



A Study of a Serious Game for Adolescents and Young Adults with Leukemia

Al-Anazi WK¹, Alsuhebah AM², Estanislao A², Al-Jasser AM³, Al-Hashmi H², Al-Anazi KA^{2*}

¹College of Computer and Information Sciences, Prince Sultan University, Riyadh, Saudi Arabia

²Department of Hematology and Hematopoietic Stem Cell Transplantation, King Fahad Specialist Hospital, Dammam, Saudi Arabia

³Department of Microbiology, Riyadh Regional Laboratory, Riyadh, Saudi Arabia

Abstract

Serious games sparked the possibility of promoting interactive technology in healthcare sector. The design of serious games relies heavily on the experience of the targeted users. The aim of this study is to design and evaluate suitable mechanics of a serious game for adolescents and young adults with leukemia in Saudi Arabia. The study followed usability testing approach by evaluating low-fidelity and high-fidelity prototypes. This study showed that the suitable mechanics in serious game design for adolescents and young adults with leukemia were: mechanics of interaction and play experience comprising of the story, different levels, and characters; mechanics of integrating knowledge and learning including brief dialogues and alerts; and mechanics concerning patients' conditions and constraints consisting of relaxing sound effects and pausing option.

Keywords: Serious Games; Usability Testing; Adolescents and Young Adults; Leukemia; Saudi Arabia

Introduction

Recently, serious games utilize game concepts in non-game context have gained attention in the field of healthcare [1,2]. Game design appeals most to adolescents and young adults since they have great exposure to technology than other age groups [3]. Leukemia treatment regimens are complex and every patient follows specialized treatment plan. Adolescents and young adults with leukemia find difficulty once diagnosed in adherence to treatment [4].

Designing serious games remains perplexing. Mechanics in serious games act as rules that possess the ability to motivate users including point system, badges, leaderboard, narratives, and avatars. There is a lack in the guidelines of designing mechanics that achieve the desired outcomes of serious games for adolescents and young adults with leukemia [5].

Arising challenges in developing serious games in health have been found in many aspects including: the experience and usability issues faced by participants; the inclusion of fun aspect in designing serious games; a game design that is aligned with the targeted group preferences; the patients' conditions and constraints; the psychological impact of the game; and the complexity of requirements as well as the content design of such serious games [6–11].

Moneta's [12] theory of flow is an essential game design principle to achieve a balance between the player's current skill level and the game challenge level. Winn [13] proposed a framework of Design, Play and Experience (DPE) that provides guidelines for serious game design which consisted of learning layer, storytelling layer, gameplay layer, user experience layer, and technology layer.

Early user involvement eliminates ambiguities of understanding the unique requirements of serious game design. The aim of the study is to choose suitable game mechanics to support adolescents and young adults with leukemia in their serious game play experience. This was tackled by identifying the requirements of intended users, developing two prototypes of a serious game, and evaluating these prototypes.

Related Work

Stinson et al. [14,15] proposed a pain assessment mobile application, called Pain Squad app, which keeps track of daily pain level for children and adolescents with cancer. The prototype

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*Correspondence:

KA Al-Anazi, Department of Adult Hematology and Hematopoietic Stem Cell Transplantation, Oncology Center, King Fahad Specialist Hospital, Saudi Arabia,

E-mail: kaa_alanazi@yahoo.com

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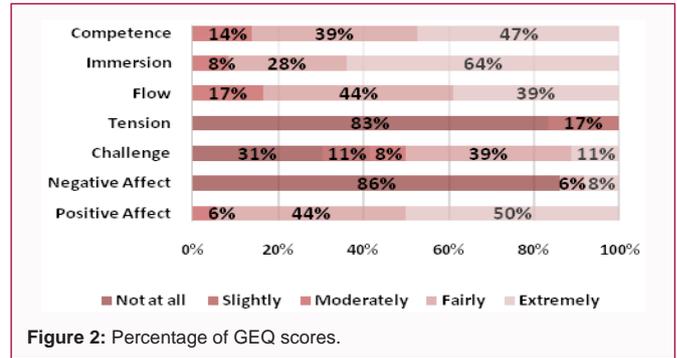
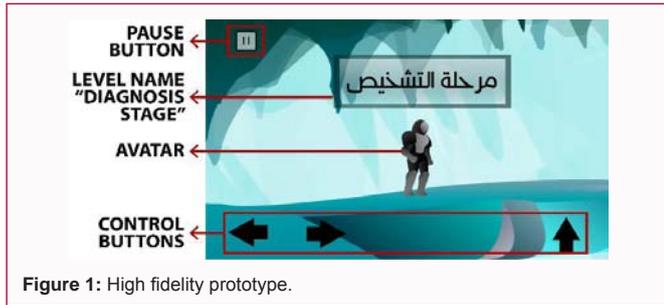
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was refined based on feedback from low-fidelity and high-fidelity testing stages resulting in early recognition of usability issues. Main mechanics in this prototype involved progress bar, rewards, and badges.

Fuchslocher et al. [16] designed Massively Multiplayer Online Role Playing Game (MMORPG) that promoted social integration among kids and adolescents with cancer during treatment. The evaluation process consisted of Game Experience Questionnaire (GEQ). Game mechanics consisted of the following: avatar, dialogues, story, leaderboards, messaging system, and pausing option.

Peters et al. [9] suggested an alternative solution to patients' written diaries that works as a remote data entry for reporting and monitoring the health conditions of adolescents and children. User Centered Design (UCD) approach was followed where experts were involved in the design process. The game design consisted of mechanics such as avatar, health bar, progress bar, and performance graphs.

Kato et al. [17] developed a serious game which promotes adherence to treatment for adolescents with leukemia and measured its effectiveness for improving positive behaviors for this age group. Avatar, dialogues, health bar, and story were examples of the main mechanics incorporated in the design.

Method

Usability testing was followed in this study [18–20]. Usability testing for serious games undergoes a cycle of:

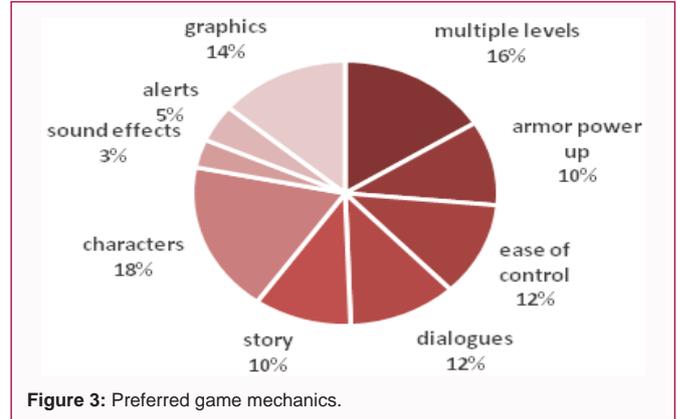
Initial study consists of defining an initial idea about the overall concept and identifies a brief game description. Initial study gathered insights about five patients game preferences by questionnaires and one physician's recommendations in creating the content of the game using a semi-structured interview.

Low fidelity design and usability testing revolves around generating game concept and game goals. A paper-card prototype was evaluated in low-fidelity stage by two physicians in a session and follow-up interview.

High fidelity design and usability testing where the actual code and design of aesthetics is generated. This stage is concerned about the development of high fidelity prototype which was accomplished using several software and hardware tools. High-fidelity testing was conducted in order to evaluate the game experience by patients.

Participants and Settings

In a high-fidelity study, a total of 29 participants (18 adolescents and young adults with leukemia) and medical and nursing team in charge of leukemia patients (five physicians and six nurses) were involved in the study. The study was conducted in the department of



adult hemato-oncology and stem cell transplant department at King Fahad Specialist Hospital (KFSH) in Dammam, Saudi Arabia. KFSH is one of the leading hospitals that provide stem cell transplantation in the Eastern region in Saudi Arabia.

Materials

A mobile-based prototype and questionnaires were used in this study. The mobile-based prototype was developed as 2D action-adventure for Android mobile devices in Arabic (Figure 1). The name of the game was Brave Ranger where this game aimed to take the player in an adventure throughout different levels of leukemia treatment plan. High-fidelity prototype was designed using Unity game engine and Adobe Illustrator.

High fidelity study included information sheet, consent form, and questionnaires. The questionnaires consisted of two parts which were:

Game Engagement Questionnaire (GEQ) questions: The in-game GEQ was adopted due to patients conditions in order to have a brief questionnaire as recommended by the physicians [21,22]. Brockmeyer [23] GEQ was designed using Likert five points scale (extremely = 4, fairly = 3, moderately = 2, slightly = 1, and not at all = 0). In-game GEQ consisted of items that measures seven dimensions which were the variables of the study including: competence, sensory and imaginative immersion, flow, tension, challenge, negative affect, and positive affect (Table 1). **Other gameplay and mechanics questions:** choosing the preferred mechanics; selecting mechanics that caused issues and dislikes; reaching the end of the game; and providing future suggestions.

Procedures and Analysis

Patients and medical and nursing team were asked to use the prototype and to complete the questionnaire afterwards. The score of each variable was derived from calculating the average of the two

Table 1: GEQ variables and their items [23].

Item no.	Statement	Variable
1	I was interested in the game's story	Immersion
2	I felt successful	Competence
3	I felt bored	Negative affect
4	I found it impressive	Immersion
5	I forgot everything around me	Flow
6	I felt frustrated	Tension
7	I found it tiresome	Negative affect
8	I felt irritable	Tension
9	I felt skillful	Competence
10	I felt completely absorbed	Flow
11	I felt content	Positive affect
12	I felt challenged	Challenge
13	I had to put a lot of effort into it	Challenge
14	I felt good	Positive affect

items. This was done after calculating the percentage of responses for these items in the 5-Likert scale.

Findings

The initial study gave an insight about the serious game design based on requirements gathered from the patients and their physicians. The patients preferred playing games in Arabic language. Patients were frequent players who preferred sophisticated games with an adventure and clear gameplay. The patients' player types were achievers, socializers, and explorers while their favorite game platform was PlayStation then Android and iPhone.

Boosting patient's positivity and avoiding mention sad and terrorizing events were considered in the design. The three main levels in the game as suggested by the physician were diagnosis stage, control stage, and cure stage. The serious game story began with a character (a brave ranger) who discovered the existence of monstrous cells and acquires certain abilities to eliminate them throughout the levels.

Level 1 (Diagnosis Stage): The first level showed the beginning of the appearance of cancer cells. The player met the medical team as characters that were not controlled by the player at the end of the level. The medical team provided an armor (chemotherapy armor) that helped the player in second level.

Level 2 (Control Stage): The player fought cancer cells and defended cancer cells attacks wearing the chemotherapy armor. An alert message was triggered by the player at a certain point during the gameplay which showed an advice for the player. At the end of the level, the player interacted with the medical team and received an armor upgrade and a new ability.

Level 3 (Cure Stage): The player was able to eliminate a powerful type of cancer cells instantly by a stem cell transplant ability.

Low fidelity resulted in an inclusion of a pause button in the game considering the requirements of patients' condition. Dialogues were shortened and level names were stated clearly at the beginning of every level.

The findings of high fidelity evaluation showed that the majority

of the participants were males. GEQ variables which are immersion, positive affect, and competence had the highest scores. Tension and negative affect were found to be the least in the game. The participants were strongly interested in the story and felt successful when playing the game. A fair level in the flow of the game was stated by the respondents. Competence was higher than challenge element in the game. Although the participants found that the game carried some element of challenge, they did not put a lot of effort in the game (Figure 2).

The preferred game mechanics were characters and multiple levels while alerts and sound effects were least chosen by the respondents (Figure 3). The majority of the reported issues were in jump command. There were minor issues experienced in movements, enemies, and sound. All of the participants successfully completed the game. Suggestions for future improvements included adding difficulty levels and improve the knowledge aspect in the game.

Discussion

The initial study was the first step in designing a serious game tailored for specific users. Bartle's [24] model gave an insight in incorporating desired game mechanics that were closer to the player types. The existence of game world (gameplay) was suitable for the respondents' player types including achiever, explorer, and socializer. These player types required interaction and acting features in a world [13,25]. It was noticed that game genres chosen by the respondents including role-playing and action-adventure consisted of a gameplay design. This entails that serious game with a gameplay rather than a mobile application with gamification elements should be pursued in the design [13].

Flow dimension which was the attribute of measuring the level of engagement was fair in this study similar to Fuchslocher et al. [16]. However, competence scores were found higher than the flow of the game which implied that participants were highly skilled in playing the prototype. As a result, the participants' competence scores affected the challenge dimension where the game experience had fallen under the category "easy" according to Moneta's [12] theory of flow. Suggestions for achieving the desired balance could include difficulty levels since the participants were skilled players and it was requested by them in high-fidelity study. This point might be supported by the guidelines of designing serious games to adolescents and young adults where they thrive for challenge in using games [26]. Tong et al. [6] found that the game was too easy for the participants which showed similar outcomes in this paper. Suggestions by Tong et al. [6] included using different levels ranging from easy to challenging in order to cover different aspects of skills. The majority of the participants in this study were males and this was similar to the study conducted by Kato et al. [17]. The results could follow the suggestions of Nielsen et al. [27] and Tondello et al. [11] which highlighted that males were motivated by higher challenge levels and competitive play more than females when playing games.

Designing the learning layer was found challenging in DPE model. As Graafland et al. [28] stated, early involvement of medical team was necessary for validation purposes, but it was vital in creating the concept of game design especially for complex and varying treatment plans for leukemic patients. Gathering requirements and designing content were found challenging and this highlighted a similar aspect reported by Peters et al. [9]. Another challenging aspect was conveying knowledge using dialogues game mechanic since most

of the respondents requested to increase the level of knowledge in this game. Winn et al. [13] showed that having a balance between story and learning sides of DPE storytelling layer in serious games was difficult to be achieved. The heterogeneity of cancer diagnosis and treatment plans was noticed as a challenging factor in this study which resembled the points raised by Kato et al. [17]. In user experience layer, jump control caused the majority of the issues and dislikes in high fidelity study.

The participants of the study found the concept of serious games appealing and encouraged future implications in the patient management. The study showed an immersive experience where characters and different levels reflecting disease stages were the main factors that contributed to this experience as selected by participants. Different levels could be incorporated to show variation of levels in gameplay mapped with distinct treatment stages. Ease of control and story came next according to patients' responses. A convenient approach was followed in presenting the story and content of the disease for patients in the serious game according to the physician's recommendations. Although death was a critical element of game design, this was approached by having the player being respawned (recreated) immediately after losing without displaying "you lose" message.

Furthermore, the design of serious games in healthcare is critical and may trigger unpleasant feelings for the patients. According to Baranowski et al. [7], there were concerns regarding the psychological impact since game mechanics affect the player's real life activities. Graafland et al. [28] and Majeed-Ariss et al. [29] urged the need of the involvement and the approval of physicians and nurses in order to validate the safety and the privacy of the patients. This study involved both medical and nursing team similar to other studies [9,14,16,17].

Arabic language was the main language of the prototype. This result imposed similarity of designing games based on the preferred language of participants which were found in adopting German language in studies done in Austria and Germany [9,16].

Low fidelity provided an early discovery of new mechanics (e.g. pause button) and enhancements of existing mechanics (e.g. dialogues). A pause button was added in order to ensure the continuity of play since patient condition might change suddenly and the patient loses progress in the gameplay. Kato et al. [17] recommended a smaller version of the game to be designed for patients who have advanced conditions or those who were not able to withstand longer times of play. Similarly, this prototype was brief taking into consideration the condition of the patient. As Tong et al. [6] stated, this study followed the recommendations of the physician in testing the prototype using portable devices that were easily carried in hospital settings.

The least selected game mechanics were alerts and sound effects. Sound effects act as an important mechanic in game development which ensures a complete immersive experience [30]. It is important to understand the culture when designing games for specific users. Some patients may not prefer to listen music during difficult times including sickness. This indicated that sound effects must be incorporated wisely for the targeted users such as including mute option in the game design.

The findings of Fuchslocher et al. [16] pointed out that there was a strong social and online community support whereas the results of this study revealed that it was least suggested as future improvement. The findings of this study may agree with several studies which

showed that adolescents do not prefer to have a game with mandatory online community support but may be an optional choice for them [3,26,31].

Game mechanics of the serious game were designed and evaluated for adolescents and young adults with leukemia in Saudi Arabia pursued the requirements of three purposes: (1) mechanics for interaction and play experience were: story, different levels, and characters; (2) mechanics for integrating knowledge and learning were: brief dialogues and alerts; and (3) mechanics concerning patients' condition and constraints were: relaxing sound effects and pause option.

Conclusion

Designing appropriate serious games in health for targeted users remains challenging. This study tackled the process of the design and the evaluation of a serious game for adolescents and young adults with leukemia in Saudi Arabia.

The methodology of the study consisted of the following usability testing approach which had three major parts of this study which are: initial study, low fidelity, and high fidelity. The mechanics of the serious game covered the three following purposes: interaction and play experience, knowledge and learning, patients' condition and constraints.

Understanding participants' requirements were necessary in the process of discovering suitable game mechanics. This study has a specific time-frame with a small sample size. The inclusion of a larger sample size can uncover new insights for future improvements. Future studies can explore more mechanics in the serious game based on the targeted group preferences. There is a need to tailor challenge aspect in order to provide a better flow and a better experience such as adding difficulty levels.

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