

# Stimulating Children’s Physical Play through Augmented Reality Game

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*Abstract*—Physical play includes activities that use physical movement to allow children to perform any task and helps children to develop gross and fine motor skills, learn new things, and socialize. The Child Development Institute stated that physical plays help children to develop connections between the nerve cells and the brain as 75 percent of brain development occurs after birth. Nowadays, children prefer indoor activities compared to outdoor activities, and this might harm their physical play as they become more passive and introvert. Hence, this project aims to design and develop a mobile game using augmented reality technology to foster children’s attention and interest to stimulate their physical play. This paper specifically explores how a mobile game with augmented reality technology can stimulate children’s physical play. This project has identified three findings corresponding to the themes related to the AR mobile game in supporting children’s physical play. The findings are i) AR games can stimulate physical interaction among children; ii) AR games can increase cognitive and memory skills development among children and iii) AR games can help children to have better interaction with real-world context. Thus, mobile games with augmented reality technology can support in simulating children’s physical play.

*Index Terms*—Augmented Reality (AR), Mobile Game, Children, Stimulate physical play.

## I. INTRODUCTION

Augmented Reality (AR) is a technology enriching the real world with digital information and media where the new technology such as augmented reality would enlighten everyone. AR is globally known due to the interaction of superimposed graphics, audio, and other sense enhancements over a real environment. However, AR is still a new technology used in this globalized era. The first person to use augmented reality was Boeing on 1990 and in 1999, the ARToolKit was released by Hirokazu Kato. This development enhanced technology, as ARToolKit is the open-source development process of AR applications. There are numerous libraries encouraging the usage of AR in the development of applications. Thus, AR technology enables a user to participate in activities in a virtual world such as in entertainment, education, business, and others.

Moreover, children nowadays are intrigued by television and computers. In 2001, the Cabinet Office of Japan reported that school-aged children in Japan spent a large fraction of time in front of the television or video games rather than participating in activities that would stimulate physical development such as exercise. Numerous articles have highlighted the disadvantages of childhood exposure to television or video games such as “Watching TV: Even Worse for Kids than You Think” on TME headline. This scenario would create an unhealthy environment as it would negatively affect children’s behavior, health, and

cognitive development. Hence, this paper specifically explores how an AR mobile game application can stimulate and develop children’s physical play.

## II. RELATED WORK

The literature review discusses prior work on augmented reality mobile games on how it can stimulate children’s physical play. Opportunities and implications for design in the field are also presented in this section. The details of each aspect will be discussed below.

A. AR games can stimulate physical interaction for children.

AR game can develop physical engagement and create experience for children [1]. According to [2], play has become an indispensable influence of children’s lives because they learn via exploration, trial and error, and experimentation during play. Moreover, [3] stated that learning can be achieved through active participation and interaction among children since physical engagement can enhance children’s focus. It is being identified that the more senses involved such as hearing, sight, touch, and emotions, the more impactful the learning experience will be.

Children are exposed to new experience due to role-playing activities. For example, [4] employed Flash-Poles, a stimulating and safe game which was designed for the outdoor environment to motivate children to play and perform physical activities such as running and jumping. In addition, the study mentioned Battle-bots, a physical game in which children’s body movements are used to control battle tank toys remotely. Thus, these two games positively showed that games can stimulate children’s physical play throughout a play session. Augmented reality games can benefit children’s lives such as skill development through physical manipulation [1].

AR games also allow children to experience augmented 3D space that will significantly influence them, especially related to motor manipulation and spatial cognition. Hence, these games improve children’s abilities in performing precise movements (fine motor skills) and large-scale movements, and the ability to sustain prolonged postures or repeated movements. Specifically, video games have utilized physical input devices called “exergames”, referring to games that combine play and exercise. Therefore, the games influenced players toward active physical gameplay and AR technology can be an important element. As mentioned by [5], the game design must be modified to motivate players to stimulate their physical play while playing games such as giving virtual game rewards when they complete the physical activity.

B. AR games can increase cognitive and memory skills development among children

Video games have been used to stimulate cognitive functions such as attention, concentration, and memory [6] and it is beneficial for developing skills such as creativity, attention, memory, concentration, and others. Additionally, studies [1] identified that AR games showed a positive impact where it enables the children to understand and mentally visualize spaces. This means that children can understand objects and relations in visually observed space (spatial perception) and children are able to imagine and transform space (spatial visualization) mentally. AR games also can support children's cognitive development [4]. Thus, in the perspective of spatial knowledge acquisition and cognitive, AR games may utilize unique cognitive mechanisms for spatial acquisition [7].

Moreover, these studies also mentioned that the cognitive basis for AR is by involving the visuo-motor (related to the coordination of movement and visual perception by the brain) for information processing.

Memory reversal abilities are crucial because children around 8 years old may have trouble in reversing items in memory. Therefore, in some of the AR games, children need to remember how to interact with the system. Plus, AR games enable abstract thinking in children, where they are able to process information and reflect on one's previous actions and think strategically.

C. Children have better interaction with real-world context and a simple interface of AR game.

AR games enable groups of players to sit around and play the game in a real-world context [3]. Moreover, AR games allow the relationship between concrete objects and virtual objects that will be displayed in real-world contexts where children can easily demonstrate their interest and attention. In addition, activities such as handling, arranging, sharing, or discussing the chosen physical resources naturally will become familiar to the children. The physical objects support collaboration by their appearance, their immediate physical properties (weight, texture, and etc.), and their use as semantic representations, their spatial relationships, and their ability to help focus attention on real problems. Interactions between the user and the game are critical in game development as it enriches the user experience throughout the play session. Based on an article by [8], there are three main contents in designing the interaction which are (1) the construction of AR scenes that consist of acquiring the real scenes and modelling the virtual scenes, (2) touch screen interaction, and (3) body motion interaction which consists of smartphone sensors.

Besides that, [9] mentioned that AR games can be enhanced by physical and spatial 3D user interfaces that can be used to develop effective face-to-face collaborative computing environments. Furthermore, based on [10], using tangible cubes as the user interface for AR games is encouraging as children enjoyed playing the AR game more than playing the real game. Thus, in designing and creating the interface, it is very important to incorporate four aspects, which are physical, emotional, social and mental of the target audience. In addition, according to [11], player's experience is very important in creating a game world as it might be from player's imagination in response to other stimuli such as background music, game level, and others.

Hence, in this paper, Whack It!, an AR mobile game was used to stimulate children physical play.

D. Whack It! AR Mobile Game Application

The authors designed and developed the Whack It! mobile game with integration of augmented reality technology. Thus, this game focuses on the enhancement of AR technology in mobile game. Whack It! is inspired by a game called Whack-A-Mole which is a popular arcade game where player uses a mallet to hit toy moles that appear at random. Therefore, Whack It! is designed and developed as a digital game for the mobile game platform. Whack It! is aimed to stimulate children's physical play through interactive games. The game targets children between 8 and 10 years old since children around this age can understand the rules of the game and able to interact according to the simple rules given. In addition, the development process of this game is motivated by the statistics of children involved in mobile gaming and video games. Hence, the game flow was designed according to the understanding of children regarding mobile games. Figure 1 shows the main menu of Whack It!. The main menu was designed in a simple manner to encourage children's understanding where players need to touch the play button to start the game.

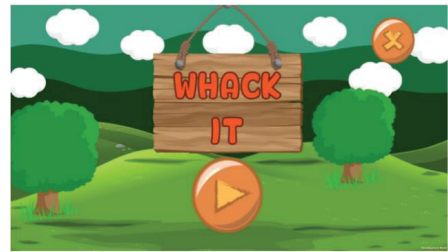


Figure 1 Main menu of Whack It!

Next, as shown in Figure 2, the players are allowed to choose any enemy character that the players want to defeat. Therefore, three enemy characters provided in this game which are the ghost, slime and rabbit. These enemy characters will attract children's interest in this game.



Figure 2 Enemy Character Selection of Whack It!

Figure 3 shows the gameplay of the game. Whack It! will spawn the enemy character chosen by the players at random time. Thus, the players need to move around and find the enemy to defeat it. The shooting button at the bottom right of the screen was used to shoot the enemy.

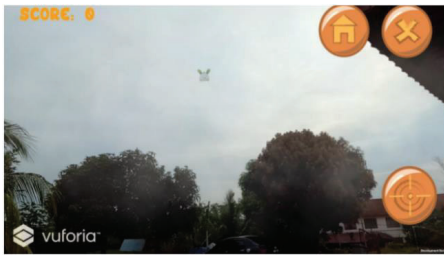


Figure 3 Gameplay of Whack It!

Hence, playing Whack It! can help children to increase their development of physical, cognitive behavior, and memory skills. In addition, it will improve children's hand-eye coordination by playing the game. As youth are familiar and comfortable with advanced technology, this project is an effort to argue that games are not beneficial for children. Furthermore, this study is also expected to help children to spontaneously engage in more physical interactions while playing this game such as those requiring a simple handheld controller which can lead to stimulating physical play.

### III. METHODS

The study protocol was approved by Universiti Teknikal Malaysia Melaka (UTeM). Several methods were employed in conducting the usability testing. However, only one method was used during the usability testing which was retrospective probing (RP). Basically, retrospective probing required facilitator to wait until the session is completed, and questions were asked to inquire on the participant's thoughts and actions. The usability testing was conducted with three categories of participant. The first category was five children between the age of 8 and 10 years old and the second category was five amateur play testers age between the age of 18 and 19 years old and third category was five expert play testers between the age of 22 and 26 years old. Overall, the total duration for usability testing took about 3 weeks for all three different groups of participant which each group was conducted with a week of trial; group 1 with five children, a group 2 with five amateur play testers and group 3 was conducted with five expert play testers. As shown in Figure 4, the procedure for conducting usability testing for each category of participant. The participant was brief regarding the game to be tested and how the usability testing was conducted. Each of the participant was given 15 minutes to play Whack It! In addition, to ensure the data collection was efficient, pre-test and post-test questionnaires were distributed to ensure the differences of participant's thoughts before and after conducting the test were identified. Furthermore, the facilitator took notes on the participants to ensure a thorough analysis. Hence, the strategy of usability testing is by observing the participant and analyzing the pre-test and post-test questionnaire.



Figure 4 Procedure for conducting the usability testing

Moreover, during 30 minutes of conducting the usability testing, the facilitator observed and recorded every moment and behaviours of the tester. This is to ensure the aim of this game was achieved. The emerging themes from the analysis are discussed in the next section.

### IV. RESULTS AND DISCUSSION

Through the survey and testing conducted, three findings emerged. The details of each theme are further discussed.

Theme 1: AR games can help in stimulating children's physical movement.

This game encourages physical movement and it was validated in the post-test where 100% of the participants said that they need to move around as they need to find the enemy that spawned around them. Based on the observations, we found that the participants would move forward and backwards and turn around as they try to find the enemy. They also constantly move the mobile phone up and down. The authors justified that this project enables to stimulate physical movement based on the data collected. Hence, this finding supports [1] where the AR game enables the children to move both hands simultaneously and perform larger-scale movements. Furthermore, AR games also increase the development of fine motor skills, as mentioned by [3] that active participation and interaction among children by physical engagement can help them to focus.

As shown in Figure 5, there are two examples where the participants show two different movements when playing the game. These images demonstrate that different players stimulate different physical movements.



(a) Participant turn to the right and keep moving the devices to above  
(b) Participant turn to the left and keep the devices parallel to his eye level

Figure 5 Examples of test participant's movement throughout the play session

Besides that, the data have been compared with three category of test participant and it shown that the participants agree that they required movement to play the game. Hence the data of movement were observed and recorded as shown in Figure 6. The chart shown clearly states that 40% of participants admit when playing the game, they tend to turn around to find the enemy while only 13% of participants said they only move forward and backward in order to defeat the enemy.

Number of participants required movement when playing the game

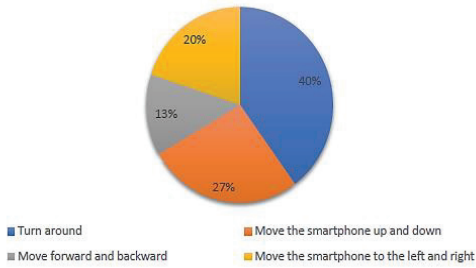


Figure 6 Overview of data movement each of participants attempt during usability testing

Theme 2: AR games can help coordinate the control of eye movement with the hand movement of children.

Whack It! can help children to undergo the processing of visual input to guide reaching and grasping along with the use of proprioception of the hands to guide the eyes. Typically, these skills are coordinated with or in response to visual input. Through observation, the participant reacted quickly to the enemy's assault and the participants enjoyed the fast-paced game environment. Meanwhile, there are several participants required briefing from the facilitator on how to play the game. Indirectly, this project helps children's eye-hand coordination. However, we identified that the players were terrible at the beginning of the play session, but participants that have experience in action game and AR game became significantly better as the play session progressed and can cope with the game. This finding supports [7]. They demonstrated that AR can improve the visuo-motor (related to the coordination of movement and visual perception by the brain) for information processing. Thus, the working memory acts as a mechanism that holds pieces of information in mind while performing a task. As shown in Figure 7, test participants were able to react quickly to defeat the enemy and know how to handle the devices.



Figure 7 Example of a participant during usability testing

Theme 3: Real-world context can help children engaged while playing the game.

Each participant reacted differently when playing this game, as AR experiences are different due to the content that overlays the real world. Hence, the observations conclude that participants were satisfied as they played this game because of

the need to interact with real-world by moving around to find the enemy that spawned and as well to look at the screen and the position of the enemy.

Figure 8 illustrates two examples of how participants react when playing the game. Besides that, 40% of participants admitted that the game influenced them in doing spontaneous actions such as moving forward, dodging the enemy, and turning around. This finding supports [3]. They demonstrated that AR games allow the relationship between concrete objects and virtual objects in real-world context as it will enrich the user experience throughout the play session.



(a) Participants try to kill enemy tend to move forward.



(b) Participant trying to avoid the enemy attack tend to move their body as well.

Figure 8 Example of interaction between augmented reality and real-world context

## V. CONCLUSION

This project demonstrated that playing is a natural and enjoyable way for children to keep active and stay well even when playing mobile games. Therefore, the findings recommend AR mobile game as one of the tools that can help stimulate physical children as it assists in stimulating children's physical movement and spontaneous behaviour while playing the game. In addition, it also helps to develop connections between the nerve cells and the brains. Hence, its improved child's fine and motor gross skills, socialization and problem solving. This gave the children a greater opportunity to support their growth.

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