Educational Research and Reviews Vol. 7(9), pp. 207-214, 5 March, 2012
Available online at http://www.academicjournals.org/ERR
DOI: 10.5897/ERR11.296
ISSN 1990-3839 ©2012 Academic Journals

Full Length Research Paper

Secondary school students' attitudes towards Mathematics computer – assisted instruction environment in Kenya

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Accepted 9 March, 2012

This paper reports the results of research conducted in six classes (Form IV) with 205 students with a sample of 94 respondents. Data represent students' statements that describe (a) the role of Mathematics teachers in a computer-assisted instruction (CAI) environment and (b) effectiveness of CAI in Mathematics instruction. The results indicated that: majority of students incline towards constructivist Mathematics teaching-learning beliefs in a CAI environment; and CAI would encourage positive attitude towards Mathematics and instruction while negative attitudes are attributed to the design and development of CAI software among others. Prior student computer experience and skills are determinants for effectiveness of CAI in Mathematics instruction. The recommendations are that CAI catalyses a constructivist environment in Mathematics, and design and development impacts on its success in Mathematics instruction.

Key words: Attitudes, computer, computer-assisted instruction, Mathematics, secondary school.

INTRODUCTION

Governments and nongovernmental organizations (NGOs) particularly in developing countries in Africa emphasize gradual introduction of computers into the pedagogy of school curriculum. These efforts are based on the successes in the developed countries and international efforts (for example, [United Nations Educational, Sciencetific and Cultural Organization (UNESCO), World Summit on The Information Society (WSIS) and New Partnership for Africa Development (NEPAD)]. In spite of technological and educational development variations in different countries, the computer is becoming inevitable in the society and the school in particular in the twenty – first century. Therefore, systematic approaches (such as experiments and pilot studies) should be employed in order to promote integration of the computer into instruction and the curriculum in general.

However, the use of educational technologies to enrich a classroom environment depends largely on the unique attributes a particular technology affords. Salomon (1991) contended that unique attributes of technologies ought to be integrated into some more general multidimensional map. This map entails at least four dimensions for aligning various technologies pointing out their unique attributes: (a) 'Information' (particular content that a technology can present to or elicit from the learner), (b) 'Symbolic modality' (or symbol system of information presentation, for example, word, picture, number, space and tone), (c) 'Activities' a technology requires or affords (for example, viewing, reading, measuring, testing, hypothesizing and reconstructing) and (d) *Relations* possible between the student user and the technology (for example, one-sided or interactive). The computers are part of a wider category of instructional technologies - they provide for interactivity with visual and textual information presented.

The computer affords visual illustrations that have significant role in the learning process due to their ability to enrich the learning environment by arousing interest, stimulating imagination, raising questions, discussions, and a desire to find out more or solve some problems (Kariingithi, 1998). Visual media have the ability to

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demonstrate the physical aspects of lesson objectives as well as translating non-visual concepts in the lesson. If computers are to accomplish unique instructional function let alone to cultivate abilities, they must become fully integrated into the school curriculum (Salomon, 1991). This objective is achievable only if locally developed instructional software that suit local (for example, Kenyan) school curriculum is available with students' ability to appreciate and make use of the computer in the instructional process.

Behavioural approaches in Mathematics education have remained in practice without major innovations in Kenya specifically concerning the pedagogical paradigm. It is typical in a classroom set-up that variety of teaching methods and activities in the teaching-learning of mathematics is inadequate. In fact, chalk-and-talk is the dominant mode of instruction. Computers have the ability to provide the variety required in an enriched learning environment. For the situation to change it calls for a gradual transformation in the perceptions of the teacher's role from an authoritative source of information (behavioural) to a guide or facilitator of learner's self-propelled exploration (constructivist) .

Winer and Mothe (1978) corroborated this position that computers in the classroom environment will change the whole pedagogical experiences considerably. The contribution of the computer to learning arises from its ability to offer participatory learning, individual and self – pace, inquiry and discovery, interaction, problem solving, immediate feedback and inculcating positive attitude towards the school subject.

CAI, as the name suggests, is the use of a computer to provide instruction. The format can be from a simple program to a complex system that uses the latest technology. CAI draws on knowledge from the fields of learning cognition, human computer interaction (HCI) amongst others. The computer or CAI programs were taken to be electronic teachers or tutors and they are capable of providing individualized learning and "keeping accurate account of the learner's interests, aptitudes, knowledge and skills" (Kiboss, 1997), suggesting a pedagogical rationale for introduction of computers into school curriculum.

Consequently, Hawkridge et al. (1990) identified four rationales behind the introduction of computers into education. The 'social' rationale that students should be aware and unafraid of is how computers work; the 'vocational' rationale that many students should be able to operate a computer at least at a basic level; the 'catalytic' rationale that schools can be changed for the better by the introduction of computers; and the 'pedagogical' rationale that students should be able to use computers in learning subjects (for example, physics, art, mathematics etc). These rationales are bases for a deliberate effort to introduce computers in schools but the use of computers in education in the developing countries has lagged behind.

Pelgrum and Plomp (1993) noted the decision to introduce computers in schools for teaching about computers and their many applications. At this point in time, success of computers in various sectors of the global economy is evident, thus, the concern of the decision makers in education systems should be on adopting and adapting programs that enhance successful integration. The present century demands educational technologies that can support problem-solving, discovery, critical thinking, and collaboration (CISCO, 2008). Being a means to facilitate classroom teaching and learning computers have not accorded equal attention in all schools and across all educational systems.

In identifying the roles of information and communication technology (ICT) in education, it is helpful to distinguish three ways students can relate to a computer. The first is "learning about" the computer- the focus of early days of CAI. Secondly, "learning from" computers- the role of computers to assist instruction. Finally "learning with" computers- using ICT as tools to facilitate an enhance communication among students, between students and sometimes with some unknown public (Newman, 2006). Various ways of using computers in the process of education, based on a different pedagogical theory, have been proposed and implemented over time (for example, PLATO and LOGO).

A review of studies, mostly quantitative in nature, on the effects of computers on attitudes; concluded that (a) computer use most affects attitude towards school and subject matter and (b) computer use appears to have a positive impact on improving student's self-image and self-confidence (Khatoon and Mahmood, 2011 in Ward, 2002) and learning process (Kiboss, 1997). Students exposed to computer instructional programs develop positive attitudes towards mathematics (Mwei, 2011; Wanjala, 2005).

There have been mixed gender effects on attitudes towards computers in Mathematics. (a) Both male and female students show no difference (Adebowale et al., 2008; Bovee et al., 2007). (b) Gender differences (Barkatsas et al., 2009; Fančovičová and Prokop, 2008), in some cases, female students held more positive attitudes than males (Khatoon and Mahmood, 2011; Adebowale et al., 2010).

The present paper reports both quantitative and qualitative descriptions using students' own words on attitudes toward computer adoption in secondary school Mathematics instruction.

Theoretical framework

A CAI environment is capable of supporting a wide range of different ways that allow the students to learn. Cognitive psychologists and constructivists view the learner as "active" and continuously involved in cognition about self and environment. Therefore, to design and conduct this study, Gagne's information processing (IP) model was adopted. The information processing model gives us a blueprint of how the mind; senses, processes, stores and recalls information (Saavedra, 1999). Gagne details important events generalizable in instruction and learning of facts. Saavedra suggests that learning tasks for intellectual skills can be organized in a hierarchy according to complexity: Stimulus recognition, response generation, procedure following, use of terminology, discriminations, concept formation, rule application, and problem solving (http://tip.psychology.org/gagne.html). This knowledge is important to design instruction with particular concern to content, sequence and structure. In the process of students abstracting from the environment, attitudes about knowledge (content), methods of instruction, classroom organization and management, and the instructional "object" (for example, teacher or computer) are formed.

MATERIALS AND METHODS

Research objectives

The questions emanating from the review of literature led to the following objectives:

1. To examine the roles of a Mathematics teacher in a Computer-Assisted Instruction environment.
2. To study the students' attitudes towards CAI Mathematics lessons.

Sampling and sampling techniques

Six schools randomly selected from a total of seventeen schools in Uasin Gishu County (Kenya) offering computer studies to Kenya Certificate of Secondary Examination (KCSE, as an examinable subject) level made up the sample. The assumption for this population is the long history of students being exposed to computers at one point in time because basic computer skills were necessity. The six selected classes had 205 students and only 94 selected responded to the interview questions (48 Experimental and 46 Control groups). Three classes each (1 Boys', 1 Girls' and 1 Mixed) for each group Experimental (treatment) and Control. This was done to account for the effect of gender and school type as possible moderators.

Instrumentation

The qualitative nature of the research methodology was undertaken with the help of a student interview guide (individual interviews – consisting of four items) to unravel meanings that the students attach to their classroom experiences with the instructional methods – CAI module and conventional/traditional methods.

RESULTS AND DISCUSSION

Randomly selected participants (Control, 46% and Experimental, 45.7% with an equal number of male and female) interviewed provided views about how the CAI module fit in with their learning and instructional needs. The interviews were conducted after the Mathematics lessons. Generally, the interview period lasted approximately 20 min for experimental groups while it lasted about 10 min for the Control groups after a lesson.

To eliminate researcher biases, the information from the interviews was reviewed and copies given back to the students concerned to confirm the data. This was done in order to increase the researcher's confidence in the reliability and validity of the results (Neuman, 1989). SPSS software was used to analyze data.

Research Objective 1: To examine the roles of a Mathematics teacher in a computer-assisted instruction environment. To achieve this objective, the following hypothesis was tested. "There is no significant difference on the opinion on the role of Mathematics teachers between male and female students". To seek participants' opinions on this question, the selected participants were asked the following: 'What would you say your teacher should do when you are learning the Mathematics course through the computer?' This item targeted the Experimental group only. The results indicates, for example that majority (35.4%) of the students in the Experimental groups would like independence with minimal assistance [response (a)] from the teachers (Table1).

Pearson Chi-Square (χ^2) was computed to test whether the participants' responses were independent according to gender. A (χ^2 (3) = 1.02, p = 0.796) was obtained indicating no significant difference between male students and their female counterparts in the way they perceive teachers role in a CAI environment. Both males and females portray similar tendencies, traditional and/or constructivist roles of the Mathematics teacher (Adebowale et al., 2008; Bovee et al., 2007).

Research objective 2: To study the students' attitudes towards CAI Mathematics lessons. To achieve this objective, the following hypothesis was tested. "There is no significant difference on the students' opinion on the Mathematics presentation between Experimental and Control groups". Participants' opinions on this question were gathered using three items. The first item "What do you think of the way the Mathematics lessons were presented?" This item sought opinions from both Experimental and Control groups. An examination of Table 2 indicates that in both instructional groups there were positive responses [Responses (a) and (c)] and negative responses [Responses (b) and (d)] about the way the lessons were presented. For instance, the lessons made 54.2% of total participating students 'learn more about Mathematics' (in Experimental groups) compared to 39.1% in the Control groups [Response (c)]. Computation of chi square ($\times^2$ (3) = 5.557, p = 0.135) revealed no statistically significant differences in the participants' opinions between the two instructional groups. When response (a and c) were clustered as positive

Table 1. Frequencies of the role of teacher by student gender.

	Gender		
Responses	**Male**	**Female**	**Total**
(a) Leave us alone and help us when we need his/her help	10(20.8)	7(14.6)	17(34.4)
(b) Telling us what we should be doing	4(8.3)	6(12.5)	10(20.8)
(c) Demonstrating with the computer	5(10.4)	5(10.4)	10(20.8)
(d) Supervising our work	5(10.4)	6(12.5)	11(23.0)
Total	24(50)	24(50)	48(100)

Figures in brackets represent % of total.

Table 2. Frequencies for Mathematics presentation by instructional method.

	Instructional method		
Response	**Experimental**	**Control**	**Total**
(a) Easy to understand	12(25.0)	20(43.5)	32(34.0)
(b) Confusing and not easy to follow	9(18.8)	5(10.9)	14(14.9)
(c) Made me to learn more about Mathematics	26(54.2)	18(39.1)	44(46.8)
(d) Made me hate the Mathematics course	1(2)	3(6.5)	4(4.3)
Total	48(100.0)	46(100.0)	94(100.0)

Figures in brackets represent %.

Table 3. Frequencies for Mathematics presentation by gender.

	Gender		
Response	**Male**	**Female**	**Total**
Positive	41(43.6)	35(37.2)	76(80.9)
Negative	6(6.4)	12(12.8)	18(19.1)
Total	47(50.0)	47(50.0)	94(100.0)

Figures in brackets represent % of total

positive and (b and d) were clustered as negative against instructional method, similar results were found (χ^2 (1) = 0.180, p = 0.672). These results showed that there is equal probability for both Experimental and Control groups to display different opinions about Mathematics lessons. When considering "Mathematics presentation by gender" (Table 3), there was also no statistically significant difference between male and female students (χ^2 (1) = 2.474, p = 0.116).

The second item "What are your feelings about the way the computer received and responded to instructions?" is a follow-up for the first item seeking more information on the participants' feelings in the Experimental groups. An analysis of the responses for this item indicated that 33 (68.8%) of the participants displayed positive feelings, 12 (25%) displayed mixed feelings and 3 (6.2%) displayed negative feelings. A sample of particular responses presented will provide more insights into the students' feelings at this stage (Table 4).

Positive responses

From the excerpts of these positive responses, the CAI module and the computer, the following categories emerge (a) Reinforce / motivate /encourage /challenge the students/learners, (b) To be time saving, (c) Give immediate feedback to the student solutions/answers, (d) Give more examples and exercises, (e) Enhance active participation from the students, and (f) Build confidence in students. In each of the excerpts, the authors gave the possible categories they fall into (a to e).

"Computer gives us the chance to try again, more practice on the sums to get correct answers" [d, e].
"… Was accurate and effective" [f]
"Encouraging because the responses from computer were polite and motivating for the trial of a wrong answer" [a]"… The solutions to problems are displayed in organized and orderly manner which enhances easy understanding

Table 4. Frequencies for Mathematics presentation by gender and instructional method.

		Instructional method	
Gender	**Response**	**Experimental**	**Control**
Male	Positive	20	21
	Negative	4	2
Female	Positive	18	17
	Negative	6	6

Table 5. Frequencies for Mathematics presentation by gender for experimental group.

Response	Male	Female	Total
Positive	20(41.7)	18(37.5)	38(79.2)
Negative	4(8.3)	6(12.5)	10(20.8)
	24(50.0)	24(50.0)	48(100.0)

Figures in brackets represent %.

of the topic" [f]

"Through use of computer, it made me understand more about computer and made it easy for Mathematics to be done *more easier* [emphasis mine] with different methods through instruction from the computer and the teacher" [c, e, f]

"Through computer, I was able to understand; it was fast and gave the message 'try again'" [b, f]

"It responded in the right manner. It corrected us and gave us the right answer" [a, c, e, f]

"I feel happy, if you have inserted the wrong instruction it reply by saying 'try again', this encourages me" [a, f]

"As you follow instructions, if your answer is wrong the computer also tells you 'try again' of which it challenges you to calculate again" [a, e]

"It is direct and does not need a lot to operate. In fact the instructions are brief and clear"[b]

"It is good, for it explained and showed the way. I can read and understand because it gives me feedback immediately." [a, c, f]

"Very nice, it encourages the student to try working out the sum again whenever one gets wrong at times". [a, e]

"They give examples and they encourage people to be active since they will be the ones operating the computer themselves" [a, d, e]

"I feel good because the Mathematics programs installed in computer were easy to operate and furthermore it was friendly." [a, f]

"It was faster and the respondent give the same answer as what I get from the calculation" [b, f]

* "Computer response according to my feelings was positive. I wish the government could accept and introduce the learning of computer to some students." [a]

"It is good; there is need for the program to be improved to an extent that acts as a 'virtual teacher' may be by inputting sound devices to be used with the application. This can help students improve listening skills other than just reading instructions which sometimes is prone to misunderstanding and misinterpretations, therefore students may end up getting the wrong concepts and in turn low understanding capacity in Mathematics" [a]

The response marked* extends to the policy issues, which has been captured in the government's policy on e – learning (MoEST, 2005). The last responses emphasized on the type of CAI program, particularly, the artificial intelligence (AI) as applied to the teaching of Mathematics.

Mixed responses

From the excerpts of these mixed responses, the following categories emerged (a) The misconceptions that the computer will do everything (that is, do the thinking for the learner), (b) the learners are seen to be impatient (that is, the computer takes more of their time), (c) most students are bend towards fixed procedures or algorithms, and (d) the prior knowledge on the operations of a computer is paramount to its effective use.

"A bit difficult but after using the example it became easy" [d].

"Well, it was not that bad. The moment you understand the tips, you will enjoy it" [d].

"…it responded well but if the student fails in the second part of the question the computer does not explain well [referring to limited hints]" [a, b]

"Sometimes, what I saw to be a bit unfamiliar is that, after entering your answer you are told whether its right or wrong after repeating the question, again, you are told that 'please try again' of which you keep on trying, taking a lot of time. If not that, I find it quite okay to learn using computer" [b].

"Very interesting but it still need your knowledge to be applied and also need genius people in Mathematics"[a]

"It is good because it contains examples and exercises for more practice although after doing you might not know whether the procedure you used to get the answer is correct and at long last you might end up failing" [a, c].

"I think learning with computer is quite interesting, but might not be easy to follow and understand without close supervision of the teacher. The instructions should be made more friendly to students to avoid them asking for help from the teacher always but be independent on their own operations." [a, c]

"It responds quickly when asked and some examples were not showing well [clarity of diagrams]" [a]

"It was fast in responding. It gives clear example but difficult to understand because we were not having good knowledge over computer" [d]

"… Fast in responding but it is difficult operating [computer]

if not taught." [d]
"It responded fast but not showing methods clearly." [a, c]
"It is fast but not that understandable like when the teacher teaches." [a, c]

Negative response

These negative responses are attributable to basically three factors: (a) The students required explicit (as in most Mathematics textbooks or by teacher) answers rather than implicit, (b) Sometimes students are not flexible, they assume that whatever answer they get is correct, and (c) They have little faith in the computer giving instructions.

"More dull, should not be used as a mode of teaching." [a]
"It received the instructions well but on responding it was more difficult because the exercises were difficult and the computer does not give answers [Referring to implicit answers]. It gives some instructions which are more difficult to follow than the exercise itself" [a, b, c]

The third item is "*Do you feel that the computer should be used in teaching other Mathematics lessons/topics?*" This item required a 'yes' or a No' answer with or without elaboration, which came out clearly from the students. Thirty eight (79.2%) of the students said 'yes' while 10(20.8%) said 'No'. It should be noted at this point that some of the 'mixed responses' in questions 3 and 4 were 'yes' response. Perhaps, the only explanation could be that the 'mixed responses' had more positive tendency, than negative. The students were probed for elaboration. There were students who said 'Yes' with a clear explanation others said 'yes but …'. The 'No' answer were also elaborated. The following paragraphs will give samples of the elaborations for 'Yes', 'Yes but …' and 'No'.

The types of responses to this question were greatly influenced by: (a) The prior knowledge in the use of computer, (b) the particular experience with the computer (good/bad), (c) the mode of presentation of the Mathematics content of computer versus teacher (previous experience), (d) patience and interest of the learner in Mathematics and computer and (e) learning styles or strategies–concrete and abstract.

Elaborations for a 'Yes' response

"Shows examples and ask when you need exercise you can practice." [b, c, e]
"Computer provided questions and answers on the spot which are very accurate" [b, d, e]
"It is easy to understand when you see examples." [c, e]
"Computer gives more *impression* and give accurate information including the example followed" [b, e]
"No matter how a topic can be too long, it can be covered in a short time because computer is fast, accurate and more effective thus saves time." [b, c, d, e]
"Easier for Mathematics lesson to be taught quick and fast and lowers the cost of purchasing textbooks" [b, d, e]
"Computer gives more information than the book [Text]. It is easy or it make one to understand easily" [b, c]
"Because according to me it is easy to understand through computer than teaching on the blackboard" [c, e]
"Enhances the Mathematics lessons by making it enjoyable other than the teacher calculating on board." [b, c, e]
"For it makes me to be independent when doing it [learning Mathematics]." [e]
"Teaching Mathematics using computer was enjoyable and understandable and give more detail than when the teacher was teaching." [b, c, e]
"Though I had not managed in getting to know more about the topic, it is the time I learned using the computer that I understood well." [a, b]
"Makes one not give up easily [as compared to] when the teacher teaches you, you may not understand and therefore you may end up giving up." [b, d]
"It breaks the monotony of calculating Mathematics everyday with the teacher" [c, e]

Elaborations for a 'Yes but…' response

"It needs [computer] literate people." [a]
"… If only the inventor can get the fact that people understand things in different dimensions [ways] so to make the understanding uniform, the computer should 'talk' and it should be programmed in a way that the student is able to ask it questions" [e]
"In condition that the Programme should be installed in almost all computers in order to create a conducive environment for learning" [b, e]
"Students should be helped to reduce frustrations arising from other statements that may be misunderstood" [b, e]
"If only teacher would be telling us what to do and demonstrating using computer" [c, e]
"Provided there is help from the teacher" [c, e]
"With good demonstration by teachers until we understand using computer [the learner came from a school (Form 1, 2 and 3) without computer studies]." [a, e]
"Only to show some examples, because they can sometimes make the student lazy to think on their own." [c, e]

Elaborations for a 'No' response

"Not necessary [with no further explanation, just not necessary]." [d]
"It is somehow complicated to use computer." [b, c]
"Computer lessons are very hard to follow and understand." [b, c, e]

"Students may be un-aware of the steps and instructions. It is dull, boring and tiring." [b, c, e]
"I strongly disagree with this because I really had a rough time and it took me hours to understand what I was supposed to do." [a, b]
"Because it does not explain well" [c, e]
"Students will be confused and not able to do Mathematics on their own without computer." [c, e]
"Computers are confusing and worked examples are not easy to understand". [a, b, c]

Conclusions

Results and discussion presented in this paper so far suggest the following:

1. In a CAI environment, majority of the students will expect their Mathematics teachers to assist them on a need basis. This point to the fact that CAI facilitates a constructivist learning environment, where a student is allowed to explore and only seek assistance if the need arise. This finding does not relate to gender that is, both male and female students will perceive teacher's role alike.
2. Majority of the students will develop a positive attitude towards Mathematics and instruction – as a result of CAI facilitating a constructivist learning, students exposed to CAI tend to "learn more about Mathematics" than those not although marginally. Attitudes towards CAI Mathematics environment are independent of student's gender.
3. The positive roles of CAI in an instructional process are: CAI reinforces students – motivation and encouragement, time saving, immediate feedback, more examples and exercises, and builds confidence in students. Therefore, well design CAI instructional software is important when adoption of computers in education is to bear fruits.
4. Negative student attitudes in a CAI environment are a function of:

a. Students learning styles characterized by:

i. High expectations that the computer is the ultimate solution to instructional challenges; a misconception about the role of computer.
ii. Fixed mathematical procedures and/or algorithms which depict a static view of the mathematical process (traditional approaches).
iii. Expectation of direct and explicit answers to mathematical questions to confirm answers as either "right" or "wrong".
iv. The unquestionable teacher's role as a source of Mathematical knowledge.

b. Students prior computer knowledge and skills characterized by:

i. Experience with computers; good or bad.
ii. Computer interest; a source of patience.

RECOMMENDATIONS

Basing on the foregoing conclusions, the following recommendations are made:

1. CAI is an innovation that will lead to students "learning more about Mathematics". This is attributed to the discovery approaches supported by CAI. Therefore, CAI is one important means to catalyze a shift from traditional (static) to constructivist learning.
2. CAI is important to put a check on the accepted norm of gender difference in attitude towards Mathematics and instruction.
3. The success of CAI in building positive attitudes towards Mathematics and instruction is highly dependent on the quality of software design for particular concepts in Mathematics. A careful design and development of CAI Mathematics instructional software is paramount with objective piloting. The pedagogical concerns of the software are central to its very achievement of lesson objectives.
4. Student exposure to basic computer skills and the role of computer in instruction will impact greatly on how computers are received and acted upon in a classroom situation. Misconceptions and unwarranted superiority (which borders on mystifying the computer) will be dealt with at the right time.
5. Students' learning styles are also important variables in the success of CAI in Mathematics instruction. Bearing in mind the various classes of CAI (e.g., tutorials, multimedia etc.) should be incorporated in the design and development so as to cater for majority students' learning styles. Concrete students may want a tutorial that parallels a traditional teacher while open-ended and hypermedia will suit the abstract students.

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