are presented in Table 2.

TEST	F-ratio	P-value
MAT	0.183	3.07(ns)
SAQ	0.825	3.07(ns)
SPQ	0.529	3.07(ns)
SMQ	0.964	3.07(ns)

Table 2: One Way ANOVA of the Pre-test Scores on the MAT, SAQ, SMQ and SPQ.
ns- not significant at $p< 0.05$ level

An examination of the results in Table 2 indicates that the mean scores for both groups E_I and C_I on all the dependent measures are not significantly different. In all cases, the F ratios are less than one and the tabulated values are greater than unity. This is an indication that the groups in question are comparable. This implies that the groups had similar entry behavior before commencement of lessons in probability. Hence the groups used in the study were homogenous and suitable for the study.

However, to determine the relative effects of the CBI in enhancing students' performance, post-tests were done on all measures and the analysis by one way ANOVA performed whose results are as in Table 3.

TEST	F-ratio	P-value
MAT	54.84	0.57
SAQ	4.05	0.52
SPQ	88.11	0.57
SMQ	5.18	0.43

Table 3: One Way ANOVA of the Post-test Scores on the MAT, SAQ, SMQ and SPQ.
ns- not significant at $p< 0.05$ level

Results in Table 3 shows the posttest scores on the MAT,SAQ, SMQ and SPQ. An examination of the F-ratios indicates a statistically significant difference on all the dependent measures because the respective F-values exceed the critical value needed to reject the hypotheses in question. This is a clear indication that the posttest scores obtained by the CBI treatment groups and control groups are statistically different. It is revealed that the control groups taught by regular methods had lower mean scores and hence were out performed by the two treatment groups.

In this regard, it is established that students exposed to computer based instruction program improved the understanding of probability and acquired related performance competencies and skills. This can be inferred from the higher mean gains obtained on all the dependent measures by students exposed to the CBI as compared to those not exposed. The students also made fewer errors in their conception and computation regarding probability concepts. In addition, the CBI program created a positive environment for the learning of probability concepts. The higher mean scores in the students' perception score in favour of the treatment groups confirm that the CBI had a positive effect on students' perception of their leaning environment. This explains why students in the treatment groups had significant learning gains unlike those in the control groups. .

Moreover, the results show that the CBI lessons provided appropriate opportunities for interpersonal communication and relationship. Both the qualitative and quantitative results ascribe to the effect of the CBI on classroom interaction patterns during mathematics instruction. The CBI software developed for teaching and learning the topic on probability in mathematics was found to be readable, understandable, clear and simple in presenting probability concepts and skills on the part of the students. Teachers on the other hand found it to have clear and elaborate lesson notes that were simplified for students to understand even on their own. This implies that the program succeeded in enhancing the instructional process of probability concepts and skills and self pacing in the learning process. Indeed, the conducive learning environment seen in the CBI augmented classroom facilitated mutual interactions during the lessons in probability. Overall, the results reveals that the CBI program enhanced the development of cognitive, affective and psychomotor dimensions.

An important area that is not reflected by the findings of this study is the use of language in classroom discourse. This oversight has occurred probably because in Kenyan schools, English is the accepted medium of instruction. As such, teachers and students alike must communicate in English during the instructional process. Seldom do they communicate to each other in their home language or "Kiswahili" (another national language) in classroom discourse. This somehow creates a dilemma for both the teacher and his/her students. Studies show that language is important for the sole use of second or even third language may interfere with mathematics learning and learning in classroom discourse using a shared language may facilitate the participants understanding of mathematics and science (Wasike, 2003; Kiboss, 1997).

4. Conclusion

The design and use of CBI program has demonstrated a great potential to promote the development of cognitive, affective and psychomotor skills among secondary school students during the learning of probability. Overall and on the basis of these findings it is clear that the use of digital multimedia such as the CBI enhanced the learning of high cognitive demand mathematical concepts such as probability and associated development of cognitive, psychomotor and affective skills among secondary school students. It is thus imperative that since students like all other human beings, have a limit to which they can grasp, perceive, conceptualize, and apply what is orally or visually presented to them, the learning of mathematical concepts should be presented to them with texts that are programmed via the computer system.

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APPENDIX A

Main Menu of Probabibility Instructional Software

An item is selected by pointing with the mouse pointer, then clicking the mouse button.