NetAIDS: Digital Learning Environment for HIV/AIDS Education in Ugandan Schools

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Abstract. In this research, we analyze the first design efforts taken to create a web-based learning environment, called NetAIDS, for use by Ugandan teenage school children and teachers. We present the features of the first implemented version of the environment followed by evaluation results of NetAIDS gained from the Ugandan high school students and teachers. The components of NetAIDS environment include online lessons for HIV/AIDS education, online discussion forums and games. We used questionnaires to evaluate NetAIDS. The results of the quantitative evaluations indicate that NetAIDS environment influences the learning process of the students which in turn influences the learning outcomes. More than 80% of the students were satisfied with their experiences of using the environment. The evaluation results provide concrete steps for the future development of the environment.

Keywords. Behavioral change, Content Analysis, NetAIDS, Path analysis, Web-based learning Environment

1. Introduction

HIV/AIDS is unprecedented in human history. It has affected mankind in the past 30 years and the worst is yet to come. Unlike other epidemics, it affects young adults, particularly women. Children are at high risk of HIV/AIDS infection with millions already infected with the deadly virus [1]. Children lose teachers at school and parents at home and remain without support [2]. Many youth will grow up deprived, dissocialized and disconnected.

According to the Joint United Nations Program on HIV/AIDS, African countries carry an HIV/AIDS burden a hundred times that of developed countries. There is need to develop educational programmes for young people who are not yet infected with AIDS to learn about the epidemic and change behavior [3]. For now prevention education is the best vaccination, especially for young generations [1], [2]. Web-based learning environments play an important role in HIV/AIDS preventive education when they are designed purposefully [4], [5].

In this research, we analyzed the first evaluation carried out with an experimental prototype of a web-based learning environment, NetAIDS. The aim of the environment is to provide HIV/AIDS preventive education for high school students in Uganda. The study is part of the design and development research work with dual objectives: 1) to

design and implement NetAIDS learning environment for immediate use by students in schools (local result); 2) to evaluate the effect of a web-based HIV/AIDS learning environment in order to support students' learning process (global result). We further discuss related work on technology enhanced HIV/AIDS preventive education. This is followed by the pedagogical and conceptual design of the NetAIDS environment, and the description of the features of the experimental prototype of the environment. We also discuss the experiment that was carried out with the experiential prototype in Ugandan high school context. After the experiment, the students evaluated NetAIDS with questionnaires. We present the analysis of the quantitative and qualitative data collected from the experiment. In the last part of the paper we conclude and discuss the research results.

2. Related work on Technology enhanced HIV/AIDS Preventive Education

In our previous work, we observed that the existing technology enhanced learning approaches for HIV/AIDS education provide limited educational services to teenagers with most solutions presenting static online content, carton-based stories and social networks using email as a means of communication [6]. The existing technology enhanced HIV/AIDS preventive education solutions related to our work include: World Links and the AIDSWEB Project [7], ePresence Software [8], e-AIDS Project [5], the World Starts with Me [9] and Nigeria: Learning about Living [10]. From the existing literature we established that computer games and virtual classrooms have not been used for formal HIV/AIDS preventive education in schools [11]. This paper addresses this gap in literature by experimenting the viability of computer games and virtual classroom for HIV/AIDS preventive education in schools.

3. Research design and methodology

The aim of our work is to design technology supported instructional constructs for HIV/AIDS prevention and to establish new or enhanced models that support their development [12], [13]. Design and development research is increasingly undertaken in disciplines such as information system science, learning sciences, and educational technology, to design systems that perform computing, communication, or information processing tasks. Experimental prototyping is one of the most important methods in design and development research for conducting experiments and drawing knowledge from the prototypes [14]. They used the term "physical hypotheses" to describe the method of using experimental prototyping in order to draw valid conclusions about the design process and the design construct. The creation of working prototypes is often the only way for researchers and designers to test their design ideas in practice [13]. We next present research questions.

3.1 Research questions

We formulated two categories of research questions for the study:

Category 1: What are the concrete effects of the NetAIDS environment to the learning process of the students? Is there direct relationship between NetAIDS environment and learning process of the students? Is there direct relationship between the NetAIDS environment and learning outcomes of the students? Is there direct relationship between learning process and learning outcomes of the students?

Category 2: How did the students respond to the use of NetAIDS computer games and online discussions?

Latent variables are research abstractions that cannot be measured directly, such as beliefs or perceptions. Instead the abstractions are measured indirectly through several items in a research instrument. Each measurement is, thus, assumed to reflect one latent variable. In this study we identified three latent variables: *learning process (LP), learning outcome (LO) and NetAIDS environment (NE)*. Each of the latent variables is measured with a set of constructs using multiple items in the closed section of the questionnaire [15], [16] and [17].

The following theoretical constructs were used to depict the Learning Process (LP) latent variable:

1) Learning new things about HIV/AIDS related issue.
2) Ease of understanding lessons.
3) Participation of the students. Learning is viewed as processes of socialization and participation [18]. Participation minimizes feelings of alienation and improves communication; it is a preventive measure to potential conflict and plays an important role in determining the degree of agreement [19].
4) Facilitation of networking.
5) Sharing ideas.

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

1) Course meeting its objectives. These objectives were: imparting HIV basic knowledge to students, learning and taking self-assessment questions when using computer games, and peer discussions on HIV epidemic by use of online discussion forum.
2) Course meeting learners' expectations.
3) Self-assessment of learning outcomes.

The third latent variable, NetAIDS Environment (NE), is measured using clarity of the structure of NetAIDS for HIV/AIDS education and the level at which students' experienced technical problems with the environment. Table 1 summarizes the latent variables, measured constructs and supporting research in order to answer the Category 1 research questions

Table 1. Constructs for the research

Latent variables	Measured constructs	Supporting Research
LP	• Learning of new things from the online lessons. • Ease of understanding lessons provided by the NetAIDS environment. • The level of participation of the students in the online learning environment. • The willingness of the learner to respond to online questions in the discussion forums. • Sharing ideas in online discussions.	[17, 18 &19]
LO	• The accomplishment of the overall purpose of the course. • Learners' satisfaction of how the course met their expectations. Self-assessment of students' own learning outcomes.	[20 &21]
NE	• Clarity of the structure of the learning environment • Technical problems in using learning environment	[16, 17 & 22]

3.2 Hypotheses Formulation

We formulated three hypotheses related to the three latent variables as depicted in Figure 1.

1) H1: There is direct relationship between NetAIDS environment (NE) and learning process (LP).
2) H2: There is direct relationship between learning process (LP) and HIV/AIDS prevention education outcome (LO)
3) H3: There is direct relationship between NetAIDS learning environment (NE) and HIV/AIDS prevention education outcome (LO)
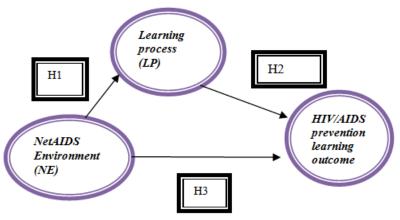

Figure 1: Hypotheses H1, H2 and H3.

Category 2

We used qualitative research method to answer the research question in Category 2. This is students' evaluation of computer games and online discussions.

In the next section we present the principles that guided design of NetAIDS environment.

4. NetAIDS ENVIRONMENT

We first present the pedagogical and conceptual design of the NetAIDS environment. This is followed by presentation of the features of the first prototype, which was used in the experiment.

4.1 Pedagogical and conceptual design of NetAIDS

One of the most fundamental aspects of any educational environment is the pedagogical design solution that supports the learning processes of learners. Learning theories can work as guidelines for planning educational support for learners [23]. The aspects of constructivist learning theories that inspired the pedagogical and conceptual design of the NetAIDS environment are: active construction [24], cognitive skills [25], related cases [26] and collaboration [27], [28].

4.2 Design Prototype: first version of the NetAIDS environment

We used Modular Object-oriented Dynamic Learning Environment (MOODLE) Learning Management system (LMS), an open source software tool, as our technical platform to implement NetAIDS. Specifically we chose MOODLE because we have several years experience of working with the environment and it includes all the basic functionalities required for implementing the features of the NetAIDS environment.

The NetAIDS environment components include: online learning modules; videos with HIV/AIDS real life stories and drama, discussion forums; and computer games.

4.3 Data collection in the experiment

After the experiment, the students evaluated NetAIDS prototype. For category 1 questions, the questionnaires include closed questions that were designed to elicit responses related to the latent variables: the learning process, the digital learning environment and the learning outcome. Table 2 shows latent variables and related theoretical constructs with corresponding cronbach's alpha.

Table 2. Constructs, questionnaire items and their Cronbach alphas

LATENT VARIABLE	THEORETICAL CONSTRUCTS	CRONBACH'S ALPHA
Learning process (LP)	Learning new things	0.693
	Lessons easy to understand	0.680
	Participation of students in the online learning environment	0.740
	Online learning environment facilitated networking	0.777
	Sharing ideas in online discussions	0.746
Learning outcome (LO)	Course meeting its purpose	0.716
	Course meeting learners' expectations	0.691
	Self-evaluation of the learning	0.716
NetAIDS (NA)	Clear structure of learning environment	0.700
	Technical problems experienced when using learning environment	0.702

The students were asked to evaluate the statements depicted above on a five-point Likert scale, where 1 indicates complete disagreement to the statement and 5 shows complete agreement to a given statement. The students completed the questionnaire and submitted it along with their written comments. Cronbach's alpha was computed for each construct to identify whether they measure the underlying construct. There are a number of opinions on acceptable levels of Cronbach alpha. For example, possible alpha value can be 0.80 [29] or higher, or an alpha value can also be 0.7 [30] or higher. As seen in Table 2, most of the constructs were above 0.7 or very close to it, which in our opinion are good values.

5. RESULTS

First we used descriptive statistics to present the results of the questionnaire (table 4). We then analyzed relations between the latent variables. The second part of the result section presents the analysis of students' responses to open questions in the questionnaire. This is done to answer the research questions in Category 2.

5.1 Category 1: Quantitative analysis of the questionnaire

The students who participated in the experiment were teenagers from high schools. The details about their ages and sex categories are presented in table 3.

Table 3. Demographic data of the students who answered the questionnaire

Number of total answers	N=32	100%
Age 12-15	17	53.1%
Age 16-20	15	46.9%
Male	9	28.1%
Female	23	71.9%

Table 4 presents summary of students' responses for the evaluation of NetAIDS digital learning environment. From the table, we note that the acceptance rate of NetAIDs educational environment for HIV/AIDS preventive education is above 80%. This gives high expectation of using this approach for HIV/AIDS education to teenage students

Table 4. Summary of students' answers to questionnaire items (N=32)

Latent variable	Item	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Answer missing
LP	Learning new things	22	9	1	0	0	-
	Lessons easy to understand	26	1	1	2	1	1
	Active participation to online education via the NetAIDS environment	20	8	2	0	2	-
	Online learning via the NetAIDS environment facilitated networking	14	14	1	1	0	2
	Value of discussion forum to share ideas	25	2	3	1	-	1
LO	Course meeting it purpose	14	12	0	0	0	6
	Course meeting learners' expectations	9	17	3	0	0	3
	Course attaining its goals	14	9	4	0	1	4
NA	Clear structure	22	3	4	2	-	1
	Experienced few technical problems	11	13	5	1	1	1

In the next step, we analyzed the important factors that explain the variance better. Table 5 shows the loading of the 10 constructs. The bold-faced formatting of the numbers was added manually in Table 5 to emphasize the loading of the measurement

items on the constructs to which they are assigned. The table also shows the individual code assigned to each of the constructs.

Table 5. Factor Analysis and Model Constructs

Latent variable	Items	Item code	Factor 1 Loading	Factor 2 Loading	Factor 3 Loading
Learning process (LP)	Learning new things	LP1	**0.367**	0.230	0.178
	Easy lessons to understand	LP2	**0.432**	0.213	0.273
	Sharing ideas in online discussions	LP3	**0.623**	0.137	0.453
	Active participation in online class	LP4	**0.568**	0.530	-0.016
	Desire to respond to online questions	LP5	**0.914**	0.433	0.444
Learning outcome (LO)	Course meeting its purpose	LO1	0.164	**0.482**	0.045
	Course attaining its goals	LO2	0.460	**0.872**	0.213
	Course meeting learners' expectations	LO3	0.325	**0.546**	0.201
NetAIDS environment (NE)	Clear structure	NE1	0.499	0.189	**0.536**
	Few technical problems	NE2	0.328	0.217	**0.924**

Next we present path analysis result we obtained from the ten constructs. The weights (W) assigned to the manifest variables are the item loadings on the constructs or latent variables in this case.
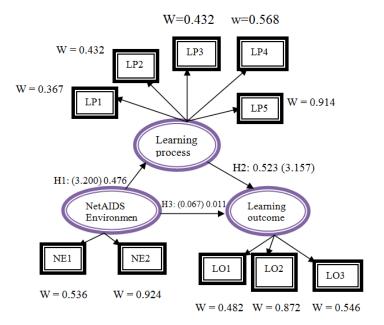

Figure 5. Direct and indirect relationship between learning outcome and learning process or digital learning environment (t-statistics are in parenthesis)

The latent variables *learning process*, *learning outcomes* and *NetAIDS Environment* cannot be measured directly, but manifest variables or indicators can be combined to measure each of them. Thus, to measure learning process we use LP1 (learning new things) with weight of 0.367, LP5 (desire to respond to online questions) with weight w of 0.914, similarly LP2, LP3 and LP4 are weighted in the same way. The weight of a manifest variable or observable explains the contribution of the variable to the latent variable. The latent variable NetAIDS environment is described by observables NE1 and NE2. Finally the latent variable learning outcomes is represented by manifest variables LO1, LO2 and LO3 and their corresponding weights. Table 6 below shows *measures of fit* we used as references for path analysis.

Table 6. Measures of Fit

Statistics	Recommended value	Our model
Sample	-	32
Factor loading	0.4-0.6	0.3-0.9
t-statistics	t-statistics > 1.96	3.2, 3.257, *0.011

When we tested the hypotheses H1, H2 and H3 based on the results of the analysis, we discovered the following.

1) H1: There is direct relationship between NetAIDS environment and learning process. The path coefficient of 0.476 is good value and t-statistics 3.200 is above the cutoff value of 1.96. Therefore, the hypothesis H1 is supported.

2) H2: There is direct relationship between learning process and HIV/AIDS learning outcome. The path coefficient of 0.523 is a good value and t-statistics 3.157 is above the cutoff value of 1.96. Therefore, the hypothesis H2 is supported.

3) H3: There is no direct relationship between NetAIDS environment and learning outcome of the HIV/AIDS education. The path coefficient of 0.011 is very low value and t-statistics 0.067 is far much below the cutoff value of 1.96. Therefore, the hypothesis H3 is not supported.

5.2 Qualitative analysis of students' answers to open questions

In this section, we present the results of analyzing students' responses the open question in the questionnaire.

In Table 7 we summarized the opinions of students on the benefits of games and online discussion forums in HIV/AIDS preventive education.

Table 7. Students' opinions about the benefits of NetAIDS games and discussions forums

Games	Discussion forums
• Games provide entertainment • Games were easy to play after the lessons and provide an easier way to learn • Games made a student to think about the HIV/AIDS issues • Games assessed the students and helped to evaluate the status of learning • Games activate the mind to remember what has been learned in the lessons	• We received and shared ideas with friends. • We received replies to questions and learned from the answers to the questions asked by other students • Online discussions provides a possibility to ask questions that were hard to ask in classrooms • Online discussions were interactive and provided a way to understand other students' opinions • Discussions allow cross-school discussions • Discussions expose problems and solutions to them

5.3 Limitations to the Study

- In this research 32 students participated in system evaluation, we need at least 100 participants in the future research
- The future research needs to have control group in the experiment
- The major obstacles to online learning were the slow speed of Internet and the limited time students are given at schools to access Internet in computer labs.

6. Discussions

The findings from this research imply that computer games and virtual classroom are appropriate learning objects for HIV/AIDS preventive education to teenage children in secondary schools. The teenage children are enthusiastic to learn social problems through collaborative networks and computer games. In our previous research we discovered that secondary school children in some countries like Tanzania and South Africa informally used cartoons for AIDS education. This research enhances the existing practices by experimenting and evaluating new approach of combining computer games and virtual classroom for formal HIV/AIDS preventive education in schools. The research result indicates that computer games when designed appropriately for formal teaching enhance learning and self-evaluation of students in classroom. Similarly, virtual classroom creates an appropriate educational environment for teenagers to engage in active and productive discussions of social problems. This networking promotes knowledge generation from children and brings out salient issues to the attention of professional counselors to address.

7. Conclusion

We established that the online learning environment which is measured in terms of its clarity, simplicity and number of technical problems experienced by the users influences the learning process. The learning process influences the learning outcome which is measured by students' achievement of course purpose and objectives. We infer that the online learning environment does not directly influence the learning outcome as the path coefficient is not significant. An online learning environment, such as NetAIDS, alone cannot influence the learning outcome but rather it influences the learning process which in turn influences learning outcome.

In developing countries HIV/AIDS epidemic is still a big problem, there is need to use ICT tools for preventive educational measures targeting teenage children. The educationists should invest in ICT for HIV/AIDS education in schools. Our next step is to develop methodology for designing digital learning environment that combines computer games and virtual classroom for HIV/AIDS education and counseling support to teenage children.

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