

An iterative process for developing digital gamified-sexual health education for adolescent students in low-tech settings

Hussein Haruna, Zamzami Zainuddin, Robin R. Mellecker, Samuel Kai Wah Chu, Xiao Hu

Faculty of Education, The University of Hong Kong, Pokfulam Road, Hong Kong.

To cite this article: Haruna, H., Zainuddin, Z., Mellecker, R.R., Chu, S.K.W., & Hu, X. (2019). “An iterative process for developing digital gamified-sexual health education for adolescent students in low-tech settings”, *Information and Learning Sciences*, DOI: 10.1108/ILS-07-2019-0066

Abstract

Purpose - Digital technology has great potential for educating today’s digitally oriented adolescents on health. In particular, digital health gamified learning can make the promotion of the sexual wellbeing of adolescents more effective. Although venereal diseases, such as HIV/AIDS, have become a greater problem in Sub-Saharan African countries than in any country outside of Africa, little is publicly known about the development of gamified learning for use in counter-measures. This article addresses that deficit by presenting the process of developing one such game. The article highlights how the “My Future Begins Today” game for sexual health education was developed, evaluated, and refined in the real-world of low-tech settings and made improvements based on the response of users.

Design/methodology - A design-based research (DBR) was used to guide the design, develop, test and refine the digital game in iterative cycles. The evaluation of the effectiveness of iterations of the game was done using adolescent sexual health literacy tests (ASHLT) and the validated MAKE framework we developed based on existing approaches. That framework combines the elements of motivation, attitude, knowledge, and engagement: effectiveness was evaluated based on the game’s ability to motivate students, improve their attitudes, increase their acquisition of knowledge, and engage them in learning self-rating surveys and interviews. The whole process of game design, testing, evaluation, and refinement were underpinned by the activity theory, design-based research, and participatory design research.

Findings – Participants in the gamified learning platforms demonstrated higher average scores on their post-tests than their counterparts subjected to the traditional teaching classroom. Also, gamified learning groups commented positively on the effectiveness of their instructional approach than their counterparts in the traditional learning group. The stakeholders’ involvement in developing gamified learning provided a good understanding of the importance of the game to the adolescent students and how it was going to be used to address the problem identified. The application of participatory design (PD) contributed to the effectiveness of the game. It involved various actors from various fields who were relevant to the game. Also, engaging targeted users from the beginning resulted in the creation of a better correspondence with the preferences of end-users.

Practical implications – This study has contributed to a better understanding of sex education and knowledge in the area of adolescent reproductive health issues, using developed innovative game mechanics and its applicability in low-tech settings.

Originality/value – The study will be a recommendation for future researchers in applying this gamified learning concept in their teaching practice, particularly regarding sexual health education and adolescent reproductive health issues in low-tech settings.

Keyword: gamified learning; iterative cycle; participatory design; design-based research; sexual health education; Sub-Saharan Africa; digital savvy adolescents, low-tech settings.

Introduction

Digital technology refers to the use and application of information technology resources and devices to support the solving of problems. Digital technology devices, including the internet, smartphones, and tablets, are increasingly influencing the lives of adolescents (Kachur *et al.*, 2013). It has also been used to educate them on health promotion and behaviour change (Temple-smith, Moore and Rosenthal, 2016). Digital games are among the digital technology products which refer to “an interactive program for one or more players, meant to provide entertainment at the least, and quite possibly more.” In an educational context, digital games sometimes refer to serious games, which are designed for a meaningful intention of delivery learning rather than entertainment only.

Generally, there has been a rapid increase in the use of digital health gamified learning platforms to support and promote adolescent sexual wellbeing (Chu *et al.*, 2015; Fiellin *et al.*, 2017; Zhang *et al.*, 2017). Digital games for sexual health education increase engagement and make the learning environment more interactive. They also offer practical skills through hands-on learning activities that are translatable to the real world (Hieftje *et al.*, 2016). Their repetitive nature is ideal for improving learning. Digital gamified learning for sexual health education provides immediate feedback, which is beneficial to the learner (Hieftje *et al.*, 2016).

The use of digital health gamified learning platforms has been found to affect the sexual health behaviour of adolescents. Some digital games focus on a general promotion of sexual health education (Chib, 2011; Chu *et al.*, 2015); some focus on HIV/AIDS prevention (Hieftje *et al.*, 2016); some focus on preventing the spread of Chlamydia and other sexually transmitted infections (STIs) (Jiang *et al.*, 2017); some focus on encouraging human papillomavirus (HPV) vaccination (Cates *et al.*, 2018); and others aim to eliminate coercion and pressure in adolescent relationships (Arnab *et al.*, 2013).

Digital health gamified learning platforms have been designed to be used on various learning platforms. Though the game Neighbourhood (Jiang *et al.*, 2017) has its video games available on YouTube, it is unclear which learning platform technologies were used on the Land of Secret Gardens (Cates *et al.*, 2018) and the PR:EPARe (Arnab *et al.*, 2013) video games. PlayForward uses an iPad learning platform to play video games during learning (Fiellin *et al.*, 2017). The Making Smart Choices game was developed to educate adolescents using a number of popular digital learning platforms, including iPad, Facebook, and the Web (Chu *et al.*, 2015). Furthermore, the computer multimedia game platform was used in Chib (2011). Of these studies, only one was conducted in a low-income country (Chib, 2011). Overall, most of these studies indicate the usefulness of digital game interventions in reducing risky sexual behaviours and promoting healthy sexual behaviours among adolescents.

Researchers have employed different approaches to evaluating the effectiveness of the designed digital health gamified learning platforms for the delivery of sexual health education. For example, Chu *et al.* (2015), Fiellin *et al.* (2017), and Jiang *et al.* (2017) determined the effectiveness of gamified learning for acquiring knowledge and changing

attitudes. Of these three, Fiellin *et al.* and Jiang *et al.* evaluated one more consideration each, namely engagement as the third consideration (Jiang *et al.* 2017) and evaluated sexual initiation as a third consideration (Fiellin *et al.*, 2017). Cates *et al.* (2018) and Chib (2011) evaluated motivation. In short, these previous studies demonstrated that the effectiveness of digital health gamified learning platforms could be evaluated mainly on the basis of four considerations: motivation, attitude, knowledge, and engagement. However, none of the experimental research combined all four considerations, as we recommend herein.

The current situation in low-tech settings

Although gamified learning platforms demonstrated effectiveness in the delivery of sexual health education for promoting healthy sexual behaviour among adolescents, most of them have been developed and used in high-tech settings (developed countries) than in low-tech settings (developing countries), particularly Sub-Saharan Africa (SSA). In fact, there is a limited number of empirical studies, which have reported either the developed or the use of gamified learning in the SSA region, especially for providing sexual health education in schools. This could be due to the limited resources and expertise in designing gamified learning platforms. Governments in SSA have been making an effort to support the implementation of ICT to bring about leverage in education to enhance its usage in teaching and learning to align with the digitally-savvy generations; however, this has not been as smooth as expected since its integration encounters several challenges (Tsegay, 2016).

These challenges could be associated with limited funding to support the initiatives with ICT facilities, a lack of training for teachers in schools on how to use ICT facilities for teaching and learning, and a lack of gamified learning developers to support the use of digital technologies in schools in low-tech settings. Moreover, the stakeholders were generally not fully prepared for these initiatives. In the meantime, there were limited connectivity and network infrastructure, inappropriate ICT infrastructure and products relevant to low-tech settings. Furthermore, the majority of people could not afford the ICT products due to their poor standard of living (Parliamentary Office of Science and Technology, 2006; Swarts and Wachira, 2010; Lakkala and Ilomäki, 2015; UNESCO, 2015). This multitude of factors could explain why the use of gamified learning platforms in a low-tech setting remains something that needs an initial investment of ICT infrastructure and capable experts to implement the gamified learning platforms.

Leaving aside the use of gamified learning platforms, the application of e-learning in schools in the low-tech setting generally remains a challenge. During this study in schools, it was observed that computer labs only served as classes for ICT subjects, as not all the teachers could use them for teaching other subjects. Although the curriculum included ICT as a subject in schools, very few schools in major cities taught it (Swarts and Wachira, 2010). After all, traditional teaching involves the use of chalk and chalkboards, which are less expensive to deploy in all schools than investments in ICT in the low-tech setting of this study where only a handful of schools are equipped with ICT infrastructure to support teaching and learning (Swarts and Wachira, 2010). Yet, gamified learning platforms could not only be used in sexual health education but also in other subjects. This study also observed that some teachers thought that the game could be used only for fun and not for serious matters, including instruction. In this regard, this study could serve as a wake-up call for educators in low-tech settings to consider other ways of teaching, including e-learning rather than limiting themselves to traditional teaching.

The development and application of gamified learning in education is associated with huge investment in terms of cost and human resources. This means the development of gamified

learning is not cheap enough to enable many countries with limited resources to afford it. These challenge low-resource setting countries to invest in digital technologies for use in education. Thus, the gamified learning we developed is not that expensive, and we believe that this cost supports a low tech-setting. As such, this article presents the whole process governed the development, evaluation, and refinement of gamified learning in an iterative manner using locally available resources (i.e., expertise, technologies) and considering the low digital literacy level of the study population. In this regard, the quality of our developed gamified learning is not sophisticated (very advanced) compared to those designed and deployed in high tech school settings. Thus, a very simple gamified learning was developed and adjusted for the low-tech environment and taking into account students' characteristics.

The formative process for developing effective gamified learning in a low-tech setting

Despite such evidence affirming the usefulness of digital games in promoting sexual health education, the application to improving sexual health education in Sub-Saharan African (SSA) countries, where unhealthy sexual behaviour among adolescents is a critical public health concern associated with unhealthy sexual behaviours, is not clearly known (Aarø *et al.*, 2014; Haruna, Hu and Chu, 2018). The motives of the gamified learning for educational purposes field focused on the rigorous game development process, consistent instruments including theory-based underpinned learning content, conceptual frameworks, intervention manuals and sound evaluation strategies for developed intervention using quasi-experimental, randomised controlled trials to establish the effect of the digital gamified learning interventions (Duncan *et al.*, 2014).

Despite all these motives, limited lesson learned of the formative process for the development of digital gamified learning still exists in low-tech settings. Previous research used randomised control trials to compare the efficacy of digital health games with non-game learning (Arnab *et al.*, 2013; Fiellin *et al.*, 2017). For empirical research, two digital health games were compared: game-based learning and gamification as experimental conditions against traditional teaching methods. This article informs the design process used in the development, evaluation and refinement of an innovative, gamified learning platform solution to educating adolescents on healthy sexual behaviours and reducing the increasing trend in chronic diseases related to unhealthy sexual habits.

Besides, in this article, the details of quasi-experimental controlled trials to assess the comparative effectiveness at improving the sexual health education of SSA adolescent students of the developed digital health game are presented. The effectiveness of the developed game was evaluated and compared with two other teaching approaches: gamification and traditional teaching. The gamified learning platforms (i.e., game-based learning and gamification) acted as experimental conditions. They were compared with the traditional teaching approach (control condition). The whole process we used to develop our gamified learning and its evaluation for implementation in a low-tech setting are documented below.

Employs a sound theoretical framework

We developed the game learning platform dubbed “***My Future Begins Today***” on the basis of an extended version of activity theory (Engeström, 1987). Activity theory is one of a number of socio-cultural learning theories; with others being social constructivism, situated cognition, legitimate peripheral participation, actor-network, and distributed cognition. So activity theory shares a family resemblance with them. Like them, it speaks of knowledge construction as a social practice; that is, the design of effective learning depends on

communal interactions and is analysed within the social context (Roth and Lee, 2007). Though it is used as a framework when developing educational activities, activity theory is comprehensive and flexible enough. Hence, we also employed it, and it guided us in analysing the development of digital gamified learning for sexual health education interventions. Activity theory has seven components: instruments, subject, object, outcome, rules, community, and division of labour (Kaptelinin, 2013). The application of each component in the creation of the gamified learning is presented in Figure 1 below, and described in detail at each specific section of this article.

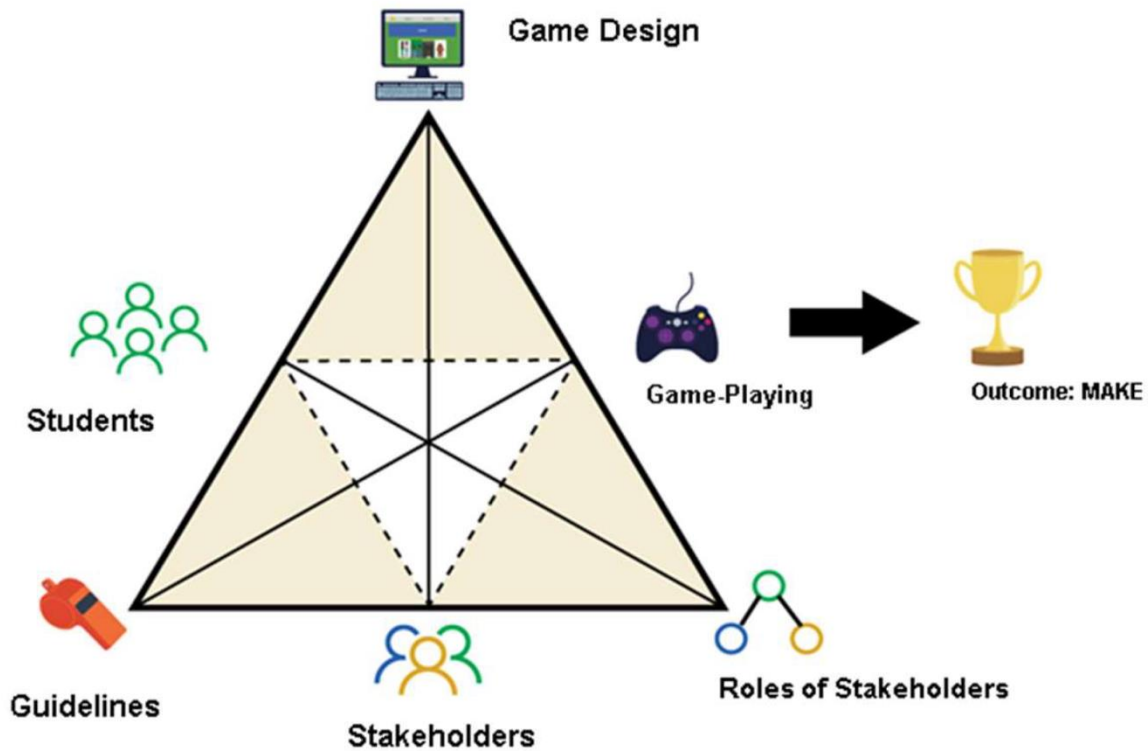


Fig 1. The Activity System theoretical framework.

Target to develop gamified learning

Our project focused on developing a gamified learning, which is known as Instruments (or tools), in our guided theory. For the purpose of improving sexual health education, we developed digital health gamified learning, dubbed “My Future Begins Today.” Before doing so, we conducted situational analysis and were informed by some the literature (Mkumbo, 2012; Sadiq Sani *et al.*, 2016; Haruna, Hu and Chu, 2018) that traditional teaching approaches are ineffective in fostering sexual health knowledge acquisition. They have allowed an increase in risky sexual behaviour among adolescents. The studies, which were conducted mostly in high-income countries (Arnab *et al.*, 2013; Chu *et al.*, 2015; Fiellin *et al.*, 2017; Jiang *et al.*, 2017; Cates *et al.*, 2018), also developed digital health gamified learning for the same goals as we did. Our digital health gamified learning used a participatory design research, which was developed specifically for application in the low-tech setting with limited resources, expertise, and little digital literacy skills of users in the study area. This helped to ensure that social and cultural circumstances of the targeted study population were factored in (Chu *et al.*, 2015).

Software used

My Future Begins Today is a scenario game that uses Unity 5 2D game engine software developed in San Francisco (Unity Technologies, 2016). Unity 5 was used for assembling and bringing together all the game's components, such as animations, avatars, and sounds. It was also used for scripting the behaviour expected in the application. The game was developed to be played on computers, but plans are underway for adapting it for use on other platforms, including smartphones, web applications, and social media (e.g., Facebook). The Unity 5 technology was used for several reasons. It is freely available, powerful, and flexible when working with animation. It is also easy to work with on various platforms. Furthermore, it has the largest user and community support of the game engines on the market today. Finally, it allows the use of the C# language.

Unity 5 allows three languages for programming: C#, Boo and JavaScript. Of the three, C# was selected as it has the most users, the largest community support, and is simpler to adopt, especially for people with a background in the Java programming language. Adobe Flash CS 6 was used for creating our animations. Adobe Flash is animation software used to create 2D animations. It is comparatively easy to use and works best with other Adobe software, such as Illustrator, which we also used. Adobe Illustrator is one of the most powerful and popular programs for creating vector images (images that can be scaled to any size without losing quality). It also works better with Adobe Flash than any non-Adobe software when creating animations out of the objects created.

Game structure

The game has five topics, each presented in a different scenario. Each topic-in-scenario allows students to acquire a different kind of knowledge [or skill]. In general, the scenario for each topic consists of teacher and students in the form of avatars. The teacher stands facing students seated in a classroom. There are conversations between the teacher and the students. The teacher asks the students to take quizzes after each scenario. There are 10 questions for each topic's quiz. Two points are earned for each correct answer, making a possible 20 points for a topic's quiz. In total, there are 100 points for the five topics/quizzes. Students were challenged with a time limit of 120 seconds for completing a quiz. To move to the next topic, students must score more than 12 points. This means that out of 10 questions, students must answer at least six questions correctly. Each topic lasted for 40 minutes per week, and students played the game individually. Students were given an opportunity to repeat a game as many times as they wanted within the 40 minutes. It took five weeks to complete the course. After it was used, the game was evaluated for improvement.

Targeted users

In activity theory, targeted users are subjects. Targeted users have two roles: using the game for learning and participating in design improvements. My Future Begins Today was developed for Form One secondary school students, aged 11–15. Before developing the game, the research team spent six months conducting workshops to obtain input from targeted users. This input made it more likely that we would create a game that was reliable and relevant (Hieftje *et al.*, 2016). During the workshops, we obtained information from students of various levels their experiences with unhealthy sexual behaviour. We also discussed their experiences with same problems in various contexts: home, school,

neighbourhood, and the community. The problems happened to family members, neighbours, friends, or other members of the community.

Based on discussions with the students, illuminations from extant literature, and insights from existing school programmes, we came up with five topics (or topic groupings): personal hygiene and good manners, responsibility and decision-making, peer pressure, the prevention of STIs, and harmful practices and sexual violence. The title of the game (My Future begins Today) was proposed by the students themselves. They claimed that they needed to be given information earlier if they were to achieve their long-term goals. There is a Swahili saying, *samaki mkunje angali mbichi*, which means *bend a fish when it is still fresh* (Sommer, Likindikoki and Kaaya, 2015, p. 592). Students also proposed a scenario game category to be developed for them. In groups, students developed a storyline for each topic. They proposed avatars, characters, and storyline presentations that reflected to their traditional learning but was more engaging and interactive. This ensured that users would participate and have the sense that they developed their own game.

Clear goal

In activity theory, the “object” is the end that the students are motivated to achieve through their study (Carvalho *et al.*, 2015). The goal of game is to improve sexual health education, that is, ensure that students acquire more sexual health knowledge and better habits than by traditional methods. Thus, a clear general goal was stipulated to make sure that the students’ motive for learning was satisfied. Moreover, each topic had a clear goal. Students were informed about what they were to achieve by the end of the topic. Since the traditional teaching method seemed ineffective in transmitting sexual health information (Mkumbo, 2012; Haruna, Hu and Chu, 2018), in developing this game we tried to consider everything that likely to make learning more effective, including increasing motivation, changing attitudes, acquiring knowledge, and engagement in the learning process.

Game instructions and rules

When the game was developed during workshops with participated stakeholders, participants were given norms to follow (respect others, manage your time, and adhere to the schedule, etc.). They were also asked to take into account existing social and cultural attitudes, as sex is a sensitive subject (Chu *et al.*, 2015; Haruna, Hu and Chu, 2018). When the digital game developed was tested, students learned the rules for using the game. They were provided with a clear orientation before game-play. It covered the goal of the learning, topics to be taught, how to earn points, the duration of play, how many times the game could be played for each topic, for whom the game was developed, the age limit, and how many points must be scored for moving to the next topic.

Stakeholder participation

Everyone has a stake or interest in attempts to limit the spread of sexually-transmitted diseases and avoidance of teen pregnancy, but some have a more direct stake or interest than others. Those who might get the disease or become pregnant have the greatest stake, as well as the families of these people. The whole society has a stake since everyone is affected by the monetary costs or loss of manpower. In making a game whose goal is to address the problem, there were particular interested parties or key stakeholders. These include paediatricians, sexual and reproductive health specialists, sexual health teachers from

participating schools, computer and information science specialists (including the game designer who is a computer engineer), and the targeted end-users themselves (secondary school students in Dar es Salaam).

DeSmet et al. (2016) underscore the importance of engaging potential stakeholders when designing, developing, testing, and refining digital games for sexual health education. Empirical research has documented the importance of participatory design research (PDR) (Chu *et al.*, 2015; DeSmet *et al.*, 2016; Hieftje *et al.*, 2016; Jiang *et al.*, 2017; Haruna, Hu and Chu, 2018). It ensures that games are developed in a way that suits the people who will use them. The involvement of various stakeholders in developing the game constitutes what is known as community engagement in activity theory. Participation of communities, including end-users, could yield active engagement between adults and children in the PDR; hence, advocate the interactions that ties their relationships between all parties in a design-by-doing without hesitation to address problems in the setting using innovative technology in practice (Yip *et al.*, 2017). The inclusion of different actors in our design led to active interactions that created a sense of ownership, and the end-users felt part of the solution to the problem. The details of PD of this study, their roles and interactions, will be published in another article.

Social roles of key stakeholders

The social roles of the key stakeholders in gamified learning development constitute what is called the division of labour in activity theory. During the development of the game, each participating stakeholder had a role to play in the workshops and meetings. For example, students developed a narrative game storyline for each topic, suggested the game structure, proposed types of avatars and characters, game mechanics, and provided initial inputs on their gaming preferences. Paediatricians, specialists on sexually-transmitted infections, specialists on adolescent sexual and reproductive health, teachers, and public stakeholders worked together on the content, assessment procedures, scores, game mechanics, learning activities, and adolescent sexual health literacy tests (ASHLT). The latter tests were used to examine the students' knowledge before and after the intervention and to compare the effects of the three teaching methods. The participating stakeholders also took into account social and cultural norms. Computer and information science specialists provided input on the game structures, user interfaces, and the learning platform. The initial game developer, who is a computer engineer and information technologist, modified the original design of the gamified learning platform based on information obtained from other key stakeholders.

The use of comprehensive evaluation

An earlier study (Hieftje *et al.*, 2016) demonstrated that during digital health game development, it is essential to understand what is going to be assessed. What activity theory calls outcome herein is the evaluation of the effectiveness of the game. We used a quasi-experimental research design to compare the effectiveness of two digital gamified learning platforms (i.e., game-based learning and gamification) as the experiment conditions against an existing and widely used traditional teaching as the control condition (Figure 2). The developed digital game for sexual health education was evaluated using different approaches for establishing its effectiveness. The approaches used were the Adolescent Sexual Health Literacy Test (ASHLT), which was used to evaluate knowledge acquisition through pre-tests and post-tests. The results were compared across the three teaching approaches.

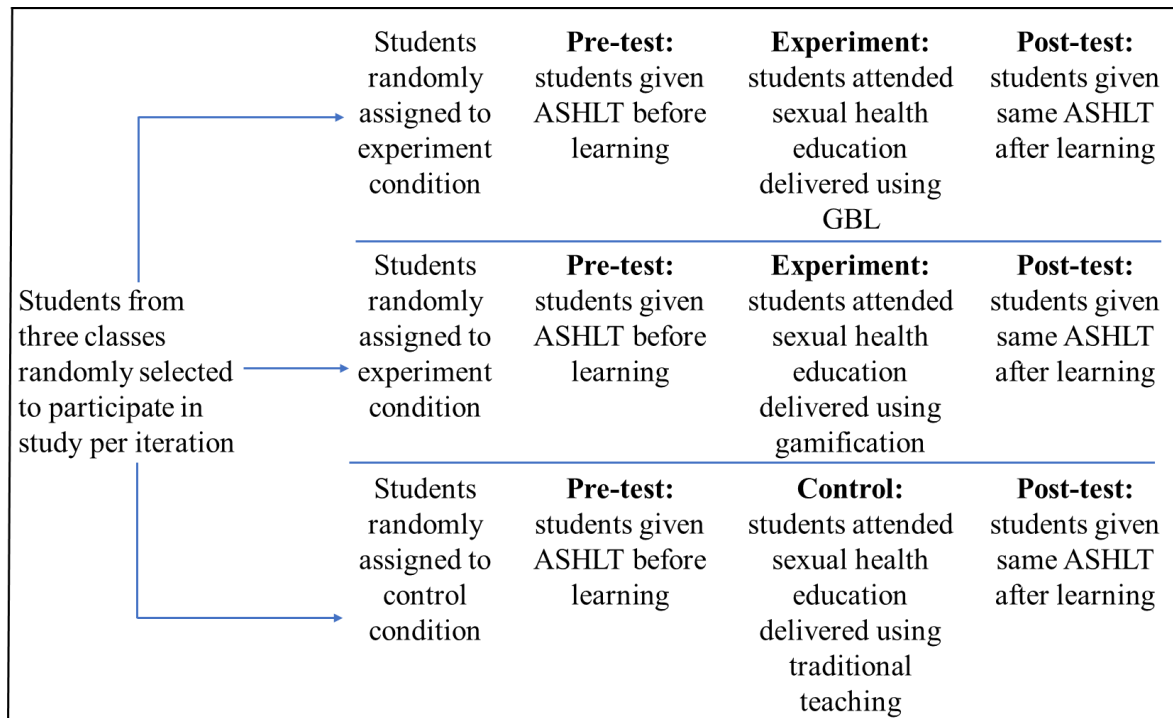
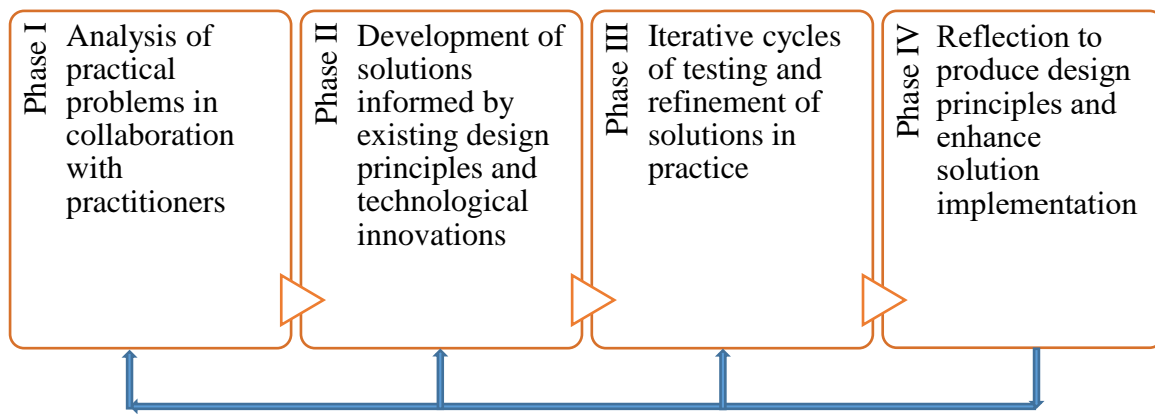


Fig. 2. A quasi-experimental research design of each iteration.

Also, we used the framework we developed named MAKE evaluation instrument to assess the efficacy of the digital game for fostering sexual health education. The game was examined for the extent to which it improved motivation, changed attitudes, increased knowledge and skills acquisition, and facilitated student engagement using self-ratings and interviews. The essence was to evaluate the students' perceptions of the teaching approaches. The MAKE framework was developed after noticing that there was a limited list of comprehensive instruments for evaluating the efficacy of digital health games from all distinct areas that determine the learning as either effective or not (Jiang *et al.*, 2017). It was found suitable for examining the effectiveness of digital health games that aim to improve sexual health education. The details of the development of the MAKE framework evaluation instrument has been reported in another article (Haruna *et al.*, 2019).

The usage of Design-Based Research

Design-based research (DBR) was used to guide the design, develop, test and refine the digital game in iterative cycles. DBR is “a systematic but flexible methodology, aimed at improving educational practices through iterative analysis, design, development, and implementation, involving the collaboration of researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories” (Wang and Hannafin, 2005, pp. 6–7). Figure 3 presents four phases of DBR and three iterations of testing and refining the developed digital health game intervention in practice (Reeves, 2006). We followed this procedure.



Refinement of Problems, Solutions, Methods, and Design Principles

Fig. 3. DBR's four phases of the development of a digital health game.

Iterative design process

We employed three iterative cycles. The testing and refinement of the game were carried out over three cycles. Three secondary schools in Dar es Salaam were selected to participate in the testing, each for a different cycle. DBR intervention is normally tested in acyclic coil face (Kelly, 2004). Table 1 presents three cycles of testing the game, and each iteration is described in detail below.

Table 1. Three iterations of testing and refine the three teaching conditions

Iteration	Time	School type	Streams/ Class	No. of Students	Teaching condition
First	5weeks	Government school	Form One	40	Traditional
			Form One	40	GBL
			Form One	40	Gamification
Second	5weeks	Private school	Form One	36	Traditional
			Form One	36	GBL
			Form One	36	Gamification
Third	5weeks	Religious school	Form One	40	Traditional
			Form One	40	GBL
			Form One	40	Gamification

First iteration

The first iteration of testing the ***“My Future Begins Today”*** digital gamified learning for sexual health education occurred from February to May 2017. The particular government school was selected based on the availability of computer facilities and a sufficiency of a total number of 120 students in three classes. The participating population comprised Form One

students, aged 11–15 years. A randomised controlled trial was used to assign randomly students to one teaching condition. Each condition had 40 students. There were two classes for experimental conditions: students who were taught using game-based learning and gamification (one for each class), and one class of control condition made up of those who were subjected to the traditional teaching approach. Using the MAKE framework, each learning approach was evaluated and compared with the others to determine its efficacy in improving sexual health education. The details of the testing of the first iteration and its results are reported in a published article (Haruna *et al.*, 2018).

After evaluation and comparison, student recommendations became the basis for refining the game. Those recommendations are presented in the second iteration section below. As suggested elsewhere. Further cycles of testing and refinement were based on the results of the first iteration (Herrington *et al.*, 2007). The following main limitation were found. The game structure tested in the first iteration is presented in Figure 4. The first draft of the digital health game could only keep records of a single user and his/her respective scores. It had no way of handling multiple users. It could not calculate their high score in comparison with one another. The user interface was limited with little interaction. These limitations were discovered during testing the digital health game. These concerns were addressed before testing in the second iteration.

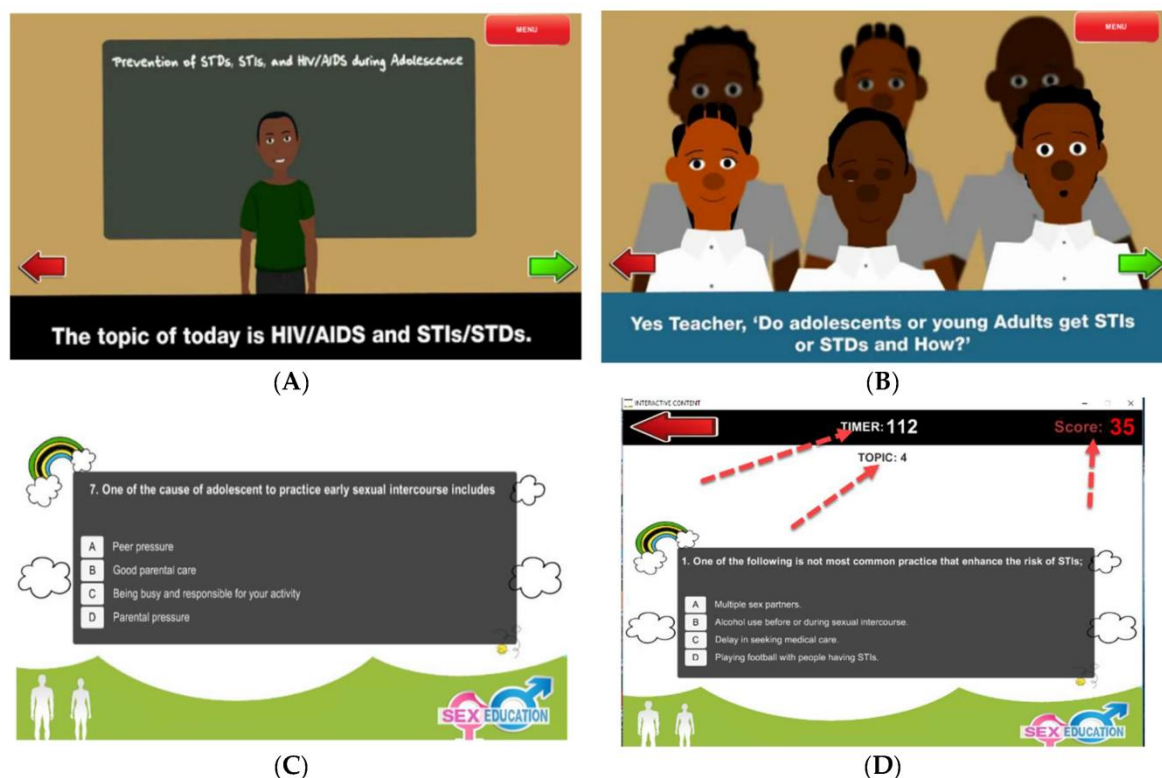


Fig. 4. The initial digital health game used in the first round. (A) Scenario: teacher presenting the topic; (B) Scenario: student attending the class; (C) Questions; (D) Activity time, topic, and scores.

Second iteration

The limitations identified in the first iteration were addressed in this iteration. After testing the game, refinements were made. The user interface was changed. The game was modified to allow for more interactions; there could be multiple users; students were able to compare

each other's scores in a leader boards; and players were ranked from highest to the lowest. Also, students were able to skip topics and select the one they wanted to play. They no longer had to start with first topic. The quizzes had avatars or images for improving engagement of the players. Finally, the game instruction were expanded and better elaborated. These changes can be seen by looking at the user interface in the second iteration, as presented in Figure 5. After these refinements, the game was tested and evaluated again. More details of the second iteration procedures and results are reported in another article. The limitations of the game that were identified in the second round were accommodated during refinement for the last round. The details are presented below.

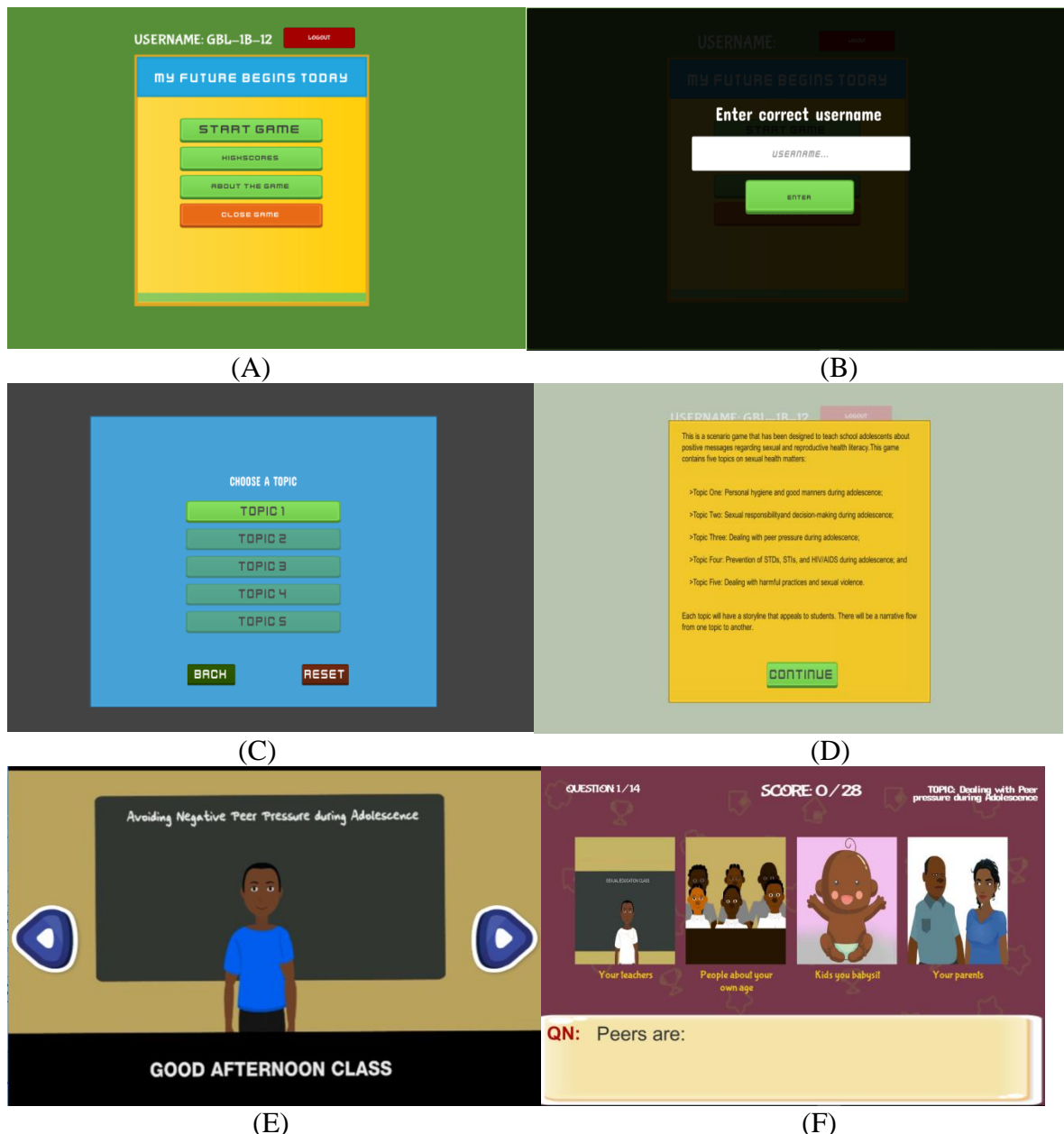
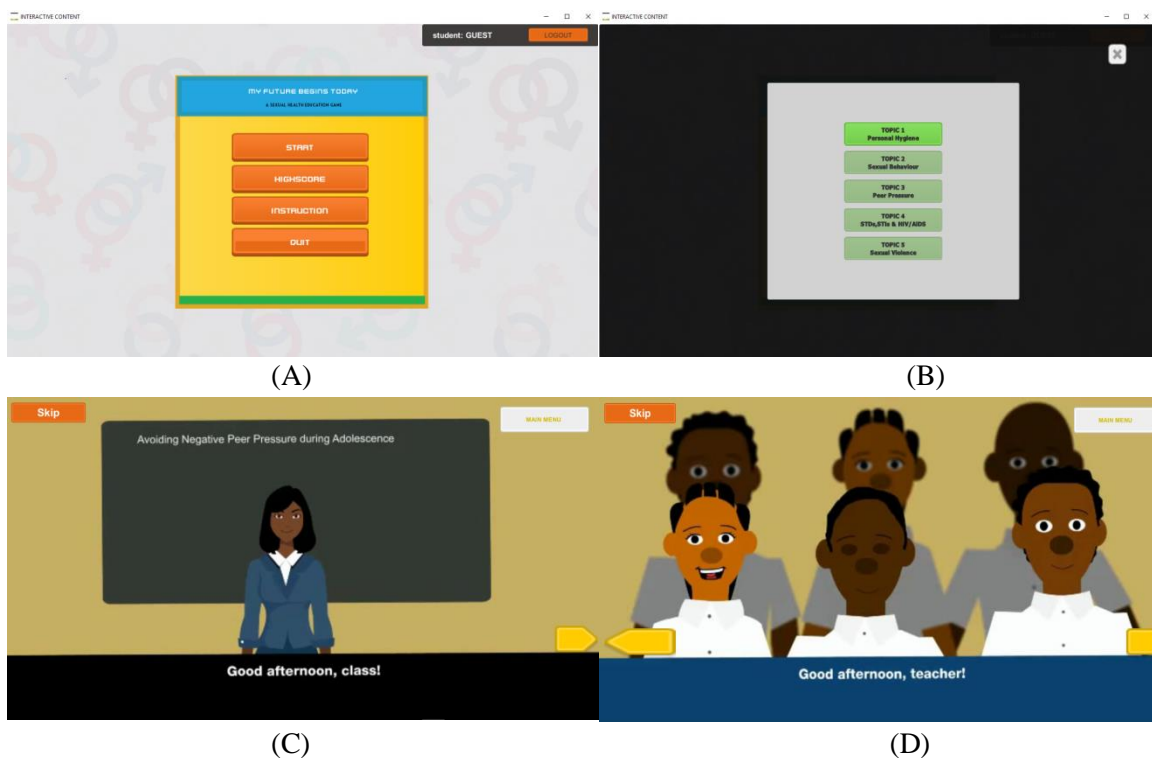


Fig. 5. The game user interface in the second iteration. (A) Home screen; (B) User login screen; (C) Topic selection screen; (D) Game instruction screen; (E) Teacher teaching screen; (F) Question screen.

Third iteration

The limitations of the game identified during the second iteration paved the way for further refinement of the game. The following changes were made: (1) Most of the codes were re-written. (2) The graphics were changed, e.g., a new, constantly moving background on the home screen. This increases interaction with the player. (2) A less crowded leader-board was added to the menu. (4) A new colour pallet. (5) A change in the positioning on the screen of the logged in student's name. (5) Ability to read the topic name before picking the topic. (6), content revision [i.e. replaced with cleaner ones]. A new, female teacher is introduced for topics three and four.

Additionally, (7) new user interface components in the classroom were added. Now the players could choose to skip the class and start attempting to answer questions. The game now disables the button that reverses what the teacher said previously upon starting, as can be noticed on the image. Additionally, a game player had the ability to go back to the menu. (8) The font sizes were standardised. Fonts are now of the same size throughout the class session. Experts had pointed to the previous inconsistency as a problem. (9) There was a new user interface and new images for the game question. The new version had improved several aspects of the question user interface. First, it included a challenging time to the player in which he is supposed to complete each questioning stage in less than 90 seconds. The question field and answer buttons have been visually improved. In addition, the new version includes new avatar answers. See Figure 6 for more details.



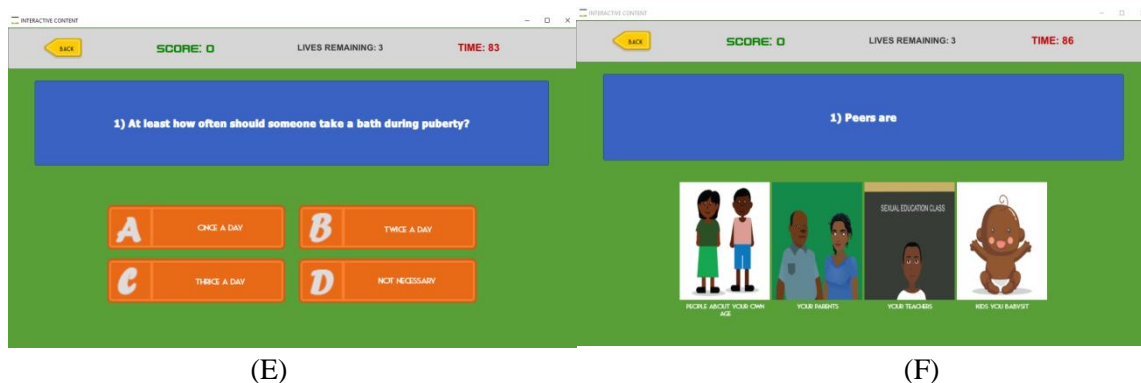


Fig. 6. The game structure in the third iteration. (A) Home: welcome screen; (B) Topic selection; (C) Female teacher; (D) Student interface; (E) Multiple choices questions; (F) Avatar question type.

Methods

This study employed a quasi-experimental randomised controlled trial research design using two experimental conditions (i.e., game-based learning and gamification) with an existing traditional instructional approach serving as a control condition. Since sexual health education is mandatory for all students in each class based on the school curriculum, schedule, and the country's strategy, the quasi-experimental research design was used to evaluate and compare the effectiveness of three teaching methods used in conducting sexual health education for students who were not randomly assigned to either experiments (treatment) or control conditions. Details of settings, participants, data collection, and analysis are presented below.

Settings and Participants

Using a clustering sampling technique, three secondary schools from Dar es Salaam were purposively selected to participate in the study. The criteria used for selection of schools to participate in this study were based on the availability of three classes (i.e., Form One A, Form One B, and Form One C) at each school per iteration, the availability of computer labs equipped with ICT facilities (i.e., enough computers to accommodate two experiment condition groups, internet connectivity, and reliable power supply and possession of a standby generator). As students were already in their existing classroom, there was no possibility of randomly assigning them to either intervention or control group apart from basing the selection on school planning (Newby, 2014; Aydın *et al.*, 2018). Thus, all the Form One students in the three selected schools each constituted a cluster as a unit of sample which represented other schools in the study settings.

A total of 348 secondary school participants (students) aged between 11 and 15 years from three schools were recruited to participate in this study; there were 193 boys (55.5%), and 155 girls (44.5%). For each iteration, students were from three class levels with equal educational status. Students in each class participated in one of the three conditions, namely game-based learning, gamification, and traditional teaching. In each iteration, each condition comprised 36~40 students, who were not exposed to the teaching methods of the other classes or conditions. Specifically, the first and third iteration each had 120 students, and the second iteration involved 108 students. The study approaches were approved by purposive Human Research Ethics Committee (HREC) at the University of Hong Kong. In addition, parental or guardian consent was obtained before data collection.

Data Collection and Analysis Procedures

A mixed research method was used to collect and analyse data for this study (Creswell and Clark, 2011). While quantitative data was collected using pre-test, post-test, and the survey, the qualitative data was collected using interviews. To assess prior knowledge and experience about sexual health, a pre-test sexual health information literacy assessment was administered before the beginning of the class (one week before the intervention). Students were given up to 45-minutes to complete the questions. To evaluate the acquisition of sexual health knowledge from the three teaching methods, all the students were given a post-test within one week after the intervention that contained the same questions and order as those attempted during the pre-test. All the tests results were compared across the three teaching conditions.

The validate MAKE model instrument (Haruna *et al.*, 2019) was used for measuring success in teaching and knowledge acquisition using self-ratings and interviews. The MAKE model is an abbreviation for teaching approaches' motivating learning, promoting a change of attitude, enhancing knowledge acquisition, and engaging students. Within one week after the intervention, the students received a questionnaire and interviews about the efficacy of the three teaching methods based on the MAKE instrument. Students were given 15 minutes to complete the questionnaire, and those attending the interviews were given roughly equal time within an hour session to provide their comments. IBM SPSS Statistics Version 24 was used to analyse the quantitative data collected using pre-test and the MAKE survey instrument. On the other hand, the interview transcripts were selected to supplement and corroborate the quantitative results based on the themes contained in the MAKE instrument.

Results

A paired t-test was used to compare pre-test and post-test scores to establish differences in test scores before sexual health literacy training and after the training. The results demonstrated that there were statistically significant differences for pre-test with an average of 26.40 (7.29) and post-test 74.12 (16.21): $t(347) = 52.230$; $p < 0.000$. The general average increase in the sexual health literacy test scores was 47.72. We performed a One Way ANOVA to compare three groups' average scores for pre-tests and post-tests. The results demonstrated an equal level of sexual health literacy scores among three groups as no significant differences were detected for pre-tests ($F(2,345) = 593$, $p = 0.553$). For post-test scores, the average significant differences were demonstrated across three groups ($F(2, 345) = 210.43$, $p < 0.001$). Furthermore, a follow-up Tukey Post-Hoc test was used to examine where the differences lie across three groups. The results indicated that the gamified learning platform groups performed better than the traditional teaching group. These results imply that the gamified learning platforms designed for low-tech settings could be better in the delivery of sexual health education than traditional teaching. Moreover, the feedback from gamified learning platform groups shows that sexual health literacy delivered using game-based learning and gamification significantly improved the participants' motivation. Additionally, the gamified learning platforms also boosted their attitude change, enhanced their knowledge acquisition, and fostered their engagement in active learning. In contrast, the traditional

teaching method was shown to have largely failed to add value or generate students' interest to engage in active learning.

Discussion

This paper aimed at demonstrating the design process used for the development of innovative “My Future Begins Today” digital gamified learning platform for sexual health education suited to low-tech in an area of SSA. This is due to the fact that the quality of developed games is not as advanced as those implemented in high tech settings. We developed a very simple game and adjusted it for a low tech environment, limited resources, and students' characteristics. Hence, throughout the three iterations, the post-test average scores for participants in the gamified learning groups were significantly higher than for those in the traditional teaching group. In other words, participants exposed to the gamified learning platforms increased their sexual health literacy than participants in the traditional teaching group. These results were consistent over the MAKE framework, with participants in the gamified learning platform groups positively perceived their gamified learning platforms regarding the delivery of sexual health education, whereas participants in the traditional teaching negatively perceived their teaching approach.

These preliminary findings suggest that the enhanced gamified learning platforms were more effective in improving the acquisition of sexual health literacy for the participating students than the traditional method. Implicitly, the enhanced gamifying sexual health literacy could potentially contribute significantly to the enhancement of safe and healthy sexual practices among adolescents and, thus, significantly improve their sexual wellbeing throughout the three iterations. This damning verdict exposes the shortcomings of the traditional teaching method when it comes to teaching sexual content among adolescents in low-tech and resource-limited contexts, where it is also culturally taboo to talk about sexual matters with the youth in public spaces. Therefore, the gamified learning and teaching approach could be viable for improving adolescents' attitude change.

The activity theory guided the whole process of creating, testing, and refining of the game. This could be a reason why the game was easily accepted in testing and showed significant improvement in sexual health knowledge acquisition and attitude change. Activity theory made the participants value their efforts as they felt they were working to address critical problems facing adolescents. This devotion of efforts to participate in the design of the game was a sign that the game is highly needed by the digital savvy population in the SSA countries. The stakeholders' involvement in developing the game provided a good understanding of the importance of the game to the adolescent students and how it was going to be used in addressing the identified problems.

Cycles of testing and refinement were also crucial in developing a sound digital game for sexual health education. As mentioned earlier, the design and development of My Future Begins Today was informed by DBR (Reeves, 2006). DBR shares some characteristics with activity theory, including stakeholder and targeted user engagement, outcome orientation, and the addressing of potential problems in a real-world setting. The three cycles refined the game through testing and feedback. This ensured that the game was user friendly and able to improve sexual health education. The use of iteration improves the performance of gamified learning platforms. It results in high interactions and performance during the learning process when playing, and that leads to better educational outcomes (Hieftje *et al.*, 2016; Jiang *et al.*, 2017).

Lastly, the application of PD contributed to the effectiveness of the game. It involved various actors from various fields who were relevant to the game. Also, engaging targeted users from the beginning resulted in the creation of a better correspondence to the preferences of end-users. PD has been recognised as an effective approach for the development of digital health games for sexual health education (Chu *et al.*, 2015; DeSmet *et al.*, 2016; Hieftje *et al.*, 2016; Haruna, Hu and Chu, 2018). It ensures that social and cultural norms are taken into consideration, making the game easily acceptable, usable, and useful (Chu *et al.*, 2015). Community engagement in designing led to the creation of effective technological interventions that cultivated social transformation (Bang and Vossoughi, 2016; Bang *et al.*, 2016) through addressing a public health threat facing the majority of adolescents during their adolescent stage in the study communities.

The designed interventions through community involvement helped participants to obtain the required knowledge and skills for practicing healthy sexual behaviours. The sexual health literacy skills obtained by participants will enable social transformation through the promotion of the sexual wellbeing of adolescents more effectively by using gamified learning platforms to deliver sexual health education and hence, improve the wellbeing of adolescents in the study communities (Bang *et al.*, 2016). PD also has a connection with both activity theory and DBR, which were also used in the development of gamified learning interventions. This enabled us to develop the gamified learning intervention that suits the local context need.

Conclusion and future research

The digital health gamified learning platform “My Future Begins Today” was developed to address ineffective teaching methods for sexual health education in the low-tech settings of SSA. The developed game was not as sophisticated as those developed in high-tech settings in order to cater to the low-tech settings’ limited resources, expertise, and students with little information technology literacy. The goal was to make an interactive learning environment using gamifying learning techniques that would improve students’ motivation, attitude, knowledge, and engagement. In SSA, there has been an increase in unhealthy sexual behaviour by adolescents. To our knowledge, this is the first digital gamified learning platform oriented toward the situation in SSA. Given that teaching sexual health in a regular classroom is uncomfortable, if not taboo, in most SSA countries, “My Future Begins Today” has the potential for improving sexual health education in low-tech settings. This could be the benefits of combining the constructs of motivation and engagement features in the digital gamified-learning-platforms, resulting in improved knowledge gain and attitude change. These features seem to be missing in the traditional teaching approach (Haruna, Hu and Chu, 2018; Sadiq Sani *et al.*, 2018; Haruna *et al.*, 2019).

Because the digital gamified learning platform, “My Future Begins Today” was developed in three cycles of testing and refinement, it best fits the context in which it was tested. So its success cannot automatically be generalised to all the approximately 50 countries of SSA. Future research is needed in the contexts of other SSA countries. Since only three of its schools participated in the testing, strictly, the testing results could not even be generalised to all of Dar es Salaam, let alone all of Tanzania or all of SSA. Nonetheless, our study no doubt provides a good starting point for work in similar environments. As such, a follow-up study could further test the validity regarding the efficacy of such game-based approaches to the provision of such sexual education to help in behavioural changes and knowledge retention, particularly on a sustainable basis. Further evaluation of the effects of digital health gamified

learning platforms need to be conducted by involving many schools. Since the digital health game was developed to be used on computers only, further development should be considered using other platforms, such as Facebook, websites, and smart mobile devices. Investigation using various variables, including social-economic status, could be a further research direction.

References

- Aarø, L., Mathews, C., Kaaya, S., Katahoire, A., Onya, H., Abraham, C. and Klepp, K. et al. (2014), "Promoting sexual and reproductive health among adolescents in southern and eastern Africa (PREPARE): project design and conceptual framework", *BMC Public Health*, Vol. 14 No 54, pp. 18. <https://doi.org/10.1186/1471-2458-14-54>
- Arnab, S., Brown, K., Clarke, S., Dunwell, I., Lim, T., Suttie, N. and Louchart, S. et al. (2013), "The development approach of a pedagogically-driven serious game to support Relationship and Sex Education (RSE) within a classroom setting", *Computers & Education*, Vol. 69, pp.15-30. <https://doi.org/10.1016/j.compedu.2013.06.013>
- Aydın, U., Tunç-Pekkan, Z., Taylan, R. D., Birgili, B. and Özcan, M. (2018), "Impacts of a university–school partnership on middle school students’ fractional knowledge: A quasiexperimental study", *Journal of Educational Research*, Vol. 111 No 2, pp. 151–162. <https://doi.org/10.1080/00220671.2016.122035>
- Bang, M., Faber, L., Gurneau, J., Marin, A. and Soto, C. (2016), "Community-Based Design Research: Learning Across Generations and Strategic Transformations of Institutional Relations Toward Axiological Innovations", *Mind, Culture, and Activity*, Vol. 23 No. 1, pp. 28–41. <https://doi.org/10.1080/10749039.2015.1087572>
- Bang, M. and Vossoughi, S. (2016), "Participatory Design Research and Educational Justice: Studying Learning and Relations Within Social Change Making", *Cognition and Instruction*, Vol. 34 No. 3, pp. 173–193. <https://doi.org/10.1080/07370008.2016.1181879>
- Carvalho, M.B., Bellotti, F., Berta, R., De Gloria, A., Sedano, C.I., Hauge, J.B. and Hu, J. et al. (2015), "An activity theory-based model for serious games analysis and conceptual design", *Computers and Education*, Vol. 87, pp. 166–181. <https://doi.org/10.1016/j.compedu.2015.03.023>
- Cates, J.R., Fuemmeler, B.F., Diehl, S.J., Stockton, L.L., Porter, J., Ihekweazu, C. and Gurbani, A.S. et al. (2018), "Developing a serious videogame for preteens to motivate HPV vaccination decision making: Land of Secret Gardens", *Games for Health Journal*, Vol. 7 No.1, pp. 51–66. <https://doi.org/10.1089/g4h.2017.0002>
- Chib, A. (2011), Promoting Sexual Health Education via Gaming: Evidence from the Barrios of Lima, Peru. In *Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches* (pp. 895-912). IGI Global. Retrieved from <https://books.google.com/books?id=G9oJ8KpDbM4C&pgis=1>
- Chu, S.K.W., Kwan, A.C., Reynolds, R., Mellecker, R.R., Tam, F., Lee, G. and Hong. et al. (2015), "Promoting Sex Education Among Teenagers Through an Interactive Game: Reasons for Success and Implications", *Games for Health Journal*, Vol. 4 No. 3, pp.

168–174. <https://doi.org/10.1089/g4h.2014.0059>

Creswell, J. W. and Clark, V. L. P. (2011), *Designing and conducting mixed methods research* (2nd ed.). SAGE Publications, Thousand Oaks.

DeSmet, A., Thompson, D., Baranowski, T., Palmeira, A., Verloigne, M. and De Bourdeaudhuij, I. (2016), "Is participatory design associated with the effectiveness of serious digital games for healthy lifestyle promotion? A meta-analysis", *Journal of Medical Internet Research*, Vo. 18 No. 4, pp. 1–19. <https://doi.org/10.2196/jmir.4444>

Duncan, L. R., Hieftje, K. D., Culyba, S. and Fiellin, L. E. (2014), "Game playbooks: Tools to guide multidisciplinary teams in developing videogame-based behavior change interventions", *Translational Behavioral Medicine*, Vo. 4 No.1, pp. 108–116. <https://doi.org/10.1007/s13142-013-0246-8>

Engeström, Y. (2008), "Enriching activity theory without shortcuts", *Interacting with computers*, Vol. 20 No. 2, pp. 256–259. <https://doi.org/10.1016/j.intcom.2007.07.003>

Fiellin, L.E., Hieftje, K.D., Pendergrass, T.M., Kyriakides, T.C., Duncan, L.R., Dziura, J.D. and Sawyer, B.G. et al. (2017), "Video game intervention for sexual risk reduction in minority adolescents: randomized controlled trial", *Journal of Medical Internet Research*, Vol. 19 No. 9, 1–13. <https://doi.org/10.2196/jmir.8148>

Haruna, H., Hu, X. and Chu, S. K. W. (2018), "Adolescent school-based sexual health education and training : A literature review on teaching and learning strategies", *Global Journal of Health Science*, Vol. 10 No. 3, pp. 172–183. <https://doi.org/10.5539/gjhs.v10n3p172>

Haruna, H., Hu, X., Chu, S. K. W. and Mellecker, R. R. (2019), "Initial validation of the MAKE framework: A comprehensive instrument for evaluating the efficacy of game-based learning and gamification in adolescent sexual health literacy", *Annals of Global Health*, Vol. 85 No. 1, pp. 19. <https://doi.org/10.5334/aogh.1110>

Haruna, H., Hu, X., Chu, S., Mellecker, R., Gabriel, G. and Ndekao, P. (2018), "Improving sexual health education programs for adolescent Students through Game-Based Learning and Gamification", *International Journal of Environmental Research and Public Health*, Vol. 15 No. 9, pp. 2027. <https://doi.org/10.3390/IJERPH15092027>

Herrington, J., McKenney, S., Reeves, T. and Oliver, R. (2007, June). Design-based research and doctoral students: Guidelines for preparing a dissertation proposal. In *EdMedia+ Innovate Learning* (pp. 4089–4097). Association for the Advancement of Computing in Education (AACE). <https://doi.org/10.1017/CBO9781107415324.004>

Hieftje, K., Fiellin, L.E., Pendergrass, T. and Duncan, L.R. (2016), "Development of an HIV Prevention Videogame Intervention: Lessons Learned", *Int. J. Serious Games*, Vol. 3, No. 2. pp. 83–90. <https://doi.org/10.17083/ijsg.v3i2.110>

Jiang, R., McKanna, J., Calabrese, S. and Seif El-Nasr, M. (2017), "Iterative Design and Testing for the Development of a Game-Based Chlamydia Awareness Intervention: A Pilot Study", *Games for Health Journal*, Vol. 6 No. 4, pp. 205–216. <https://doi.org/10.1089/g4h.2016.0112>

- Kachur, R., Mesnick, J., Liddon, N., Kapsimalis, C., Habel, M., David-Ferdon, C., and Brown, K. et al. (2013), "*Adolescents, Technology and Reducing Risk for HIV, STDs and Pregnancy*". Atlanta, GA: Centers for Disease Control and Prevention. Retrieved from <https://www.cdc.gov/std/life-stages-populations/adolescents-tech.htm>
- Kaptelinin, V. (2013), Activity Theory. In *The Encyclopedia of Human-Computer Interaction, 2nd Ed.* (2nd ed.). International Design Foundation. Retrieved from <https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/activity-theory>
- Kelly, A. (2004). "Design Research in Education: Yes, but Is It Methodological?" *Journal of the Learning Sciences*, Vol. 13 No. 1, pp. 115–128. Retrieved from http://www.jstor.org.lib-proxy.fullerton.edu/stable/1466935?seq=1#page_scan_tab_contents
- Lakkala, M. and Ilomäki, L. (2015), "A case study of developing ICT-supported pedagogy through a collegial practice transfer process", *Computers and Education*, Vol. 90, pp. 1–12. <https://doi.org/10.1016/j.compedu.2015.09.001>
- Mkumbo, K. A. (2012), "Teachers' Attitudes towards and Comfort about Teaching School-Based Sexuality Education in Urban and Rural Tanzania", *Global Journal of Health Science*, Vol. 4 No. 4, pp. 149–158. <https://doi.org/10.5539/gjhs.v4n4p149>
- Newby, P. (2014), *Research methods for education. Minerals* (2nd ed.). Routledge, London. <https://doi.org/10.1017/9781316226889.002>
- Parliamentary Office of Science and Technology (2006) *ICT in developing countries, March 2006: POSTnote 06/261., Research publications/Research briefings*. Available at: <https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-261#fullreport> (Accessed: 20 April 2019)
- Reeves, T. (2006), "Design research from a technology perspective", in J. Van Den Akker, K. Gravemeijer, S. McKenney, N. N. (ed.) *Educational Design Research*, Taylor & Francis Group, London. <https://doi.org/10.4324/9780203088364-13>
- Roth, W.-M. and Lee, Y.-J. (2007), "'Vygotsky's Neglected Legacy': Cultural-Historical Activity Theory", *Review of Educational Research*, Vol. 77 No. 2, pp. 186–232. <https://doi.org/10.3102/0034654306298273>
- Sadiq Sani, A., Abraham, C., Denford, S. and Mathews, C. (2018), "Design, implementation and evaluation of school-based sexual health education in sub-Saharan Africa: a qualitative study of researchers' perspectives", *Sex Education*, Vol. 18 No. 2, pp. 172–190. <https://doi.org/10.1080/14681811.2017.1414040>
- Sani, A. S., Abraham, C., Denford, S. and Ball, S. (2016), "School-based sexual health education interventions to prevent STI/HIV in sub-Saharan Africa: a systematic review and meta-analysis", *BMC Public Health*, Vol. 16 No. 1, pp. 1–26. <https://doi.org/10.1186/s12889-016-3715-4>
- Sommer, M., Likindikoki, S. and Kaaya, S. (2015), "'Bend a Fish When the Fish Is Not Yet Dry': Adolescent Boys' Perceptions of Sexual Risk in Tanzania", *Archives of Sexual Behavior*, Vol. 44 No. 3, pp. 583–595. <https://doi.org/10.1007/s10508-014-0406-z>

- Swarts, P. and Wachira, E. M. (2010), *Tanzania: ICT in education-situational analysis*. Dar Es Salaam.
- Temple-smith, M., Moore, S. and Rosenthal, D. (2016), *Sexuality in Adolescence: The digital generation*, Taylor & Francis Group, New York.
- Tsegay, S. M. (2016), "ICT for post-2015 education: An analysis of access and inclusion in sub-Saharan Africa", *International Journal of Research Studies in Educational Technology*, Vol. 5 No. 2, pp. 1–14. <https://doi.org/10.5861/ijrset.2016.1447>
- UNESCO (2015), *Information and Communication Technology (ICT) in Education in sub-Saharan Africa: A comparative analysis of basic e-readiness in schools.*, *Information Paper No. 25*. Montreal. <https://doi.org/10.15220/978-92-9189-178-8-en>
- Unity Technologies (2016), *Game engine, tools and multiplatform*, Unity Technologies. Available at: <https://unity3d.com/es/unity> (Accessed: 14 November 2016).
- Wang, F. and Hannafin, M. J. (2005), "Design-Based Research and Technology-Enhanced Learning Environments", *Educational Technology Research and Development*, Vol. 53 No. 4, pp. 5–23. Available at: <https://www.jstor.org/stable/30221206>.
- Yip, J. C. *et al.* (2017) "Examining Adult - Child Interactions in Participatory Design", in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, Denver, pp. 5742–5754. <https://doi.org/dx.doi.org/10.1145/3025453.3025787>
- Zhang, Q., Huhn, K. J., Tan, A., Douglas, R. E., Li, H. G., Murti, M. and Lee, V. (2017), "'Testing is healthy' TimePlay campaign: Evaluation of sexual health promotion gamification intervention targeting young adults", *Canadian Journal of Public Health*, Vol. 108 No. 1, pp. e85–e90. <https://doi.org/10.17269/CJPH.108.5634>