Approachability Evaluation of Virtual Reality Educational Game: The Case of Keepin

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Abstract. Educational game technology now in advance phase where virtual reality is adapted into it. But when the educational game is not designed well, it become no point to use the game for education. Educational game not only could be played, but also should be understandable and entertainable at the same time, especially for new player (approachable). This study has purpose to evaluate the approachability of game KEEPIN a virtual reality educational game about waste handling that has been design using Game Approachability Principles, students participated in experiment consist of play the game session, simulation, and questionnaire. Total respondents are 35 students. The evaluation gave result 23 students find the game enjoyable by give positive experiences during empirical usability testing, they also success play the game at first attempt and can achieve the goal of the game. 5 students give negative experiences but success play the game at first attempt and can achieve the goal of the game. 7 students close the game without finished it. It shows that KEEPIN can be understandable oand quite approachable for new player.

1. Introduction

Recent years virtual reality becomes popular and spread among society through any platforms such as game console and smartphone. Empirical studies show the use of virtual reality in educational game and results rapidly expansion. Virtual Reality (VR) is adapted in Educational Game aims to increase immersiveness of game so players will engage deeply at it [1]. Virtual reality provides artificial environment in 3-dimentional form and required several equipment for proper use. Player will use VR console and sometimes smartphone and bluetooth controller. If virtual reality educational game is targeted for children it has to be understandable and approachable by children, if not it would be no point to use virtual reality game in education for children.

This study describes the evaluation experiment of game that has been conducted and how the game affected the player. The game that has been tested is called KEEPIN and is meant to teach children about waste handling and environment awareness [2]. Approachability is about how fast and well (new) player can learn the game. Game that approachable is game which has good introduction,
presentation, and clear tutorial. In other hand, approachability is measure the user experience towards game [3].

2. Description of the Tested Games: KEEPIN
KEEPIN is a virtual reality game for android smartphone. Targeted player is Indonesian children in range age 7-12 years old. This game educates children about types of waste and how to handle it. The game is open world adventure game where player should explore the world of game to complete the mission from non-player character (NPC). The environment of game is colorful to attract children. At the end of game, player is expected to choose the right trash based on the type. Some of the game preview can be seen in figure 1 (a) and (b).

To ensure the approachability of KEEPIN, designed of introduction, tutorial, and levels of game apply some principles to facilitate players learning from game. Challenge and obtain information is important in educational game but entertainment aspect should not be ignored since children interest with doing fun activity [4].

2.1. Principles of Educational Game Design
Educational games are not edutainment games, where educational games require critical thinking, strategizing, or problem solving in every possibly scenario within the games. Challenges, goals, and rewards are important to establish engagement between player and game. Nevertheless edutainment games focusing on rehearse memorized by repetitive action which is a barrier of approachability [5]. Principles that is used to design game KEEPIN is based from Game Approachability Principles (GAP) that is developed by [6], [7]. GAP highlight the good experience of players when they play the game for the very first time, which determined by focusing on initial state design, tutorial, and game flow. While there are more than ten principles, this study focusing on five particular principles that is more suitable for KEEPIN.

1. Self-Efficacy
2. HEP and PLAY Based Guidelines (varying to reduce boredom)
3. Coolness and Entertainment
4. Information On Demand and In Time
5. Knowledge Transfer

Figure 1. Preview of Virtual Reality Educational Game: KEEPIN

3. Evaluation of Game
Evaluation of game is taken at Madrasah Diniyah Awaliyah (MDA) Darul Hikmah and MDA Al-Muhsinin Pekanbaru, Riau, Indonesia. MDA is defined as non-formal elementary school. Evaluation consist of two phases of visiting. Initial visit consists pretesting, training, and play the game session. Second visit is a week later to post-test.
3.1. First Phase (Initial Visit)
All respondent should be student who not familiar with waste segregation concept, to assure that, respondents answered questionnaire about waste handling and segregation during first visit (pretesting). Total respondent in this stage is 40 students.

3.1.1. Pretesting
At the beginning, total 40 students fill the questionnaire. Based on result of questionnaire five children can correctly answer all question, and they already do waste segregation at their home, taught by their parents (information based on interview after). So, only total 35 students around 7-9 years old who has lack knowledge about waste are selected as respondent to proceed training stage and play the game session. Those 35 students could not answer all question in questionnaire.

There are total 20 questions, questions are in objective format with (a), (b), (c), (d) options which only one option can be pick as an answer. For every question that correct equal to score 5. If answer is wrong equal to 0. The questions can be seen in Table 1

3.1.2. Training
Those 35 students that be selected from pretraining will proceed to training session as respondents. In training selected respondents learn how to navigate the game KEEPIN using VR Console, then they play the game until all mission is complete.

3.1.3 Play the Game Session (empirical evaluation)
To evaluate approachability of the game, empirical evaluation is occurred. At the time during play the game, one respondent will be watched over by one researcher. Respondents were asked to said “out-loud” their respond about everything they feel when they play the game. Researcher monitored the respondent move in game and denoted respondent reactions, actions, comments, or failures. Every positive experience was defined as increasing of immersion, pleasure, or/and challenge in the game. Negative experiences were defined as situation when player want to quit the game in the middle of the game, confused, or bored. After respondents finish the game, they asked to write their feedback and comment toward KEEPIN and tell what their feeling when they play. Those feedbacks were used to verify any assumptions made by researcher before.

3.2. Second Phase (Follow-up Visit)
One week later occurred follow-up visit to do post-testing. Post-testing has two stages. Stage 1 all 35 respondents asked to answer question about waste types, the questionnaire is precisely like questionnaire that they got in first visit. Stage 2 respondents will demonstrate their acknowledgement about waste handling using picture and simulation.

3.3. Result of Empirical Evaluation
Researcher noted 12 respondents gave more than six negative experiences (the number of six is the mean of all negative experiences for every respondent) during playing game session. From that 12 respondents, 7 children quit the game before finish it. Those children written feedback commonly said about uncomfortable feeling using VR Console, getting nauseous (motion sickness), and could not understand the mission. 23 respondents give less than six negative experiences. Their written feedback confirms the researcher’s observation.

3.4. Result of Quantitative Evaluation
The questionnaire of respondents before and after play KEEPIN and simulation result was used to compare comprehension of respondents about waste handling. Then, respondents experience during playing game session also becomes parameter to be compared. Table 2 shows the results of quantitative evaluation to show game approachability and effect of it to the goal of the educational game.


| No | Question                                                                 | Option A                                      | Option B                                      | Option C                                      | Option D                                      |
|----|--------------------------------------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| 1  | What is recycle means?                                                   | use again or more than once.                  | convert (waste) into reusable material.       | Throw waste in the bin                        | Minimize the amount of waste                  |
| 2  | What is reduce means                                                      | use again or more than once.                  | convert (waste) into reusable material.       | Throw waste in the bin                        | Minimize the amount of waste                  |
| 3  | What is reuse                                                             | use again or more than once.                  | convert (waste) into reusable material.       | Throw waste in the bin                        | Minimize the amount of waste                  |
| 4  | How to manage waste                                                      | Do not use any stuff at all                   | Use only expensive stuffs                    | Segregate the waste                           | Put any waste in the same bin                 |
| 5  | I have a plastic garbage and leftovers, what should I do?                | Put those in recycle bin                      | Put those in same bin                         | Put those in different bin based on its substance | Put those in anywhere                        |
| 6  | Snack wrap is kind of garbage                                            | Metal                                         | Reuse plastic                                | Single-use plastic                            | Recycle plastic                               |
| 7  | Plastic bottle of mineral water is kind of garbage                        | Metal                                         | Reuse plastic                                | Single-use plastic                            | Recycle plastic                               |
| 8  | A used glass jar should be                                                | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 9  | Plastic straws should be                                                  | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 10 | A used can should be                                                      | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 11 | A paper bag should be                                                     | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 12 | Old newspaper should be                                                   | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 13 | Plastic bottle should be                                                  | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 14 | Jerry can should be                                                       | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 15 | Scrap metal should be                                                     | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 16 | Leftovers should be                                                       | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 17 | Used paper should be                                                      | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 18 | Rotten tomato should be                                                   | Recycled                                      | Reused                                       | Reduced                                       | Composted                                     |
| 19 | Which action does save environment?                                       | Turning off and unplugging all appliances when not in use. | Always ask for plastic when go to supermarket | Use hygiene plastic every drink water          | Use paper bag than reuse plastic bag to do shopping in market |
| 20 | Which action does NOT save environment?                                   | Always Use paper tissue or paper towel to clean our hand | Walk or use bicycle if want to go to near destination | Make compost from old leaves                     | Use steel straw than plastic straw             |
Table 2. Results of Evaluation

| Respondents | Score of Questionnaire before play the game | Score of Questionnaire after play the game | Simulation result | Main Point of Empirical results |
|-------------|--------------------------------------------|--------------------------------------------|-------------------|--------------------------------|
| 1           | 0                                          | 100                                        | Success           | The graphic is good            |
| 2           | 0                                          | 100                                        | Success           | Game is fun                    |
| 3           | 0                                          | 100                                        | Success           | VR headset uncomfortable        |
| 4           | 0                                          | 100                                        | Success           | The graphic is good and game is fun |
| 5           | 0                                          | 100                                        | Success           | Game is fun                    |
| 6           | 0                                          | 100                                        | Success           | The graphic is good            |
| 7           | 0                                          | 35                                         | Not success       | Game is fun                    |
| 8           | 0                                          | 100                                        | Success           | The graphic is good            |
| 9           | 0                                          | 100                                        | Success           | The graphic is good            |
| 10          | 0                                          | 100                                        | Success           | The graphic is good            |
| 11          | 0                                          | 100                                        | Success           | Game is easy to play           |
| 12          | 0                                          | 100                                        | Success           | The graphic is good            |
| 13          | 0                                          | 100                                        | Success           | VR headset uncomfortable        |
| 14          | 0                                          | 20                                         | Not success       | getting motion sickness        |
| 15          | 0                                          | 100                                        | Success           | Game is fun                    |
| 16          | 0                                          | 100                                        | Success           | VR headset uncomfortable        |
| 17          | 0                                          | 20                                         | Not success       | Getting motion sickness        |
| 18          | 0                                          | 100                                        | Success           | The graphic is good            |
| 19          | 0                                          | 100                                        | Success           | VR headset uncomfortable        |
| 20          | 0                                          | 100                                        | Success           | The graphic is good            |
| 21          | 0                                          | 100                                        | Success           | The graphic is good            |
| 22          | 0                                          | 100                                        | Success           | Game is fun                    |
| 23          | 0                                          | 100                                        | Success           | Getting motion sickness, can not understand how to finish the mission |
| 24          | 0                                          | 100                                        | Success           | Getting motion sickness        |
| 25          | 0                                          | 35                                         | Not success       | Getting motion sickness        |
| 26          | 0                                          | 100                                        | Success           | The graphic is good            |
| 27          | 0                                          | 100                                        | Success           | VR headset uncomfortable        |
| 28          | 0                                          | 15                                         | Not success       | Getting motion sickness        |
| 29          | 0                                          | 100                                        | Success           | The graphic is good            |
| 30          | 0                                          | 100                                        | Success           | The graphic is good            |
| 31          | 0                                          | 100                                        | Success           | The graphic is good            |
| 32          | 0                                          | 100                                        | Success           | The graphic is good            |
| 33          | 0                                          | 100                                        | Success           | The graphic is good            |
| 34          | 0                                          | 100                                        | Success           | The graphic is good            |
| 35          | 0                                          | 100                                        | Success           | Game is fun                    |
From Table 2, results of empirical evaluation and quantitative evaluation shows that 23 respondents who give positive experience can answer all question in questionnaire correctly, they find the game enjoyable by give positive experiences during empirical usability testing, they also success play the game at first attempt and can achieve the goal of the game. 5 respondents give negative experiences but success play the game at first attempt and can achieve the goal of the game. 7 respondents give negative experiences and close the game without finished it.

4. Conclusions

For educational game targeted for children, it is necessary to input approachable introduction and tutorial where children who play the game at the very first time can easily follow the instruction and enjoy the game. But not only that, challenge and reward must clear and suitable with the goal of the game that has been intended during the development process to avoid confusing of player.

KEEPIN already input principles for approachability during game design, to avoid ambiguity when player play the game. It is because waste handling and segregation quite a new thing for most children in Indonesia, so do VR game technology. Clear definition and instruction should be able reach by player in game for that reasons.

Based on the evaluation, KEEPIN quite success as educational game, even though 12 respondents give negative experiences and 7 of them not finished the game, but 5 of that 12 respondents can finished the game and get the proper knowledge about waste handling. They success answer questionnaire and simulation correctly. So, total 28 new player (23 respondents whose give positive experiences plus 5 respondents whose give negative experiences) of this game can reach the goal of the game to educate about waste handling and segregation. But like most technology, negativity and deficiency is not avoidable. Some people not suitable for VR games because effect of motion make them feel nauseous. So, it concludes that KEEPIN approachable enough for new player.

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