



Developing an open-source serious game for control and education on HPV and Cervical Cancer

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Abstract - HPV - short for human papillomavirus - is a virus capable of infecting the mucous membranes and skin, being the most prevalent involved on Sexually Transmitted Diseases and the main cause of Cervical Cancer. However, reaching out to and inviting all eligible people for cervical cancer screening and vaccination against HPV is a difficult task. A possible solution is the use of social inducement and gamification through modern means of communication, which may encourage the attendance of unscreened or unvaccinated people on related programs. Therefore, this paper presents the development of a serious game for the Android platform designed for children and preteens with the purpose of foresting HPV and Cervical Cancer awareness, information seeking, and communication, thus possibly increasing the number of vaccinated and screened people.

Keywords: serious games, HPV, Cervical Cancer, Android, open-source.

I. INTRODUCTION

HPV infection is very common, but transient, regressed spontaneously most of the time. However, there are more than 150 different types of HPV, with at least 13 considered oncogenic, presenting a greater risk or probability of provoking persistent infections and being associated with cancer precursor lesions [1].

Approximately 291 million women in the world are carriers of HPV, with 32% of these infections due to types 16, 18 or both, responsible for 70% of all cervical cancer cases worldwide. These numbers are small when compared to the 80% of all sexually active women who will be infected by one or more types of HPV at some point in their lives [1]. Although the possibility of reducing the number of Cervical Cancer cases through HPV vaccination is a global perspective and that the latter has been present on many countries, studies have shown that there still is an unsatisfactory knowledge rate about the subject.

Evidence suggests that many parents are hesitant to decide on HPV vaccination at the recommended ages. Engaging preteens in this dialogue can be particularly challenging for parents because it involves discussing how the virus is transmitted [2]. Therefore, communication strategies tailored to children and preteens, both boys and girls, to motivate HPV and Cervical Cancer discussions are urgently needed, since they may lead to an uptake on HPV vaccination.

Serious games have become very useful tools to encourage behavioral changes among the players. Because they have the ability to approach players in different ways

from other media [3], health-related games can help players learn about prevention and self-care by improving their health-related habits and skills [4]. Such games are also increasingly being used to train health care professionals in methods of diagnosis, patient monitoring, medical procedures, and support in epidemic and natural disasters scenarios.

There is a history of using serious games with patients since the beginning of the first home video games in the 1980s, and this has evolved into a focus on developing tailor-made games for different groups of diseases [5]. Currently, health games are being developed and tested on a wide range of diseases, both for prevention and treatment, and several studies have been published on games related to medical and psychiatric conditions, rehabilitation, public health, as well as on patients and survivors of cancers.

To promote healthy behavior to players, such games often feature relatable characters, introduce scenarios involving making health decisions and portray realistic consequences for the player's actions and choices. Some of the many advantages of the format is that games offer unlimited chances for replay and training, and communication can be customized for each player according to their performance.

Thus, this work seeks to present the prototype of a serious game for control and education on HPV and Cervical Cancer that is particularly focused on displaying relevant information about their prevention.

This paper is structured as follows: on section 2 we present the concepts relevant to the objects of study, including employed technologies. Section 3 explains the process of conceiving and implementing an open-source serious game.

II. FUNDAMENTAL THEORY

A. Study Context

It is worth mentioning that the game is designed to be part of a larger multidisciplinary program, which aims to identify the challenges related to women's health and to elaborate actions aimed at their prevention and protection.

Among the strategies adopted by the program is the use of knowledge and data generated by multiple researches in the service to the female population and in training of health professionals, as well as in technological innovation, with the development of applications, electronic questionnaires and computer vision software for quality monitoring models.

Development of the game is driven by a partnership between researchers from Pharmacy and Computer Engineering, and is intended to be used in conjunction with specific community actions, including an effort for its advertisement at certain municipal schools, where the game will be initially made available to general public.

B. *Serious games for health*

Most people think of video games as entertainment. There is a growing interest, however, in video games as a means to educate and train people [6]. Serious games is a term that has been used to describe video games that have been designed specifically for training and education [7], mainly through gamification techniques and relevant information exposure.

Rather than didactic presentations, serious video games promote learning by scenarios and consequences, in which players can learn through exploration and experimentation [2].

A serious game may be defined as a merge of entertainment, communication, information and teaching. Although it was firstly proposed for military purposes, serious games are present in the most diverse areas, such as education and health [8].

Encouraging participation on health programs is of paramount importance to elevate the general population health and to decrease significantly the mortality rate due to certain diseases, hence one of the main reasons for using serious games to approach health related subjects is their ability to increase motivation.

Video games can reach young people who are unmotivated to learn about health because playing is a very leisure activity, but game design and health information transfer can be hard to reconcile. If an educational game is both entertaining and manages to offer challenges that are neither too easy nor too difficult, as well as desirable rewards, many players will play repeatedly over the course of several weeks or months and many of them will remain interested in playing the game until they are able to complete it with ease [4].

Even though we have seen positive results from health related games, additional research to determine the game design that best promotes information transmission efficacy and minimization of possible adverse effects is still necessary.

C. *HPV and Cervical Cancer*

HPV infection affects men, women, adults and children practically in the same proportion, though the consequences might be harder on women. These infections have drawn attention especially since the 1980s, when a correlation of these lesions with cervical cancer was identified.

Cervical cancer is a tumor that develops from changes in the cervix. These alterations are called precursor lesions and are fully curable most of the times, but if left untreated, can turn into cancer [1].

HPV infection does not usually present symptoms, but it can be diagnosed by several specialists, such as gynecologists, urologists, dermatologists, pediatricians, etc., mostly because sometimes it presents an indicative of

the infection by the presence of warts, papules or spots, somewhere in the skin and mucosa.

Although always recommended, the use of preservatives during sexual contact does not fully protects from the virus, since it does not cover all areas passive of infection[1].

Preferably, men and women should start their sexual lives already vaccinated, with sexually active women periodically participating in cervical cancer screening as well, for maximum avoidance of infection by the types of HPV contained on the vaccines and early diagnosis and treatment of the tumor, respectively.

Different types of HPV are divided between low-risk and high-risk groups:

- Low-risk: There are 12 types of HPV that are called low-risk because they cannot cause cervical cancer. They can, however, cause genital warts or very minor cell changes on the cervix. These types of HPV are known by the numbers 6, 11, 40, 42, 43, 44, 53, 54, 61, 72, 73 and 81. Types 6 and 11 are the mostcommon and are linked to about 90% of genital warts [9].
- High-risk: There are more than a dozen types of high risk HPV that can cause abnormal cells to form on the cervix and these may gradually develop into cervical cancer if not removed. The 13 types of high-risk HPV that are of most concern are known by the numbers 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59 and 68. Types 16 and 18 are the most dangerous, since they cause about 70% of cervical cancers [1], [9].

For the work here presented, we focused on types 6, 11, 16 and 18, since they are contained on most publicly available vaccines. In Brazil, there are two HPV prophylactic vaccines approved and registered by Anvisa and commercially available: the quadrivalent vaccine, which provides protection against HPV 6, 11, 16 and 18; and the bivalent vaccine, which provides protection against HPV 16 and 18. These are accessible to girls from 9 to 14 years old and boys from 11 to 14 years old for free through the SUS program, but other age groups can get the vaccines in private services, given indication by their doctors [1].

D. *Related works*

While still early in the development process, we studied the work [10], which proposes a constraint-based model of a mobile app game called Fight HPV, designed to nudge people to attend cervical cancer screening and vaccination to evaluate the difficulty of each level and to help the game designer in improving the player experience. Fight HPV was used on this project to define certain aspects of gameplay and, more importantly, the format of game - puzzle, in this case - that would be popular and retain players for longer periods of time. Also, it helped us to decide on which key moments are the best to display messages about HPV and cervical cancer during gameplay, so that we can successfully balance learning and entertainment. Figure 1 presents some screenshots that show the game.

Figure 1: Levels 1 and 50, respectively.

On [2] an iterative process was used to develop a mobile game called Land of Secret Gardens. In the game the player is responsible for taking care of a garden and protecting it from threats. All of the resources needed to buy seeds and potions are obtained through minigames that expose players to messages about the virus and the vaccine. As a result, the paper introduces feedback data from parents and children about HPV vaccination and the use of a serious game as a mean of communication, which served our own project to define some of its core characteristics. Part of the game can be seen on Figure 2.

Figure 2: Garden the player is responsible for.

On [11] a vaccination campaign created by Brazil's Health Ministry is advertised. One of its communication strategies is the use of a mobile game, Detona Virus, to motivate information seeking and discussions about the vaccine. Game invites players to confront villains inside the human body, receiving at each new level, health content and the importance of vaccination. Figure 3 illustrates the game, featuring the character of the player and some of the villains faced.

Figure 3: Player and a villain.

Recent research has provided evidence that, in the industrial context, developing video games diverges from developing software systems in other domains, such as open source system (OSS) context. Specifically, authors of paper [12] investigates how developers contribute to video games vs. non-games by working on different kinds of artifacts, how they handle malfunctions, and how they perceive the development process of their projects. Results of research confirm the existence of significant differences between game and non-game development, in terms of how project resources are organized and in the diversity of developers' specializations. Moreover, game developers perceive more difficulties than other developers when reusing code as well as performing automated testing, and they lack a clear overview of their system's requirements.

III. GAME PROTOTYPE

In this section we detail the methodology applied in the development of the game and consequently the prototype implemented.

A. Technologies used

Development was made through Unity engine, with its main programming language C#, and designed and built for mobile platforms, particularly Android. Unity was chosen because of its gratuity and popularity as a tool for developing high quality 2D and 3D games. Former familiarity with the language was also important for the decision.

B. Design

Based on the popularity of the format, the decision was made to follow the Match-3 puzzle pattern, in which the goal is to combine different types of HPV on a board so they can be removed and replaced by new elements. Additional gameplay mechanics include maximum time stipulation to reach the required score on the level. Each level of the game has a different board format and the difficulty increases as the time required to reach the score decreases.

Gameplay depends especially on the format and contents of the board. It is composed of several elements with different functions, such as different types of HPV and powerups related to HPV prevention (vaccine, preservative, etc.) that may cause special eliminations on the board.

Regarding the setting of the game, the inside of the human body is depicted and the player acts as the hero of the represented world by being called by the human immune system to save the body from threats, in this case HPV viruses. Each episode is introduced as a "quest" or "mission", in which the characters request the help of the player to destroy the existing viruses in the represented location of the body.

C. Information Exposure

Throughout the game messages about HPV are displayed by an avatar created and customized by the player himself. These messages are presented primarily at the beginning of each level. Once stipulated time to reach the required score has elapsed, the player can opt to answer a question related to the message transmitted earlier and, given a correct answer, receives a second chance to continue playing his current level from where it stopped. This allows us to correctly measure information retention and motivate players to read messages presented during gameplay.

D. Implemented Prototype

Figure 4 shows the prototype implemented for the game. It is important to notice the correlation between time, score and star accolades. At this stage, star accolades are granted accordingly to score reached and score needed to pass the level ratio: between 100% and 149% for one star; between 150% and 199% for 2 stars; over and equal to 200% for 3 stars.

Figure 4: Screenshot of the game.

IV. CONCLUSION

Prototype is ready to be tested by children and preteens, preferably under parent supervision. Although some feedback was collected, there still is a need for testing and data acquisition on player retention and the learning experience provided.

Also, we conclude that the main goal of the project has been achieved, since the communication strategy approached by the game is able to successfully transmit content about HPV and cervical cancer.

Future iterations of the game should present an increase in visual quality and introduce new gameplay aspects that create a true identity to the game, differentiating it from other Match-3 puzzle apps.

REFERENCES

- [1] INCA. HPV e câncer - Perguntas mais frequentes. Available in: http://www2.inca.gov.br/wps/wcm/connect/tiposdecancer/site/home/colo_uterio/hpv-cancer-perguntas-mais-frequentes
- [2] J. R. Cates, B. F. Fuemmeler, S. J. Diehl, L. L. Stockton, J. Porter, C. Ihekweazu, A. S. Gurbani and T. Coyne-Beasley. Developing a Serious Videogame for Preteens to Motivate HPV Vaccination Decision Making: Land of Secret Gardens. *Games for health journal*, 7(1):51-66, 2018.
- [3] T. Baranowski, F. Blumberg, R. Buday, A. DeSmet, L. E. Fiellin, S. Green, P. M. Kato, A. S. Lu, A. E. Maloney, et al. Games for Health for Children - Current Status and Needed Research. *Games for health journal*, 5(1):1-12, 2016.
- [4] D. A. Lieberman. Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. *Health promotion and interactive technology: Theoretical applications and future directions*, pages 103-120, 1997.
- [5] P. M. Kato. Video games in health care: Closing the gap. *Review of general psychology*, 14(2):113, 2010.
- [6] K. Durkin. Video games and young people with developmental disorders. *Review of General Psychology*, 14, 122-140, 2010.
- [7] L. Annetta. The "I's" have it: A framework for serious educational game design. *Review of General Psychology*, 14, 105- 112, 2010.
- [8] L. S. Machado, R. M. Moraes, F. L. S. Nunes, R. M. E. M. Costa, et al. Serious games baseados em realidade virtual para educação médica. *Revista Brasileira de Educação Médica*, 35(2):254-262, 2011.
- [9] The digene HPV Test. High and Low-Risk HPV Types. Available in: <http://www.thehpvtest.com/about-hpv/high-and-low-risk-hpv-types>.
- [10] A. Gotlieb, M. Louarn, M. Nygard, T. Ruiz-Lopez, S. Sen and R. Gori. Constraint-Based Verification of a Mobile App Game Designed for Nudging People to Attend Cancer Screening. In *AAAI*, pages 4678-4685, 2017.
- [11] Ministério da Saúde. Campanha contra Meningite C e HPV. Available in: <http://portalarquivos.saude.gov.br/campanhas/vacinacao/>
- [12] L. Pascarella, F. Palomba, M. Di Penta and A. Bacchelli, "How Is Video Game Development Different from Software Development in Open Source?," 2018 IEEE/ACM 15th International Conference on Mining Software Repositories (MSR), Gothenburg, 2018, pp. 392-402.