

Serious “human papillomavirus vaccine” game for Malaysian adolescents: development and preliminary study

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Article Info

Article history:

Received Jul 20, 2022

Revised Oct 31, 2022

Accepted Nov 19, 2022

Keywords:

HPV game

Human papillomavirus

Serious game

Teenagers

Vaccine

ABSTRACT

In Malaysia, cervical cancer is the top three most common cancer among women. Vaccination and screening are mandatory for the prevention of the disease. Therefore, we aimed to develop a serious game for Malaysian adolescents, the "HPV Vaccine" game objectively to transmit knowledge about human papillomavirus (HPV), create awareness of cervical cancer, and promote HPV vaccine uptake. This game development targeted teenagers aged 10 to 17 years. We expect to complete three levels and answer all 15 questions. Inclusion criteria were Malaysian citizens, who owned a computer with connectivity to the game. We excluded those with a physical disability. This game was the first edutainment on Human papillomavirus, cervical cancer, and the HPV vaccine. We conducted a preliminary study, cross-sectionally, purposive sampling method. We recruited 20 participants; only 16 participants consented and completed the study. All participants enjoyed the wireframes of the game, with an average of 12 to 15 minutes to complete the game. Results demonstrate that participants were highly engaged with the “HPV Vaccine” game. We believe this game, is a forward technology that will beneficial for adolescents' adherence to HPV vaccination. In the future, we suggest an observational study to assess players' perspectives on this game.

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1. INTRODUCTION

Cervical cancer was the top three most common cancer among women in Malaysia. Vaccination and screening are mandatory for the prevention of the disease [1]. National health and morbidity survey Malaysia for 2011 stated only 12.8% of eligible women had a pap-smear examination done in the past 12 months [2]. Human papillomavirus (HPV) is the most common infection of the women's reproductive tract which can cause and is the cause of a range of conditions in both men and women, including precancerous lesions that may progress to cancer. Although the majority of HPV infections do not cause symptoms and resolve spontaneously, persistent infection with HPV may result in disease.

In women, frequently HPV-16 and HPV-18 infection may lead to precancerous lesions. It may progress to cervical cancer if left untreated. HPV infection had associated with oropharyngeal and anogenital

cancers as well [3]. Human papillomaviruses originated from the family *Papillomaviridae*. These viruses are highly tissue-specific and infect both cutaneous and mucosal [4]. HPV-induced changes in the cervical epithelium can be detected by microscopic examination of exfoliated cells, known as the Papanicolaou (Pap) test [5]. A recent study showed that women in Malaysia have a good awareness of risk factors for cervical cancer; however, they lack perceptions, attitudes, and interventions toward cervical cancer [6]–[11]. Several interventions have been developed addressing healthcare issues tackling the strategies for preventing diseases and managing illnesses [12]–[14]. One of the interventions was HPV vaccines which offer the best possible protection against cervical cancer and prevent the spread of the virus. The vaccine vials contained virus-like particles, mineral salts, water, and aluminum sulfate. HPV vaccines were recommended for girls aged 9 to 14 years, or women who are older than the recommended age. Mobile team nurses from the School Health Unit, Ministry of Health Malaysia suggest girl students aged 13 years get the HPV vaccination. The HPV vaccine has minimal side effects. However, some of them may experience shortened hair, dirty sclera, and irregular menstrual cycle [15].

Malaysia currently in the era of digital transformation aimed to develop a sustainable digital government, adoption of emerging digital technologies, and implement a strategy between the public sector and other agencies. Between 2020 and 2021, the percentage difference between internet users was 7.2%, mobile phone users 0.5%, and computer users 3.5% [16]. Therefore, the use of computer games is a relevant approach to educating Malaysian adolescents. Serious games on the computer and mobile phone share the capability to place the individual centered on determining health [17], [18]. Serious games are defined as the advance of games precisely considered to complete any modification in the player. For example, an amendment in knowledge, cognitive ability, health, mental well-being, attitude, or physical ability [17]. In computer games, the data generated is used as part of the diagnostic systems, and the games will form the primary part mostly the treatment approaches. The establishment of “big data” triggers “integrated gaming”, where the data in games and social networks become integrated with all other forms of personal data [17].

Serious game development is used as a first step in determining the impact on the public’s health, especially adolescents [19]. Instead of entertainment, the serious game offers efficiency and creativity in delivering knowledge and awareness to the targeted players. Game for health was rapidly evolving aim to improve healthcare issues. Experts believed that serious game for health has a big impact on teenagers [20] the game turn into a crucial medium to boost intended behavior towards a robust lifestyle, increase disease perception, and promote the healthcare services provided by the Ministry of Health Malaysia. Therefore, in this study, we developed the “HPV Vaccine” game particularly designed for adolescents to enhance knowledge, create awareness, and promote practices toward preventing cervical cancer.

2. RESEARCH METHOD

2.1. Game development

The “HPV Vaccine” game was developed at the Universiti Malaysia Pahang with aid of a physician and public health expert to assure adequate realistic information related to Human papillomavirus (HPV), cervical cancer, and HPV vaccines [21]. The game was employed with *Unity* and optimized by professional game developers. *Unity* is the ultimate game development platform with a closed-source and cross-platform game application. In *Unity*, a high-quality game is obtained by manipulating objects in 3D and various components for deployment across mobile, desktop, and gaming consoles (i.e., *Xbox*, *PlayStation*, and *Wifi*). Stated to the existing resources, the *Unity* framework is most preferred because of its availability to come up with clarity regarding the further step in the development of the professional standard game [22], [23]. To start developing the “HPV Vaccine” game, the game’s information or objective must be clearly stated. First, the background of the game and the player need to choose the correct resolution based on the screen size. Then, the process of setting the virus image is performed. All this stage creation in *Unity* software solves by using the coding script in C++ by *MonoDevelop*. *MonoDevelop* is an Integrated Development Environment (IDE) supplied with *Unity*. An IDE combines the familiar operation of a text editor with additional features for debugging and other project management tasks [24], [25].

2.2. Game specification

In this game, there is a 'boy' as the main character with animated movements (i.e., standing, jumping, and running). This 'boy' will be on a grounded platform that has been stacked at different heights and has a certain distance as a simple obstacle. Besides the platform, there was a box that is used as a platform for this character to run, and ‘timber’ acted as an obstacle. The player was enabled to shoot the Human papillomavirus (HPV) as the main enemy character of the virus which also can move. When a player crashes with a virus, the player loses one life. In addition to the HPV, there were other obstacles (i.e., rivers, rocks, and stumps). At level 2 and level 3, there were large-size viruses that can counter-shoot the player; so the player should avoid and combat the virus and thus eliminate the virus's life span. If the player's life

decreases, the player can top-up an 'additional life' by walking while touching the 'medicine box'. At the beginning of the game, the player was provided with five lives and if they diminished all five lives, the game will be over. Throughout the game, there were 15 stacked 'stethoscopes'; which play a role to throw questions to the players, and players are compulsory to answer the question. Each question has a multiple-choice answer and the player can answer by moving the mouse toward the desired answer. To move the main character during the game, players can press the 'right and left' buttons to run, the 'up' button to jump, and the 'space' button to shoot. This movement can be controlled using the 'touch screen' button as well.

2.3. Game operations

The "HPV Vaccine" game has three levels and each level has five questions. Every level has a different field of topics related to HPV. The first level concerns the transfer of knowledge on Human papillomavirus (HPV), the second level is related to cervical cancer, and the third level is related to HPV vaccination. Table 1 describes further the "HPV Vaccine" game element.

Table 1. "HPV Vaccine" game elements

Game element	Description
System	Players will receive scores and rewards if they managed to pass every question and level. The rewards will be in terms of score points and time duration.
Players	This game is designated for the individual player. The players only interact with the game content.
Abstracts	Games involve the abstraction of reality and typically take place in a game space. The games reflect Malaysian settings with various cultures and beliefs.
Challenge	The game is designed to have different challenges at every stage and has different difficulty levels.
Rules	Age restriction and demographic information are required before playing the game, playing the game in order (cannot skip), the player cannot interact with other neighbours.
Interactivity	The players interact with the game system and the game environment.
Feedback	To complete each stage, the question appeared on the screen, and feedback from the player is required.
Quantifiable Outcome	There was a typical scoring system and the players needed to pass certain scores to go to the next level.
Emotional reaction	The game involves emotions such as fear, anger, happiness, and enjoyment at each level.

2.4. Preliminary study

We conducted a preliminary study, cross-sectionally, with a convenience and purposive sampling method. We recruited 20 participants during the research product exhibition event named UMP Engineering Day (UMPed) at University Malaysia Pahang, Pekan Campus, on November 14, 2018. All participants were adolescents aged 10-17 years, attending the particular exhibition event, and willing to give consent to participate in the preliminary study. The "HPV Vaccine" game was pre-installed on a PC, and the participants log into the game after being consented. Once finished the game, participants were mandatory to answer the survey questionnaire which consist of questions on average time spent, participants' acceptability responses, and participants' engagement with the "HPV Vaccine" game.

3. RESULTS AND DISCUSSION

3.1. Target audience

This game targeted young teenagers aged 10 until 17 years. The audience includes Malaysian citizens, who possess a personal computer (PC) with connectivity to the game. Those with physical disabilities (i.e., blindness, or hand movement limitations) were excluded.

3.2. Game layout

The first feature of the scenes in the "HPV Vaccine" game is a home scene as shown in Figure 1(a) which behind is the background and shows the main players. When the 'PLAY' button was pressed, the game will turn to the play scene and the game will start; however, if the 'QUIT' button was pressed, the game will be closed. In the play scene, there is the main display where there are buttons on the touch screen control which are the buttons to the 'left', to the 'right', jump and shoot at the 'bottom' of the display. Figure 1(b) shows the top of the display with was 'medicine box' icon; showing the number of players lives, and a 'stethoscope' icon that shows the number of questions that can be answered correctly on the left side. At the top right of the display, there is a 'TIME' recording the player's performance for the whole game and a 'HOME' button, to enable players to go back to the main menu.

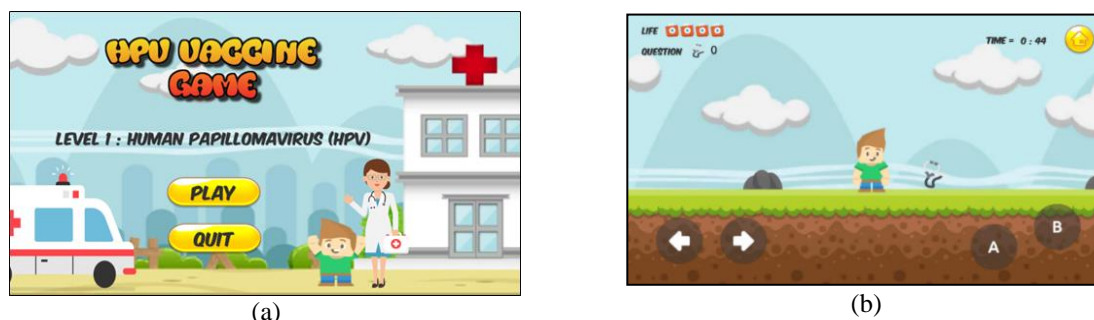


Figure 1. Feature game layout (a) The “start page” of the "HPV Vaccine” game and (b) The “stethoscope” character represents the question session in the "HPV Vaccine” game

Figure 2(a) shows two different virus sizes and colors used in the “HPV Vaccine” game but the functions of all these viruses are the same. Every virus will disappear if the shot is released from the player, but if the virus strikes the player, the player will lose a life. At the end of level 2 and level 3, there is a ‘large-size virus’ that can be moved and fired bullets toward the player. To combat this virus, the player has to shoot 3 times to get rid of this large-size powerful virus. A pause scene will appear when the player touches the pause button on top of the play scene as shown in Figure 2(b). The ‘RESUME’ button enables the player to continue the game, and the ‘QUIT’ button to close the game.

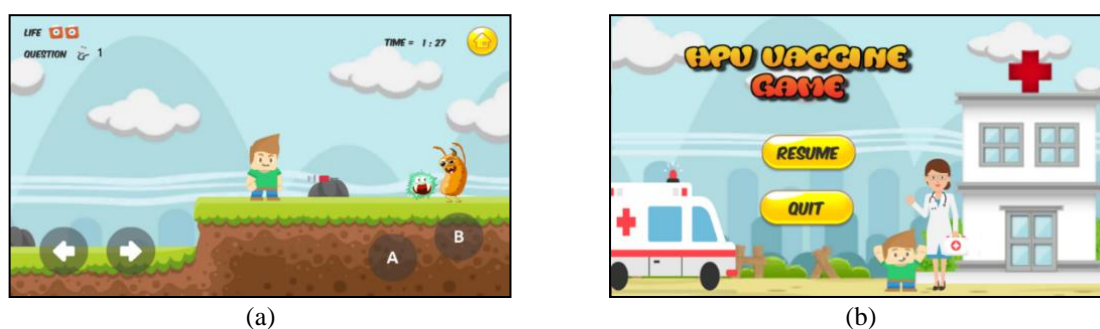


Figure 2. Feature game layout (a) The “virus” characters represent the obstacles in the “HPV Vaccine” game and (b) The “pause page” of the "HPV Vaccine” game

Table 2 shows a total of 15 questions will be offered to players where each display has the same background but different questions and answers. In this view, there are two buttons for the answer option where if the player presses the correct answer option the right symbol will appear on the correct answer but if the player presses the wrong answer option the cross symbol will appear on the wrong answer. In the “HPV Vaccine” game”, a game-over scene will show up when all five players’ life is out, and later the ‘HOME’ button will appear, showing that the game has ended. The final scene will show the score with the correct answer and a description of the value of the correct answer. The time shown in the “HPV Vaccine” game is important for players to estimate how fast the player can play the game.

3.3. The Three different levels of the “HPV Vaccine” game

3.3.1. Level 1

Transfer of knowledge is not limited to learning in the classroom but from also interacting with other materials. From this game, knowledge is transferred through questions raised to players when touching the stethoscope. At the first level, it focuses on the transfer of human papillomavirus-related knowledge in which the process goes through the way the players read the questions raised along with the answers. Players will gain knowledge about HPV by understanding questions and answers.

3.3.2. Level 2

Each person has a different awareness of cervical cancer. The development of this game promotes awareness among players where for the second level there are five awareness questions regarding cervical

cancer. The focus given during play can help the player understand and think rationally by reading the questions and responding to the questions given. The questions and answers given to the awareness of curing cancer of the cervix are indirectly making players aware of the complication of cervical cancer.

3.3.3. Level 3

At this level, the questions and answers were upgraded to a level capable of transforming the thinking perspective of the player. From a researcher's point of view, the answers provided can be easily interpreted and lead to action to understand the concept of the HPV vaccine from the player. The development of a serious game for health can change the player's perspective on the HPV vaccine; thus, the player can share information and awareness regarding HPV vaccination with the public.

Table 2. True-or-false type of questions in the “HPV Vaccine” game

Level	Question No.	Questions	Select answer
<u>Level 1</u> Low level: Human Papillomavirus (HPV)	1	What is HPV?	– Human papillomavirus (√) – Human pemillio virus
	2	Is HPV dangerous?	– No, it is just a normal virus on the skin – Yes, it can cause cancer of the anus, cervix, vagiva, vulva, vagina, throat, or penis (√)
	3	How does a person get the virus HPV?	– Hereditary; or family history of the disease – Through sexual activity; or from an infected mother during childbirth (√)
	4	How common is the virus?	– Common among sexually active men and women up to age 25 (√) – Common among men and women aged 50 and above
	5	Can HPV infection be avoided?	– Yes. Never engage in sexual activity, or by using a condom (√) – No, HPV can infect all men and women regardless of age or behavior
<u>Level 2</u> Intermediate level: Cervical cancer	6	What is cervical cancer?	– Abnormal cell growth at the cervix (√) – Abnormal cell growth at the cervical spine
	7	What causes cervical cancer?	– Sexually transmitted HPV infection (√) – Hereditary; not related to HPV infection
	8	Can cervical cancer be detected earlier?	– No, cervical cancer can only be detected at a later stage of the disease – Yes, a PAP smear test to detect abnormal cell growth on the cervix (√)
	9	How to prevent getting cervical cancer?	– Avoiding junk food or reducing fat and salt in the diet – Prevent hpv infection by the best strategy is vaccination (√)
	10	Can cervical cancer be treated?	– Yes, by early detection and early surgical and medical treatment (√) – No, there is no treatment so far
<u>Level 3</u> Highest level: HPV Vaccine	11	Why the HPV vaccine is important?	– Vaccines offer the best possible protection against cervical cancer and prevent the spread of the virus (√) – Vaccines act as the best medicine to cure cervical cancer
	12	What is in an HPV vaccine?	– Virus-like particles, Thiomersal as preservatives, mercury. – Virus-like particles, mineral salts, water, aluminum sulfate (√)
	13	Who should get the HPV vaccine?	– Girls and boys of school age who are at risk of getting an HPV infection – Girls at the age of 9 to 14 years, or women who are older than the recommended age (√)
	14	When should we get the vaccination?	– From 9 to 14 years of age (√) – From infant until school-aged
	15	What is the side effect of the HPV vaccine?	– Shortened hair, dirty sclera, irregular menstrual cycle (√) – Redness, swelling, and soreness in the arm; headache, fever, joint pain

3.4. Average time spent on the “HPV Vaccine” game

We recruited 20 participants for the preliminary study however only 16 (80%) consented. Three (15%) participants were refused due to illness or time constraints whereas one (5%) participant lost follow-up. The average time duration spent by the study participant was 12 to 15 minutes. Details result is shown in Figure 3. We approached 16 participants and all agreed to review the wireframes of the “HPV Vaccine” game. All patients enjoyed the wireframes and commented on the game storyline as personally relevant. All participants are willing to engage in a technology-enhanced version of the “HPV Vaccine” game.

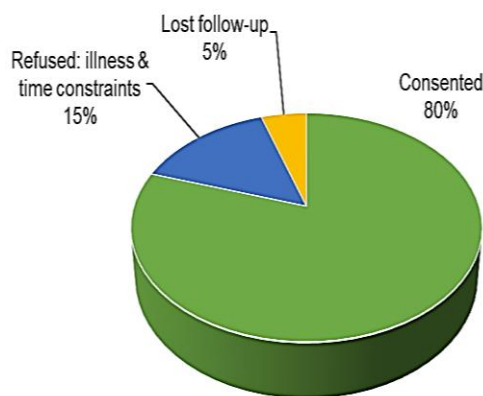


Figure 3. The percentage of participants for the “HPV Vaccine” game preliminary study

3.5. Aceptability and engagement of the “HPV Vaccine” game

Nine patients (56.25%) were accompanied by custody during the study. We investigated the participants’ acceptability responses to the “HPV Vaccine” game questionnaire based on knowledge, awareness, and perspective. Our results demonstrate that all participants were highly engaged in the “HPV Vaccine” game, although we offer only the boy game’s characters.

3.6. Key Finding

Observations made from the study can be summarized in the following three points as described: i) concerning physical participants, the HPV vaccine game showed a significant on patient consent of about 80%, refused about 15% and patients lost follow-up about 5%, ii) the results showed that all participants were highly engaged with the “HPV vaccine” game, the boy character reflects the player’s knowledge and awareness of social lives, iii) the result also showed players demanding a personalization of the game’s character by offering various characters at the beginning of the game and then preferred scenarios based on adolescents’ interests.

3.7. Implication of finding

Addressing issues in this article, the supplementary game’s character (i.e., a girl, a student, a football player, a volleyball player, a dancer player) nearly reflects the adolescents’ interest and players. Furthermore, we will increase the embracement of the game’s content, therefore, allowing adolescents player to have a self-advocacy scenery prior they log into the game as well. This preliminary study was limited to a small sample of participants mostly women teenagers. As we broaden the game to bigger populations, the request feedback form will continue to address the needs of adolescents [26]. A preliminary study on the “HPV Vaccine” game has employed a significant impact on the burden of HPV infection and disease in addition to providing insight into key mechanical processes fundamental for lesion and cancer development that have a broader reach. The multidisciplinary environment of research to date has indisputably contributed to these outcomes. While we have claimed that the necessity for further “HPV Vaccine” game study is crucial to improve morbidity nationally and globally, addressing funding constraints will be a predictable challenge as well.

The relevance of the components in the “HPV Vaccine” game was the emotional reaction established during the game such as fear, anger, happiness, and enjoyment at each level. Hong *et al.* stated in their study that the role of enjoyment in a serious game significantly influenced people’s intentions and strengthen their belief in a healthy lifestyle [27]. The “HPV Vaccine” game is equipped with a scoring system that quantifies the achievement of players and at the same time enables grading of the knowledge shared by the game system to the players. Spanjers *et al.*, also highlight a similar point where learning

experiences through the serious game were further enhanced through their affective responses provoked by the perspectives, interactivity, realism, and feedback by the players [28].

Rewards provided by the “HPV Vaccine” game system enable players to lengthen the duration of their lives and for them to be able to complete all the questions thus influencing the aesthetics and psychological effect for the players. Alexiou *et al.* found that anecdotal and aesthetics in serious games positively impact the perceived learning by expediting a state of psychological flow [29]. However, the “HPV Vaccine” game does not allow players to interact with other players as it is developed exclusively for an individual player. According to Pereira *et al.* multi-player gaming promotes social involvement and therefore has a high potential for increasing adherence and effectiveness of the game [30]. Hence, a further advanced game needs to be developed.

3.8. Limitations

This article presented our involvement in producing the first game-based learning tool to transfer basic health information related to Human papillomavirus, cervical cancer, and HPV vaccination. This game aimed to search for a beginner player. The iterative design of this game has been widely applied in software engineering for alertness and appreciating a good product or market fit. Possibly, improved characters and configurations of the evaluation groups could have improved the variety of the feedback; however, we were able to evaluate and redesign the “HPV Vaccine” game based on almost all of the relevant suggestions provided by the users. The development of the “HPV Vaccine” game might have advantages by integrating features of cognitive psychology in the evaluation of the feedback from the users. However, we feel that the methodology used was sufficiently rough to imitate a conventional systematic approach. Health and welfare sector practitioners looking for a serious game for health to activate physically inactive individuals can look for solutions from the “HPV Vaccine” game. Meaningful multiplayer gameplay seems to be important for player preservation in “HPV Vaccine” games, as evidenced by studies observing how people can learn about the Human papillomavirus, cervical cancer, and HPV vaccination. The “HPV Vaccine” game currently seems to increase the adolescent’s knowledge and informed how important the HPV vaccine is to adolescents.

4. CONCLUSION

This specially designed game delivers knowledge related to Human papillomavirus (HPV), develop an awareness of cervical cancer, and bolster the HPV vaccine uptake among adolescent. The “HPV Vaccine” game is the leading edutainment on Human papillomavirus, cervical cancer, and HPV vaccines in Malaysia. Players can collect life to accomplish to next level in the game. This game permit player to choose the best answer to conserve themselves against the obstacles. This game decreases the disparity between formal lectures and sociocultural myths about HPV vaccination.

ACKNOWLEDGMENT

The support of the University Malaysia Pahang under research grant RDU210332 and MedEHiT are gratefully acknowledged. The authors of this paper also would like to express their gratitude to Mr. Idris Mat Sahat from the Human Engineering Group (HEG) for supporting these research activities.




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


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