DEVELOPING AND EVALUATING COMPUTER GAMES: A PEDAGOGICAL PERSPECTIVE FOR HIV/AIDS PREVENTION IN SCHOOLS

Joseph Kizito Bada, Jarkko Suhonen
University of Eastern Finland, Joensuu Campus, Finland
Email: j_bada@yahoo.com, jsuhon@cs.joensuu.fi

Abstract

This research report presents design, development and evaluation of computer games as a pedagogical approach for delivering HIV/AIDS preventive education to the lower level high school students within the age range of 13-18 years. The purpose of the research was to enable students to learn and test their understanding of HIV/AIDS basic knowledge and preventive measures using computer games. The models of the games were built using Empirical modeling approach together with experiential learning. Field experiment was used to demonstrate computer games in schools and questionnaire was used for game evaluation. Descriptive statistics and partial least square (pls) were used to analyze quantitative data from questionnaire. The results from analyzed data indicated that computer games influence learning outcome of HIV/AIDS preventive education. Based on the research results and experience in game design and game prototype demonstration in three lower level high schools, recommendation has been formulated for designing similar games for classroom use. The computer game is one of the components of digital learning environment for HIV/AIDS education. Other components include video games and online lessons with discussion forum.

Key words: *computer games, experiential learning, HIV/AIDS preventive education, partial least squares.*

Introduction

According to UNAIDS (2006), sub-Saharan Africa is the worst-affected region by HIV/AIDS in the world with the highest prevalence rate (15-35%) in Southern African countries. The infection rates vary from country to country with some showing declines, notably, Kenya, Uganda, Zimbabwe and urban areas of Burkina Faso.

People's Health Movement (PHM, 2005) described education as a "social vaccine" against HIV/AIDS. This can be seen from the situation in Uganda where the rate of HIV infection among the youth dropped by half after completion of primary school education. Education is also a key factor for accelerating behavior change among young men making them more receptive to prevention messages.

Researchers in the recent years have focused on different approaches of providing ICT based HIV/AIDS preventive education to high school students in Africa and Asia. Duveskog (2008) developed carton-based stories for educating high school students in AIDS prevention in Tanzania, Bada and Suhonen (2009) designed conceptual framework of digital learning environment for HIV/AIDS preventive education for Ugandan schools, Merwe (2007) used *playing cards* for designing simple games for AIDS preventive education in South Africa.

To complement games developed by the above researchers for HIV education, this

research experiments the effectives of using computer games in classroom to formally teach and evaluate HIV/AIDS preventive education. The research results indicate that games are viable tools for improving knowledge of HIV/AIDS preventive education. The teenage children expressed their views about the computer games in different ways as presented in qualitative analysis section of this research.

Research Model

Constructs were used to formulate the model of the research. In particular, latent variables were identified, that is, constructs that cannot be measured directly such as computer game which is measured through scores learners make when playing a game, educational support it offers to the learning process and its use for self-assessment of learners. The second latent variable is the learning outcome which is measured using the learners' satisfaction with achieving course goals and course purpose. An assumption was made that computer games influence students' improved knowledge in HIV/AIDS prevention education.

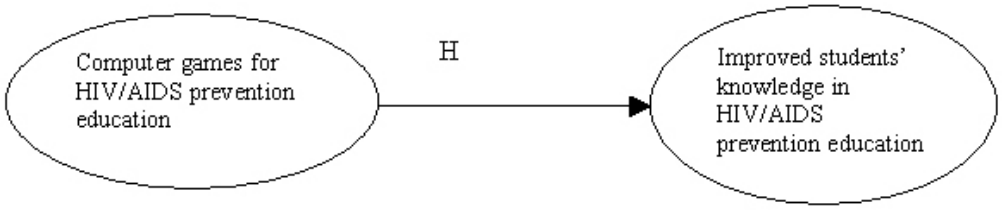

Figure 1: Computer games predicting improved knowledge in HIV/AIDS.

Research Questions

1. How can we design computer games to educate teenagers in schools on HIV/AIDS prevention?
2. Does the use of computer games for HIV/AIDS preventive education result in improved learning outcome?

Hypothesis

H: The use of computer games for teaching HIV/AID prevention improves learning outcome of HIV/AIDS education in schools

Table 1. Constructs of the research.

Construct	Description	Supporting Research
Computer games educational perception	The ease of playing computer games Developing knowledge through the content of the game Motivational benefits of playing computer games Games providing fun and intellectual curiosity Acquisition of points (scores) from game playing for formative and peer evaluation	Egenfeldt-Nielsen (2006), McFarlane, Sparrowhawk and Heald (2002), (Bonnano, 2008), Ryan et al (2006), Leemkuil (2006), (Malone and Lepper 1987 a and b), (Keri, 2003).
Learning Outcome	Knowledge construction through playing computer games, learners' satisfaction with course purpose and goal.	Leidner and Jarvanpaa (1995), Alavi et al (1995).

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Description of Theoretical Constructs

Computer Games Educational Perception

Games promote different forms of learning that forms an essential part of individual experience. The three categories of beneficial outcomes of games are: physiological, cognitive and motivational. We describe each of these below:

Physiological outcomes: physiological positive effects from gaming include increased visual processing and acuity, refined eye-to-hand co-ordination and refined hand movements (Egenfeldt-Nielsen, 2006).

Cognitive outcomes: McFarlane, Sparrowhawk and Heald (2002) acknowledged that games provide a forum in which learning is initiated by tasks stimulated by the content of the games, knowledge is thus developed through the content of the game, and skills are developed from the experience build from playing the game.

Motivational outcomes: Here two themes are considered; the first is extrinsic motivation that focuses on the influence of the games' appeal on adoption and use by different social groups, the second is intrinsic motivational benefits of games that compares games with other instructional contexts and also explores motivational benefits resulting from the experience of playing computer games (Bonnano, 2008).

In regard to the intrinsic motivational benefits that results from game interactions, there is a widespread agreement amongst the researchers about the motivation pull of games (Ryan et al, 2006) and its link to learning. Leemkuil (2006) acknowledges that the fast growth of the use of digital games has resulted into renewed attention to the role of game play in education and research in design of games. People play games because they are intrinsically satisfying (Malone and Lepper, 1987 a and b) by providing optimal level of challenge, provoking sensual and intellectual curiosity, developing competencies and providing fun.

Games for Assessment

One of the challenges facing the designers of games in learning is the question of assessment. The players evaluate their own progress through the game from the scores they make and the feedback from the game. In a classroom environment where children are encouraged to reflect upon their achievement within the games environment, the current methods that give success in games such as acquisition of points serve as a basis for formative and peer evaluation (Keri, 2003).

Learning Outcomes

According to Leidner and Jarvanpaa (1995), there has been a shift in paradigms from objectivist to constructivist learning in pedagogical research. The transfer of objective knowledge from the instructor to the learners is the belief of objectivists. This is the concept of traditional classroom where learning is instructor-centered. Constructivists on the other hand believe that learning should be shifted to the learners. The electronic classroom encourages active knowledge construction through collaborative learning. There is evidence from research that instruction using technological tools was effective in terms of perceived learning (Alavi et al, 1995). Satisfaction in learning outcome is reflected by the extent of learning in factual material, self-assessment and interest in the learning topic (Alavi, 1994).

Explanation of the Constructs in the Context of HIV/AIDS Education

The latent variable Learning outcome (LO) is measured using the following theoretical constructs:

1) Course meeting its objectives. This construct was used to measure students' opinions about the course achieving its goals. The objectives were set and communicated to students before they participated in the course. These objectives were: imparting HIV basic knowledge to students and taking self-assessment questions when playing computer games.
2) Course meetings learners' expectations. This construct was used to measure the students' opinion about how the course met their expectations and new aspects of the course that have created new ways of learning about HIV epidemic.

The latent variable *computer game for learning* (CG) is measured using the following theoretical constructs:

1) Game supports learning. A game play by students encourages active HIV knowledge construction when the game content is based on the teaching curriculum for HIV/AIDS education in schools. The game enables the learner to remember what was learned in classroom or from an online lesson.
2) Learner scoring above average in game. The level of knowledge attained by every student is measured by the scores obtained from playing the game. An average score of 50% is taken satisfactory for knowledge attained from games.
3) Games to assess the learner's progress. A computer game is a good tool for formative and peer evaluation. A student evaluates his or her understanding from the time taken to play the game and the scores made.

Evolution of Games in Education

A game-based learning environment that is designed with educational properties taken into consideration appropriately improves learning. Digital games which are user-centered can promote challenges, cooperation, engagement and the development of problem-solving strategies. The research field of computer games is not yet well established despite the progress in the recent years. The researchers in this area of study still struggle for acceptance and academic credibility with no common research language, and few basic and theoretical discussions (Begona, 2007). American researchers have less interest in finding out whether existing computer games offer content that can be relevant to educational purposes. They don't support a narrow focus on content skills and attitudes. Instead their focus is on the structural characteristics of computer games that could be used for education and social processes surrounding the educational experience (Squire, 2005).

In tradition of education, computer games or game-based learning has been a neglected area with educational practitioners having negative attitudes towards computer-games. However, in the last decade, there has been considerable attention to games in education especially in the areas of structurally aspects of the games such as influence of digital games on digital literacy, learning styles, and integration of video games into school curricula to enhance learning (Begona, 2007).

Egenfeldt-Nielsen (2005) established three generations of games on the basis of the connection between educational computer games and the progression of learning theories.

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These are:

a) The first generation (edutainment) assumes that learning occurs when a learner is given opportunity to practice certain skills in sufficient time. Edutainment did not register greater success because the games were so simplistic as compared to video games. The tasks were very repetitive and poorly designed and did not support progressive understanding.
b) The second generation was cognitive oriented with the learner as the center of attention. Here the games were meant to scaffold the learner when faced with challenges in the learning process.
c) The third generation did not only focus on the computer games but it also looked at the broader process of educational use of computer games. The teacher took the role of the facilitator adapting computer game experience to school.

Review of HIV/AIDS Educational Games

Overview of Games for Education

According to Prensky (2006) students living in a technology-permeated knowledge society, in which entertainment and play are an essential ethic, experience life in fundamentally different ways from previous generations. Digital tools with their range of functionalities are considered as indispensable components of their life style with each satisfying specific need. Entertainment, immediate access to information, a sense of connectedness, the sense of relatedness through extensive social networks, sharing information and knowledge are the identity norms of the digital generation (Bonanno, 2008). Games merge the fundamental learning ingredients which include fun, play, rules, goals, winning, and competition and community aspects. These components motivate children to learn (de Freitas, 2008). Brown et al. (1997) acknowledge that players using an educational video game for Juvenile diabetes improved on self-efficacy, communication with parents about diabetes and self-care behaviors. Examples of educational games for HIV/AIDS awareness creation are given in the next section.

South African Playing Cards for HIV/AIDS Prevention

CompuTainer is a South African based company, working with local communities, corporate, international organizations and governments in Africa to fight against the spread of HIV/AIDS, TB and Malaria (Merwe, 2007). This company has developed educational games for HIV/AIDS awareness campaign. The playing cards were used to deliver HIV/AIDS messages to the public. On the world AIDS day of 2006, CompTainer manufactured and delivered close to 150,000 decks of playing cards. These playing cards were designed with corporate logos providing exposure to the messaging around HIV and AIDS and at the same time allowing the client to receive brand exposure. The cards presented a new approach of increasing awareness on HIV/AIDS for all ages. The playing cards can retain information as the number for playing is always fixed and there is no room for losses. So the 52 educational playing cards provide more space for simple and straight HIV/AIDS awareness and prevention campaigns. Examples of messages included faithfulness and abstinence. Other messages included gender issues, good nutrition, myth busting, regular exercise, risky behavior, positive living and positive leadership. The second game developed by CompTainer is board game for education pre-teens, and teens about HIV/AIDS, sex education and HIV/AIDS prevention. There are two categories of board games: stepping stones and choices & consequences. The *stepping stones* game was designed and implemented for children aged 7 to 11 years to have fun while learning about HIV and AIDS, how infection happens and what you can do to prevent it. The game is good for HIV prevention

education in schools. The *choices and consequences* were designed and implemented for adults and teens to have fun while learning about HIV and AIDS. How an infection happens and how one can protect against it. This second game is good for tertiary institutions, secondary schools and family groups (Merwe, 2007).

Encouraging a Safer Sex Negotiation via a Specially Developed Computer Game

Thomas et al. (1997) used the interactive computer game entitled "Life Challenge" time travel adventure game. This game was developed by New York State Department of Health as a tool for encouraging adolescents to develop skills and a sense of self-efficacy in HIV/AIDS prevention programs. This game provided information and opportunities for skill practice – safer sex negotiation – in a non-threatening environment. The use of computers in the above games practices provided opportunities for health education intervention and solved problems that were going to be very difficult to achieve.

Indian Mobile Games to Fight HIV/AIDS in Africa

In 2006, Freedom HIV/AIDS introduced STAR programme to fight against HIV/AIDS in six African countries namely: Uganda, Tanzania and Kenya in East Africa, and Malawi, Mozambique and Namibia in Southern Africa. This programme aimed at designing and developing new mobile games on HIV/AIDS awareness in Africa.

ZMQ developed games across a range of mobile platforms and technologies such as WAP, SMS, J2ME, BREW, Symbian, Flash Lite 1.1, Pocket PC and Palm OS. The games were designed for a variety of devices from basic Java Phones to Smart phones and pocket PCs. The methodology for designing a game included user interactivity, flexibility, competition, excitement, reality, and usability (Sabina, 2007).

Mobile Phones for HIV/AIDS Prevention Intervention: Project Masiluleke

Project Masiluleke is a breakthrough cross-sector collaboration that uses mobile technology as a high-impact, low-cost tool for fighting HIV/AIDS epidemic and tuberculosis in South Africa. Masiluleke means "give wise counsel" and "lend a helping hand" in Zulu; the project was initiated to address tremendous suffering and premature loss of life as well as the understanding that the ubiquity of mobile devices in many parts of the developing world has the capacity to foster social change (Robert, 2009).

South Africa has more HIV-positive citizens than any country in the world. In some provinces more than 40% of the population is infected. Majority of HIV-infected patients in South Africa seek care only after they have developed AIDS symptoms which are too late for survival. Project Masiluleke brought together a world class coalition of organizations and domain experts (including MTN, Nokia, Siemen Networks) to test and scale up powerful and integrated approach to fighting HIV/AIDS and tuberculosis. The project aimed to raise widespread public awareness about accessing help, encouraging people to go for HIV testing and also encouraging the infected people to go for treatment in order to extend their lives and reduce the human and economic losses associated with deaths resulting from AIDS. In October 2008, project Masiluleke launched a mobile HIV-awareness campaign using simple text messaging. Within a period of one year, the volume of the communication tripled inspiring more than 150,000 people to reach out for help (Robert, 2009).

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Methodology of Research

The design, development and evaluation of educational games for HIV/AIDS preventive education was guided by the TEEM report for designing educational games for classroom settings. Empirical Modeling (EM) was used for game model design. The game prototype was implemented in three Ugandan schools. The game prototype was evaluated using questionnaire with open and closed ended questions. The data collected from questionnaires was analyzed qualitatively based on themes that emerged and quantitatively using descriptive statistics and path analysis was performed using *Partial Least Squares (PLS)*. In the following sections we present game design and development.

Theoretical Perspective for Developing Games for HIV/AIDS Prevention in Schools

Toastmasters Enhanced Entertainment Membership (TEEM) report was adopted for developing games for HIV/AIDS preventive education in schools. The factors that should be taken into consideration when developing such games for classroom setting (TEEM report) include: pre-set scenarios, accuracy of content, saving and restarting, information to the teacher, sound, progress, challenge and collaboration, and 'real world' expertise (Keri, 2003). Each is discussed below:

- *Pre-set scenarios*: this describes the need for children to learn the basics of the game play, and it also points out how the game is related to the curriculum and provides room for the teachers to edit game settings. *The HIV/AIDS game developed was first demonstrated to teachers and teachers after receiving training trained students to use the games. The structure of the game was described to the teachers; they understood the game content and expressed willingness to produce content for designing more games.*
- *Accuracy of content*: simulations should be based upon accepted conventional models. For classroom environment the game content should be the legitimate curriculum content. *The game content was created from the acceptable curriculum for HIV/AIDS prevention education in schools. These games were demonstrated in schools with the permission of the permanent secretary ministry of Education and Sports.*
- *Saving and restarting*: the game environment should have capacity to save classroom numbers and should be able to restart where an individual left. *The game for HIV prevention starts from time 0 seconds and continues as long as the player has not finished. Each game has 24 combinations for playing the game.*
- *Information to the teacher*: there is need to give teachers information on how to use the game
- *Sound*: there is need to control sound coming from resource in classroom setting. *The game was implemented by using drag and drop approach for moving different options to the right themes. The sound issue was not a problem.*
- *Progress*: tasks need to be progressive and games should offer non-identical repeats.
- *Challenge and collaboration*: the game environment should encourage collaborative problem solving and team work. *The students who participated in HIV/AIDS education by playing computer games started games in groups of three or four and eventually played individually after gaining enough experience of playing the games in groups.*
- *'Real world' expertise*: the game environment should be familiar to children so that they can have an understanding of it. *Some children described the game environment as a theater for acting plays. The children easily use computer games since they had experience of using computers at schools.*

Empirical Modeling was adopted for game design because it has addressed variety of computer uses in different applications and it is also a new foundation for computer science (Beynon & Russ, 1992). Empirical Modeling seeks to create the model of a computer artefact that should engage students' in exploring and experimenting ways of solving a given problem. The empiricist learning perspective is adopted for empirical modeling; this is presented in Figure 2 below:

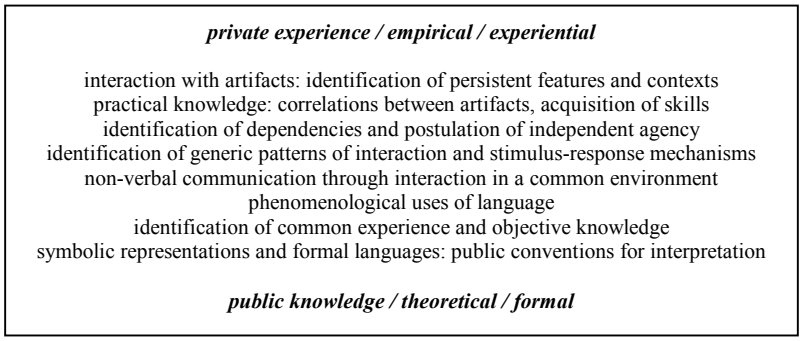

Figure 2: An Empiricist Perspective on Learning (according to Beynon, 2006).

Learning is initiated with private experience, and with interactions that reveal persistent features, contexts and objects. It includes correlation of experiences of different artifacts, and acquisition of skills while manipulating them. Interaction reveals the extent to which change depends upon actions, so making known the scope of personal agency, and the presence of independent agencies. Certain association of features becomes identified with particular kinds of agency, and with generic patterns of interaction and stimulus-response. Communication with other agents develops from pre-articulate interaction in a common environment and from phenomenological uses of language with utterances expressing aspects of the perceived current state. The empirical basis for common experience is derived from such interactions and hence the concept of objective knowledge. These then inform symbolic representations, public conventions for interpretation and the use of formal languages. The philosophy of empirical modeling considers computer as an artefact or instrument capable of achieving learning and cognition in an educational environment. The above approach is potentially good for applications in education because the principles of model construction are bound to happen with the learning process (Beynon, 1997).

Conceptual and Model Building of Computer Games for HIV/AIDS Education

Conceptual Design of HIV/AIDS Computer Games

The design of the games is based on the accepted HIV/AIDS education practices in Ugandan schools. The themes that are formulated for game design are the lessons children are taught during school assemblies and other face to face sessions where a teacher for AIDS education delivers relevant lessons to a class. Below is the presentation of the first game, Game 1, as conceptualized in table 2 below:

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Table 2. HIV/AIDS Basic knowledge.

Theme	Factors/Reasons/Attitudes
Human immunity system	Body defense system
	Production of antibodies by CD_4
	CD_4 attacked by HIV
	Reduction in CD_4
AIDS development	Acute retrovirus illness
	Latent infection
	Early symptomatic phase
	AIDS symptoms
Ways of infection	Blood transfusion
	Sex
	Brain – spinal liquid
	Breast milk of infected mother
Body fluid that cannot infect	Tears
	Sweat
	Saliva
	Urine
AIDS symptoms	Mycose of digestive and respiratory track
	Chronic diarrhea
	Weakness and muscle atrophy
	Cancers
	Ulcers
	Tuberculosis
	Brain infections
	Blindness
Theme **Sexual Temptation fac**tors	**Factors/Reasons/Attitudes**
	Emotions
	Peer pressure
	Alcohol
	Sugar Daddies or Mummies
	Adult behavior
	Hormones
HIV/AIDS Prevention	HIV/AIDS Education
	Join peer groups that fight HIV/AIDS
	Avoid pressure groups
	Get skills to earn living
	Delay sex
	Use Internet to get AIDS prevention information
	Know facts about HIV/AIDS
Reasons to delay sex	Religious reasons
	Avoiding pregnancy
	Parental advise
	Someone forcing you
	No love for that person
Responsible living	Value your own life
	Keep spiritual value
	Delay sex till marriage

	Abortion is unacceptable
	Appreciate music and drama for AIDS education
	Fight against sexual abuses against children

Table 3. HIV/AIDS Prevention.

Theme	Factors/Reasons/Attitudes
Sexual Temptation factors	Emotions
	Peer pressure
	Alcohol
	Sugar Daddies or Mummies
	Adult behavior
	Hormones
HIV/AIDS Prevention	HIV/AIDS Education
	Join peer groups that fight HIV/AIDS
	Avoid pressure groups
	Get skills to earn living
	Delay sex
	Use Internet to get AIDS prevention information
	Know facts about HIV/AIDS
Reasons to delay sex	Religious reasons
	Avoiding pregnancy
	Parental advise
	Someone forcing you
	No love for that person
Responsible living	Value your own life
	Keep spiritual value
	Delay sex till marriage
	Abortion is unacceptable
	Appreciate music and drama for AIDS education
	Fight against sexual abuses against children

The major objective of game 1 is to impart HIV/AIDS basic knowledge to children by teaching them human immunity system, AIDS development, ways of infection, and AIDS symptoms. This knowledge is important because children need to fully understand how AIDS attacks human body system. The computer implementation of the above game uses "drag and drop" approach where children use computer mouse to select a factor/reason/attitude from a pool and drop it onto the right theme it belongs to. Game 2 which is similar to game 1 is conceptualized in table 3 above and described below:

Game 2: HIV/AIDS Basic Knowledge

In game 2, students are expected to take lesson on HIV/AIDS preventive knowledge as a prerequisite before they can play the computer game. The students should be knowledgeable in sexual temptation factors, HIV/AIDS prevention methods, reasons to delay sex, and responsible

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living. Like game 1, game 2 is played by "drag and drop" approach in which a student selects a factor or reason from a pool of values and drops it on the right theme. The next section presents the game models.

Model-Building for HIV/AIDS computer games

Before the game model is presented for HIV/AIDS education, the important terms used in game design are first defined. The term *artefact* refers to the model that the learner builds in order to stress its physical experiential character. There are categories of experiences to which the artefact refers; these include a situation, an abstract procedure or phenomena. The term *referent* is used to describe such phenomena. The referent for an artist could be expression of emotion; it can be a physical entity or an idea that will be conveyed by the artefact. The learner develops tacit knowledge of the artefact and the referent through exploratory interaction motivated by establishing a close correspondence between experience of the artefact and experience of the referent.

The model of the first computer game for HIV/AIDS basic knowledge is presented in figure 2 below. This model provides a number of lessons in HIV/AIDS. The lessons include; the knowledge about human immunity system, the stage of AIDS development in the human body, the sources of HIV/AIDS infection, body fluid that cannot transmit AIDS virus, and AIDS symptoms. The referent in this model is the circle divided into five sectors, each sector representing a lesson in HIV/AIDS basic education. The observables are the circle, the lines from the center of the circle to the circumference that build five sectors, the center of the circle, the circled small letters outside the common circle, the score of +1 for correct score, -1 for wrong score and 0 for game not played, and the capital letters representing lessons.

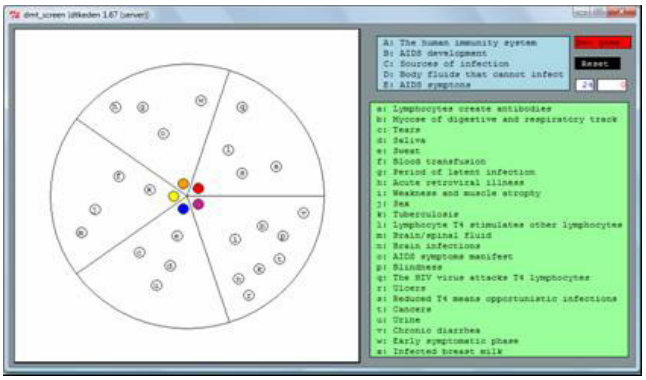

Figure 2: NetAIDS game model for HIV/AIDS basic knowledge (Screen for scoring all the 24 points for the successful game).

Rules for the game:

1. The student clicks and drags an option from available variables a,b,c,….,y and matches it with one of the themes A,B,C,D or E
2. If the matching is correct a point of +1 is scored with a corresponding color change at the background of the game interface.
3. If there is wrong matching -1 is scored
4. There is no point scored for unplaced option in the game.
5. There are 24 options for matching; if all are correctly matched a total of 24 points is scored with display of rainbow color.

Table 4. C++ Program fragment for HIV/AIDS basic knowledge.

```
%eddi
nodes (identifier char, qualifier char);
nodes << ["a", "Lymphocytes create antibodies"];
nodes << ["b", "Lymphocyte T4 stimulates other lymphocytes"];
nodes << ["c", "The HIV virus attacks T4 lymphocytes"];
nodes << ["d", "Reduced T4 means opportunistic infections"];
nodes << ["e","Acute retroviral illness"], ["f","Period of latent infection"], ["g","Early symptomatic
phase"], ["h","AIDS symptoms manifest"];
nodes << ["i", "Blood transfusion"], ["j", "Sex"], ["k", "Brain/spinal fluid"], ["l", "Infected breast milk"];
nodes << ["m", "Tears"], ["n", "Sweat"], ["o", "Saliva"], ["p", "Urine"];
nodes << ["q","Mycose of digestive and respiratory track"], ["r","Chronic diarrhea"], ["s","Weakness and
muscle atrophy"], ["t","Cancers"], ["u","Ulcers"], ["v","Tuberculosis"], ["w","Brain infections"],
["x","Blindness"];
%eden
```

The second computer game focuses on HIV/AIDS prevention education and positive attitude towards life. From this children learn four lessons namely: sexual temptation factors that are gateways to HIV/AIDS infection, ways of preventing HIV/AIDS infection, responsible living, and reasons to delay sex while still at school.
The observables for the second game are the same as the ones for the first game. In general the games are the same structurally but they differ in their functionalities and learning objectives of the lessons they teach students.

Experimental Design

A field experiment was conducted in three low-level high schools. In the above schools, the use of computer games for learning HIV/AIDS basic knowledge and preventive measures was experimented. The above games support different aspects of learning HIV/AIDS prevention and positive living. The games are played using "drag and drop" approach in which a learner picks an option from a pool of resources or options and matches it with a particular theme. Examples of themes include human immunity system, ways of spreading AIDS, responsible living. Each game has 24 options to be matched to four or five themes. For every option correctly matched to theme, there is gain of one point with a color change at the background; otherwise there is negative one for option incorrectly matched to a given theme. The challenge faced by the player is losing a point with incorrect matching. The gain comes with every good match and a rainbow color once all the 24 options are correctly matched.

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Figure 4: Students of St. Mary's College Kisubi (Left) and Gayaza High School (Right) taking lessons on HIV/AIDS Prevention using computer games.

Research Instrument

Questionnaire was designed to gather responses related to the items defined in table 5. The questionnaire had items that measured the latent variables namely: the computer games and the learning outcome. These latent variables were each measured using a set of theoretical constructs or manifest variables or indicators. The students completed the questionnaire and submitted it along with their written comments. Cronbach alpha was computed for each construct to identify whether the items belonged together within a construct. There are a number of opinions on acceptable levels of Cronbach alpha. For example, Nunnally (1967) proposes an alpha of 0.80 or higher, while Treacy (1985) suggests a value of 0.7 or higher. For our research we expected the values of Cronbach alphas to be well above 0.70

Table 5. Constructs and their Cronbach alphas.

Construct	Cronbach alpa
Course purpose	0.716
Course goal	0.729
Computer games support for learning	0.774
Scoring above average in games	0.745
Games for self-assessment	0.729

Analysis Procedure

The first step was to analyze data using descriptive statistics based on frequencies to present the students evaluation of the different constructs. This was followed by path analysis using *Partial Least Squares (pls)*. The qualitative data was analyzed by building themes for answers given by students.

Results of Research

Quantitative Evaluation of Computer Games for HIV/AIDS Prevention Education

Questionnaires were distributed to 32 students to evaluate computer games for HIV/AIDS preventive education based on the ease of playing the games, the suitability of the games as assessment instrument, and the benefits of learning from games. The summary of the answers given by students is presented in table 6 below.

Table 6. Students' questionnaire and answers (N = 32).

	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Missing value
Q1	In my opinion the course accomplished its overall purpose	0	0	0	14	12	6
Q2	The HIV education course using computer games met my expectations	0	0	3	17	9	3
Q3	I reached goals set by the course instructor	1	0	4	9	14	4
Q4	Computer games were beneficial for HIV education	0	0	2	8	21	1
Q5	Computer games were easy to play	1	1	2	9	19	0
Q6	I was able to assess myself from the scores I made in the computer games	0	3	0	9	18	2
Q7	I scored above average in computer games	2	3	0	7	18	2
Q8	Computer games supported my learning	0	0	2	8	21	1

This section presents the analysis of the manifest variables of the latent variable *learning outcomes (LO)*. Table 6 above gives the results of students' responses to the success of the course purpose. There is no student who disagrees to the fact that the course accomplished its purpose. Except six were undecided, the majority 43.8% (14) agreed and 37.5 % (12) strongly agreed. In the next question, the students were asked to evaluate how the course met their expectations. As seen in Table 6, majority of the respondents 53.1% (17) agreed that the course met their expectations, 28.1% (9) strongly agreed and only 9.4% (3) students were undecided on the course expectations. Finally, the students were asked whether the initial goal set by the course facilitator was achieved. It was noted that 43.8% (14) students strongly agreed, 28.1% (9) students agreed, however, 4 students were undecided and 1 student strongly disagreed. So at least 80% of the students acknowledged having reached the goals set by the course instructor.

The rest of the questions analyze the suitability of computer games as learning object for HIV/AIDS education. These are questions 4 to 8 (Q4, Q5, Q6, Q7 and Q8) from table 6.

In the fourth question the students were asked students whether computer games were beneficial for HIV education and in reply no student disagreed to computers games being important for HIV/AIDS prevention education. 65.6% (21) students strongly agreed that computer games enhanced their learning, 25% (8) students agreed having learned from the games, only 6.3% (2) students were undecided, and one student (3.1%) did not answer.

In the fifth question the students were asked to express the ease of playing the games, majority of the students, that is, 59.4% (19) students strongly agreed that the computer games were easy to use, 28.1% (9) agreed that the games were easy to use, 6.3% (2) students were undecided, 3.1% (1) student disagreed that it was easy to play computer games and 3.1% (1) student strongly disagreed the games were easy. The sixth question focused on the use of computer games for self-assessment where students first read online lessons and then played computer games for assessing their understanding of the lessons, the results show that 56.3% (18) students strongly agreed that they assessed themselves with the score they got from playing computer games for HIV/AIDS prevention education, 28.1% (9) agreed that the games were useful for assessing themselves and 9.4 % (3) students were undecided.

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In the seventh question the students were asked whether they scored above average in computer games, 56.3% (18) strongly agreed that they obtained above average in the computer games, 21.9% (7) agreed that they scored above average, 9.4% (3) disagreed that they scored above average and 6.3% (2) strongly disagreed that they score above average in computer games. In the eighth question the students were asked whether computer games for HIV/AIDS education in general supports classroom learning. In reply, the majority of the students (21) strongly agreed, (8) agreed that games supported classroom lessons, and only two were neutral.

The next section is presentation of factor analysis of the latent variables in relation to the manifest variables.

Identification of Important Factors

Important factors were identified to explain the variance better. Table 7 shows the loading of the 5 theoretical constructs. The bold-faced formatting of the numbers was added manually in Table 7 to emphasize the loading of the measurement items on the constructs to which they are assigned.

Table 7. Factor analysis and model constructs.

Construct	Items	Factor 1 Loading	Factor 2 Loading
Computer Games for Learning	Game supports learning	**0.636**	0.248
	Learner scoring above average in game	**0.962**	0.300
	Games to assess the learner's progress	**0.495**	0.177
Learning Outcome	Course meeting its purpose	0.333	**0.866**
	Course attaining its goals	0.148	**0.664**

Measurement of Constructs

Table 8 gives coded items that were measured in the constructs. These were the actual items under research investigations.

Item wording	Item code
The course accomplished its overall purpose	LO1
I reached the goals set by the course instructor	LO2
The computer games supported learning	CG1
I scored above average in computer games	CG2
Computer games were good for self-assessment	CG3

Acronyms
CG – Computer Games
LO – Learning Outcome

Figure 5 below presents path analysis obtained from the two constructs (latent variables) and five observables or manifest variables. The weights (w) assigned to the manifest variables are the item loadings on the constructs or latent variables in this case.

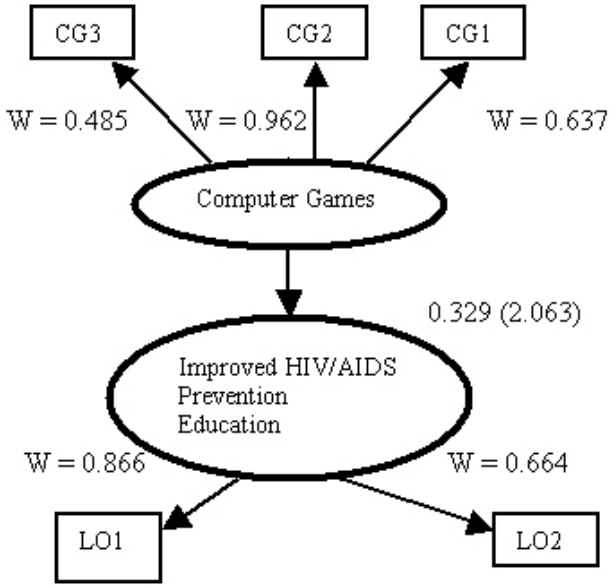

Figure 5: Computer games influence learning outcome (t-statistics are in parenthesis).

Measures of Fit

Statistics	Recommended value	Our model
Sample	-	32
Factor loading	0.4 – 0.6	0.5 – 0.9
t-statistics	t-statistics > 1.96	2.063

Test of Hypothesis

Test of H: The direct relationship between the use of computer games for HIV/AIDS preventive education and improved learning outcome when using computer games is significant (shown in figure). The path coefficient of 0.329 is a good value and t-statistics 2.063 is above the cutoff value of 1.96.

Results of testing hypothesis	
Hypothesis	Results
H: There is direct relationship between computer game and HIV/AIDS prevention education outcome.	Supported

Findings and Implication

The attributes of computer games namely: its active learning by matching correct fields and options, learners' evaluation from scores and learners score above average of overall total contribute to the success of learning outcome.

From Figure 2 above, the latent variables are computer games perception for HIV/AIDS preventive education and improved teenage HIV/AIDS preventive knowledge. These

variables cannot be measured directly, but manifest variables or indicators can be combined to measure each of them. Thus, to measure computer game, we use CG1 (game support for active learning), CG2 (score in games) and CG3 (game score for self-assessment). The weight of a manifest variable or observable explains the contribution of these variables to the latent variable (computer game). Latent variable *Improved HIV/AIDS learning outcome* is described by two manifest variables or observables LO1 and LO2. The weight of LO1 is 0.866 and this explains its strength in the latent variable. The next section presents views of students on the use of computer games for HIV/AIDS education.

Qualitative Evaluation of Computer Games by Students and Teachers

Two open-ended questions were asked to students; in response to the first question the students expressed their views on computer games for HIV/AIDS prevention education from the experience gained from playing the games.

Question: *Do you prefer computer games for learning? If so, give the reasons why you choose games.*

Responses:

1) "Games were fun and helped us to access ourselves and our knowledge"
2) "Games were fun educationally and a bit challenging"
3) "Games were easy to play after reading the lessons"
4) "Games got me thinking unlike the discussion forum where someone can lie"
5) "I had read all the lessons and I knew all the answers in the games"
6) "Games assess you in a way that makes you think in a recreation kind of environment"
7) "Games keep me going and alive"
8) "Games were an easier way to learn"
9) "Games were generally fun and positively challenging"
10) "Games were perfect, they form something like examination, help you evaluate your status of learning and remembering what you read"
11) "Games increase and test on your memory power to remember what you learned"

The students were next asked to explain how they wish the computer games should be adopted for HIV/AIDS prevention education. The following are the students' answers:

1) "I encourage more interesting games"
2) "The game CDs should be made available for HIV/AIDS education"
3) "More computer games should be created"
4) "Schools should come together and make additional plays for AIDS prevention"
5) "I think I should learn more computer games"
6) "I was just thinking that may be games would be introduced and installed on the site instead of using CDs for the games"

Recommendation for Designing Games for Classroom Use

Based on the experience of designing computer games for HIV preventive education and game evaluation in schools, the following guidelines are proposed for designing similar games.

1) An educational game should be constructed on themes (topics) with corresponding learning objectives for each theme (topic). Content contribution and evaluation by the subject teachers is important when gathering pedagogical requirements for game design.

2) The game should have an assessment component for formative evaluation of the learners' understanding of the lessons. HIV/AIDS game had +1 for every success made in game play and -1 for every unsuccessful attempt in the game play and zero for no attempt made.
3) The game environment should be lively in order to capture learners' attention. HIV/AIDS game had rainbow colors for continuous change in the background environment of the game. In general the game environment should be recreational.
4) Separate the computer user interface of the game from the interface of the lessons so that students do not switch from a game to a lesson or vice versa. Alternatively restrict one application to run at any one moment. This way the students are prevented from searching answers to the game logic.
5) In developing countries where ICT resources are limited, design games that reside on computer CDs. This eliminates the problem of paying for slow and expensive Internet services.

Conclusion and Future Research

Research in HIV/AIDS preventive education is a global issue. ICT tools offer opportunities for HIV/AIDS knowledge creation and dissemination in most affected countries. This research has demonstrated the possibility of using computer games to impart basic knowledge of HIV/AIDS and its prevention in schools based on the Ugandan context. This game-based approach of AIDS education teaches children about human body immune system, AIDS development in human body, AIDS prevention approaches, responsible living, sexual temptation factors, reasons to delay sex, and AIDS symptoms. Empirical modeling approach was used to build computer game model for AIDS education based on the context of HIV/AIDS preventive education in Ugandan schools. Two computer games were demonstrated in three secondary schools in Uganda. The games were played by a group of 20 students in each school. Game evaluation results indicate that more than 80% of the students appreciated the use of computer games for HIV/AIDS education. The games improved on HIV/AIDS prevention knowledge and games are good tools for self-evaluation for students who take online HIV/AIDS prevention lessons. The relationship between *computers games for learning* and *improved learning outcome of HIV/AIDS education* was tested and significant results were obtained. There is direct relationship between the use of computer games for HIV/AIDS prevention education and improved learning outcome.

Recommendations were developed for designing educational games for use by teenage children in schools. The future research targets web interface design for the HIV/AIDS computer game.

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Advised by Meurig Benon, Warwick University, United Kingdom

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Joseph Kizito Bada	PhD. Student, Department of Computer Science and Statistics, Faculty of Science and Forestry, University of Eastern Finland, Joensuu Campus, P.O. Box 111, FIN-80101, Finland. Phone: +256 772 365740. E-mail: j_bada@yahoo.com Website: http://www.cs.joensuu.fi/~jbada/netaids
Jarkko Suhonen	Ass. Professor, Department of Computer Science and Statistics, Faculty of Science and Forestry, University of Eastern Finland, Joensuu Campus Phone: +358 13 251 7958; Fax: +358 13 251 7959. E-mail: jsuhon@cs.joensuu.fi Website: http://www.linkedin.com/in/jarkkosuhonen Website: http://publicationslist.org/jarkko.suhonen