



Dental health education game based-on IRVO model in augmented reality technology

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Abstract — Public Dental health must be maintained from an early age. However, it is not easy to make the children interested, understand, and aware of dental health. This paper discussed alternative methods for educating the children using the IRVO model in augmented reality technology-based educational games. The game was built from several materials consisting of dental health education recommended by the dentist. Some of the interactions represented in the game application consist of point of view, selection and release, event creation, and manipulation. This educational game is implemented using the 3DS Max and D-Fusion Studio. This game has been approved for counselors such as dentists, nurses, community health workers, and children. According to the resulting test, more than 75% of the dentists and children are interested in using this game and declared that they could use this application easily.

Keywords – Augmented reality technology, IRVO Model, Dentist application, Children dental health, Dental health education game

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I. INTRODUCTION

Public health dental education is one of the Indonesian Government programs which gives counseling about dental health to the community. One of the focusing subjects is children since the information on a healthy life must be introduced from the children's stage. However, there are many difficulties in introducing dental health education in a conventional way to children because they might be bored or not interested and cannot understand the materials. Usually, conventional public health education is done by giving them a poster, a book, and a lecture.

Four factors have a directly impact how technologies for children should be designed. First, the educational technologies should be designed with new experiences so they can interact as a part of an activity. Experiences are required to build knowledge structures. Technologies can provide a unique experience or augment them through virtual environments and simulation [1]. For example, dental consists of material that needs to visualize, practiced and simulated, such as tooth structure, brushing teeth and tooth form.

Augmented reality Game is one of the solutions to make transfer knowledge more interactive; children can feel more experience, and augment them through virtual simulation.

The critical factor of children's counseling is choosing the correct method and media for delivering information [2]. The methods selection is usually based on the goal reached covering cognitive, affective, or psychomotor levels. Meanwhile, counseling media includes tools to inform counseling messages about dental health education so children can understand information more straightforwardly and more comfortably.

The development of information and communication technology-supported various aspect of life as the world business, government, education, and others. Technologies used to present reliable information media to be accepted well. One of the technologies to be applied is Augmented Reality (AR).

Recently, augmented reality technology has been developing in any way and field. There are augmented reality research in enhancing learning. Albertina Diaz

notes: “By encompassing new technological approaches, using augmented reality technology, allows the final user to experience a variety of sensorial stimuli while enjoying and interacting with the content; therefore, enhancing the learning process.” The resume of this research is that augmented reality can be an alternative method to give better understanding, knowledge acquisition, and enhanced learning experience [3].

Nowadays, children are increasingly using computer technology, both in school and home. In the article *Interaction Design and Children*, Juan P. Hourcade notes: “Given the greater exposure of children to these technologies, they must be designed taking into account children’s abilities, interests, and development needs” [1].

Based on the paper presented by Ninuk Hariyani et al., The Indonesian people’s behavior and knowledge of dental health; are still low. The method and media used didn’t suit children’s psychological development. According to the theory, the modelling method can be a powerful one in improving children’s knowledge of dental health, and puppet theatre can be an interactive one in achieving the intended goal [4].

The previous study about the learning of three-dimensional Dental Morphology in a mobile AR system, was carried out to determine an excellent learning outcome [5]. A survey about AR in dentistry as a new perspective also had been carried out to improve a better quality of learning teaching for the student and the lecturer [6]. A study about the overview of dental education using virtual and augmented reality was also conducted. This study concluded that using virtual and AR in dental education will increase the understanding of the material as a promising innovation and has lower costs of technology [7]. A study about dental simulation needs was also conducted to have the differences between virtual reality simulation and current pedagogical knowledge [8]. Meanwhile, AR implementation for children teaching education had been conducted by researchers. TeachAR is a system using the AR tool to teach English to non-native children [9], [10]. The AR is also implemented in Music-AR, which teaches sound properties like pitch, loudness, and volume [11]. The AR technology was also implemented to enhance the children’s learning in marine education in Taiwan [12]. Besides that, an educational game was also developed in the math field to understand the math problem better [13].

According to those previous studies, however, increasing the understanding and awareness of the children in terms of dental education, requires an application that can be delivered the material about dental health education. This research proposed the design of an application using Augmented Reality technology in the form of game education as a tool that can interact with the children to understand the materials. This application would be used as a dental counseling tool. Besides, the game application simplified the need for dental education tool, attractive and interactive, so children are more interested and

understand the content. The game application must be implied a dental health education material that is given to children in counseling during this time. On the other hand, this game must be user-friendly so children can use it easily as a tool guide to getting information about dental health.

The problems now are how to apply augmented reality technology and make an easy and interactive interaction game about dental health education. The media has to simplify the need for dental education tools, so the making of the 3D object has to be suitable for counseling tools. The media has to be evaluated by the user, which are counselors such as dentists, nurses, public health community workers, and children. The implementation uses D’Fusion® AR Studio (free version) and 3D Studio Max. Dentist evaluation is emphasized on exactness theory and dental health education material, objects 3D and animation, information on media. Children’s evaluation is emphasized on attractiveness, usability, and understanding of dental health education material. In brief, the summary of the contribution of this research describes as follows:

- a) Designed an education game about dental health for children
- b) Implementation of a game as a dental health education tool for children
- c) Proposed an alternative counseling method in dental education health

This paper presented the introduction to chapter one. The concept of the proposed dental health education game focused in section two. Section 3 outlined the testing, result, and discussion. Finally, section 4 represented the conclusion of the research.

II. RESEARCH METHOD

The critical factor of dental health education is choosing the correct method and media to give information. With conventional media such as a poster or a book, the children’s counseling process often gained difficulties. Children are challenging to understand and sometimes are not interested in counseling since they need to know how to maintain dental health early. Hence, it requires media to make the process more interactive and attractive, especially for children.

One of the technologies that could be applied is Augmented Reality or (AR) technology. AR is widely used in various fields, such as the education field. AR applications help the education and information transmission process become more interactive. According to that, the information can be appropriately delivered. AR technology is a visual technology that combines a virtual object with reality. One AR application example is the Augmented Reality Game which gives a high “user experience” to the user more than an ordinary game [14]. A dental health education game is expected to make children interested and receive all counseling information properly. This project aims to make a game that can support the correct

method of counseling to gain an effective and efficient dental counseling process. The methods involve counseling community participants in a demonstration process or performances and simulation.

The game must be adjusted to the purpose of learning or competence to be achieved. Based on Allen's classifications, information presentation uses media forms by many kinds of media such as text, 3D objects, audio recordings, video, and books with printed text. That media is made to provide a fair process of learning. Considering the users of dental health media are children between 5 -12 years old, the media should be easy and interesting. Based on observation with the dentist according to dental health education content, the game which needs counseling are:

- A game that consists of dental health education equipped with visualization and interesting simulation game, so the kids are more easily understood dental health information
- A game that not only be used by counselors - but can be used by parents or children independently (user friendly)
- A game that provides a facility for users to make interaction with the system in user-friendly nature

This application develops a dental education health game based on augmented reality markerless technology (colored markers), consisting of dental health knowledge in natural interaction. The system requires hardware and software; it can be seen in Table 1. The list on the table is defined as the minimal requirement of the system.

Table 1. Hardware and Software System List

Hardware	Software
Visualization unit: Head Mount Display (HMD) or webcam with resolution 640x480	D'Fusion® AR for developed application
Processing Unit: dual-core processor 2.4 GHz, RAM 1 GB, harddisk space remaining 10 GB and 1 GB for Software	D'Fusion Exporter for exporting 3D objects and animation to D'Fusion® AR
Interaction Unit: pointer ring and game card	Autodesk 3D Studio MAX
Addition unit: Speaker	D'Fusion® Home Player

D'Fusion® AR is a real-time engine that controls the loop process and plays a role in scheduling and prioritizing tasks. Making an AR application consists of image or object recognition, target tracking, rendering 3D objects in real-time, 3D models, textures, animation and sound database, and LUA scripting, as shown in Fig 1. The scenario of an augmented reality game is developed using D'Fusion® AR with Lua script.

The first procedure is to capture images of the objects used as markers. For example, an image that becomes a marker in a toothbrush simulation game is an image on a ring where the image will later issue a 3D virtual toothbrush object. This marker object is then rendered to display a 3D virtual object. The part of D

Fusion AR that performs a real-time rendering engine of the images captured by the camera is the ogre 3D engine.

The following procedure is to create virtual 3D objects animations and perform sound recordings – creating virtual 3D objects and animations using 3DS max application software. The virtual 3D objects created include gums, different types of teeth, healthy and unhealthy foods, toothbrushes, pointing sticks and puzzle pieces of tooth structure. The animation made is a moving figure of the jaws of the teeth that open and then close to being displayed in the healthy food game. Voice recording is made for audio-guiding gameplay and applies to all games. All this is stored in the database.

The next step is to create a scenario with the LUA scripting Module to design events on the image captured by the camera (marker). The scripting program is made to adjust the appearance of the 3D virtual object to the captured image (marker) and to design the interaction mode that will be carried out on the image. The Computer Vision Module is a part of D'Fusion® AR that manages image tracking, image processing, and natural interaction.

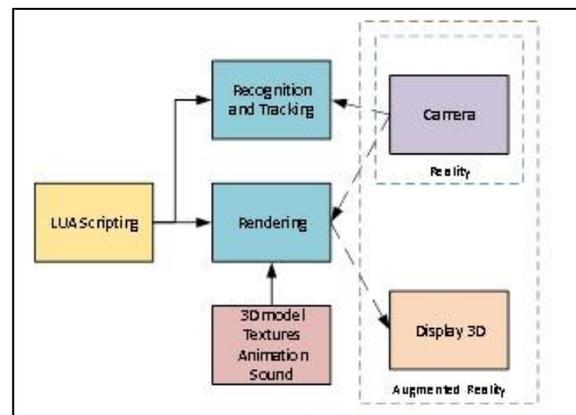


Fig.1. Structure of designing and implementation

The dental health education AR Game is designed to be used by children, easily. Users only manage the hardware, use interaction marker games, and run the Dental Health Education Game software to use this game. Fig 2 shows the use of case global software described activity that can be done on the system in general.

The interaction is designed based on the concept of TAR (Tangible Augmented Reality). In a tangible AR interface, the visual display of the AR content is coupled to a tangible object. Tangible AR interfaces combine the enhanced display possibilities of AR with the intuitive manipulation and interaction of physical objects or Tangible User Interfaces [15].

The contents of a dental health education game consist of four parts and are determined based on observation with the dentist. Those are represented in Table 2. The first section is the introduction. In this section, children will explain the various types of teeth material, and after that, they will play with the position of the teeth on the gum as puzzle gum. Finally, users have to put the tooth in the right position of the gum, as seen in Fig 3.

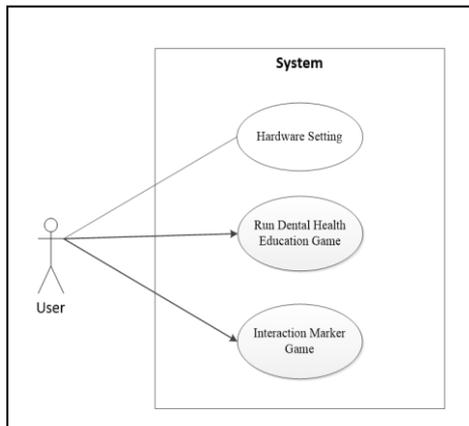


Fig.2. Global Use Case of Dental Health Education Game

Table 2. Game List

Game	Material	Description
1 st Section	Introduction	Introduce the type of the teeth and describe their position on the gum
2 nd Section	Puzzle	Playing puzzle teeth layer structure
3 rd Section	Healthy Food	Choosing the healthy food
4 th Section	Simulation	Brushing teeth simulation

This application is presented in Indonesian since the case is in Indonesia. This game will give knowledge about the position of each tooth on the gum and represent the teeth model. The interaction used in this section are viewpoint control, selected and release, and pointing detection. In addition, children have to use AR Ring to appear on the virtual stick.



Fig.3. Gum Puzzle Game

The Virtual stick is used to pick and move the tooth placed on the gum. The game consists of four questions

about tooth position. Users picked the question by pushing the virtual button, which appears using pointing detection. The children will get a star if they put a tooth in the right position. The game is finished if users can completely place the tooth in the right position.

The second section is a puzzle. In this section, the user will interact with a tooth structure puzzle, as shown in Fig 4 (a). Animation and audio are added as an introduction and tutorial of the game. Users have to arrange a card showing a text of tooth structure pieces such as dentin, enamel, gums and alveolar bone, and the pulp cavity.

Each card will appear as a virtual 3D puzzle piece of tooth structure to can help children arrange puzzles, easier. If users arrange the puzzle correctly, it will show the full 3D puzzle of the tooth structure model. The interaction used in this game is an event generation in the position, and distance between markers can cause an event.

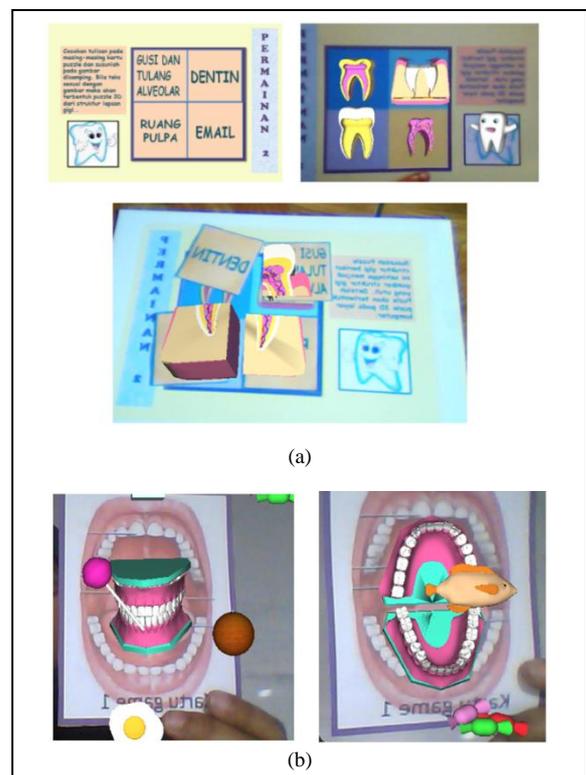


Fig.4. Game of: (a) Tooth Structure Puzzle Game and (b) Healthy Food Game

The third section is healthy food, as seen in Fig 4 (b). This section represented the introduction and game of nutritious food for healthy teeth. This game showed some food that is including in health or unhealthy food for dental health. This game uses a marker card to bring up the virtual teeth model. The virtual teeth model provides the chosen eating food by bring it close to the mouth.

The children should choose healthy food for healthy teeth. If they choose healthy foods, they will get a score

in the form of a star. On the contrary, if the children choose unhealthy food, they will get a score in germs. This game used event generation interaction. The game ended after they had chosen six pieces of appearance food. The fourth section is the simulation of brushing teeth. This game use face detection. While the face is detected, the game will show the teeth model on the captured face, as described in Fig 5.

In this section, the children have to use an AR ring to play this game, and the ring will show a virtual toothbrush. The position of the teeth model can change according to face movement. Through this game, the children can learn and practice brushing their teeth correctly. The interaction used in this game is viewpoint control.



Fig.5. Brushing Tooth Simulation

The interaction of the whole game application and the relation between reality and virtual used an IRVO (Interacting with Real and Virtual Objects) Model, as shown in Fig 6. IRVO is modelling the interaction between users and the Mixed Reality system by explicitly representing the objects and tools involved in their relationship [16].

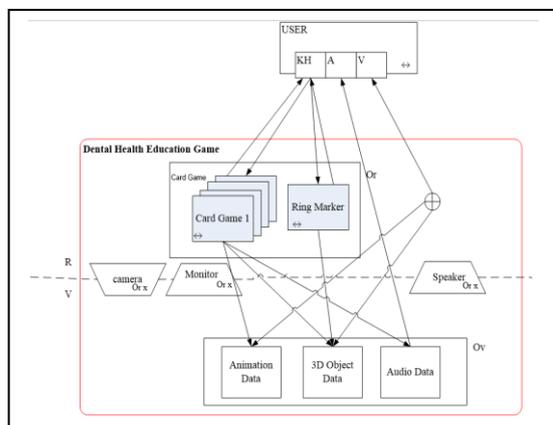


Fig.6. IRVO Model of Dental Health Education Game

The card game and ring marker are tools used to play this game. The real object, such as the card game and the ring marker, has the mobility, so they can move freely. While the camera, monitor, and speaker are in a fixed position, the user enjoys the visualization, such as

3D Objects and animation accompanied by sound. KH means kinesthetics/haptic channel represented as the output such as handling, grasping, gesture, etc.

III. RESULT

Two-kind of respondents examine the dental health education game application as seen in Table 3. The first respondent is a counselor such as a dentist and medical workers in the public health community. The children are the second respondent. Dental health education game application made based on observation of dental health counselor. During the development of this application, the selection of the content is guided by the dentist because the content should be by the dental health education material delivered to the children. A counselor tested this application on two things: the content and the ease of using the application. The questions are given after the dental health counseling was conducted.

Table 3. Respondent

Kind of Respondent	Respondent	Number
Counselor	Dentist	5
	Medical Worker in public Health (Nurse)	2
Children	Elementary School age 5-12 Years Old	20

The tests carried out at the time of dental health education are implemented. The game was introduced to the children, and the children played with guidance from the counselors. At the end of the counseling, counselors give them several questions corresponding to the dental health material. The test results are used to benchmark the successful dental health materials through the game. At the end of the counseling, the agent then fills out questionnaire about the content and the ease use applications.

The survey conducted on children aims to determine the performance of the dental health education game on users with the following test scenarios:

1. Children are given instructions and explained how to play the dental health education game
2. Children play dental health education games such as the healthy food game in Fig 7(a) and 7(b)
3. Children respond to the use of the application through interviews from the questionnaire that has been prepared
4. Analysis of survey result response data

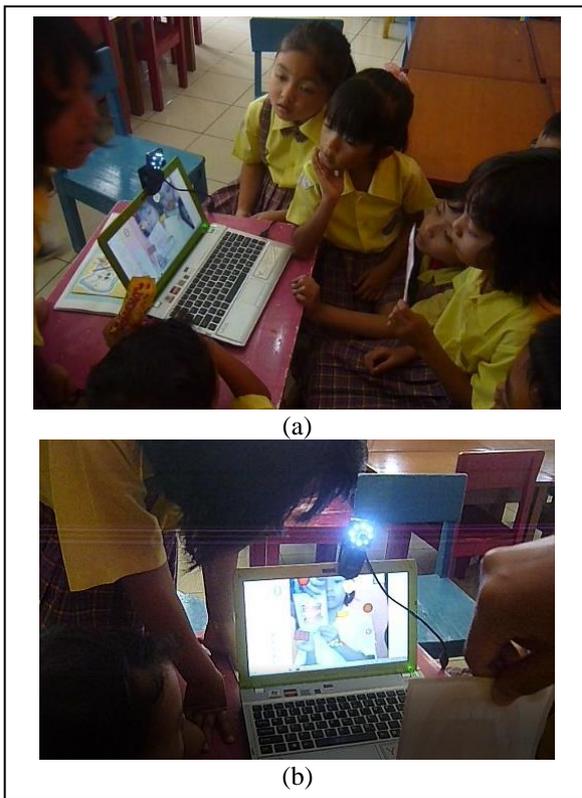


Fig.7. Test of Dental Health Education Game on Children: (a) Children playing healthy food game (b) Interaction card to virtual 3D object

Fig 8 shows a diagram of the counselor questionnaire result. The result concluded that the Dental Health Education AR Game produces a more fun process for children and helps counselors convey dental health materials to the children. Besides that, the material is easy and more comfortable to deliver to the children.

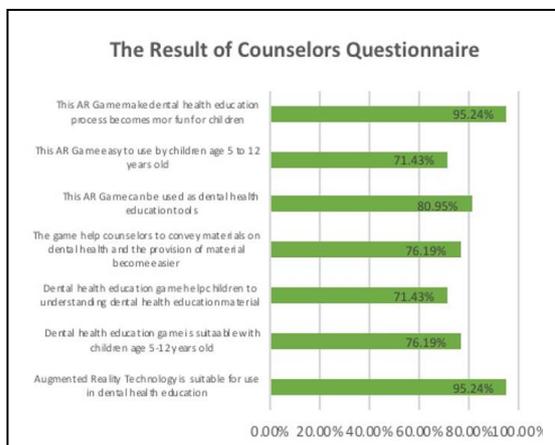


Fig.8. Results of counselor’s Questionnaires

The diagram shows 95.24% of AR is suitable deliver information and children’s fun, while children’s understanding to the material is 71.43%.

The question was also conducted to counselors to determine whether each game has been in accordance

with the criteria which the counselor gives. The question emphasizes the suitability of three-dimensional objects with the material, the ease of the game, and how great the game can help children in understand the material

The diagram of the test results in Fig 9. It is shown that the most enjoyed game in the application is the healthy food game (G3). It is because the interaction used in this section is quite easy and interesting. In contrast, the children’s simulation game of brushing teeth gets an inadequate response. This is because the 3D Object used are still elementary, and the interactions are made only in terms of viewpoint control. The second is puzzle, a puzzle game of tooth structure game (G2) becomes the easiest to play by children because the game is guided by a virtual 3D puzzle that appears on a puzzle piece.

After playing the dental health education AR game, the children answered the questionnaires’ questions during the interview. The children’s questions are focused on the attractiveness and the ease to use game. This test involves 20 children aged between 5-12 years old.

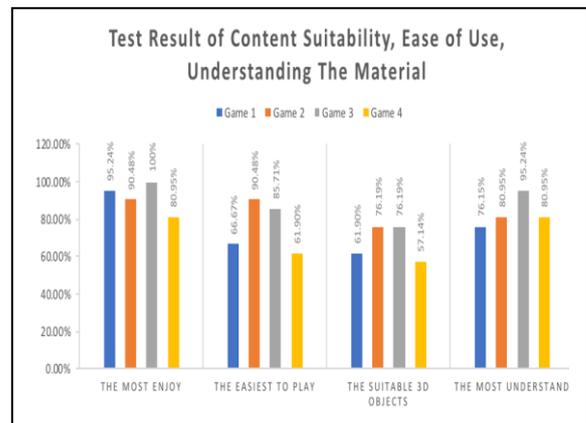


Fig.9. Result of Content Testing

According to Fig 10 (a), 95% of the children stated that the dental health education AR game is easy to use. At the same time, the rest said that the application is difficult to use. This is because users vary between age 5-12 years old. 5% comes from children who are aged below seven years old.

According to Fig 10 (b), 85% of the children stated that they could accept and understand the materials on the dental health education AR gam. In comparison, 15% of the children were still confused and found it difficult to understand the material.

The same as previous testing, the children were also tested based on their interest and impression of the game. According to Fig 11 (a), 95% of the children are interested in playing the Dental Health Education AR Game. Besides that, most children feel happy and interested in the game the children’s impressions after playing such games. Fig 11 (b) shows that almost 85% of the children feel fun and enjoy this game.

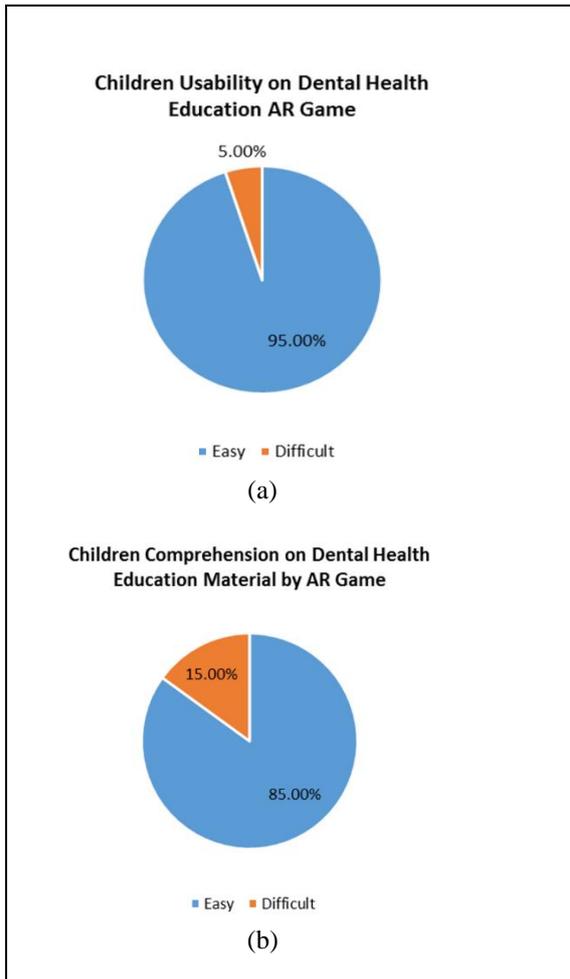


Fig.10. The percentage of (a) usability of the application and (b) comprehension of the application

The children were also given a question about dental health content to determine their understanding after playing the game. The counselors provide dental health questions about the subject matter contained in each game to determine the level of knowledge of children about dental health materials. The result can be seen in Fig 12.

Fig 12 is shown the children's diagram of understanding the material properly, implicitly in the first and the third game. It can be seen from the percentage that more than 75% of the children understand the material properly. While the percentage of material in the second game and the fourth only get 61.25% of the children who understand clearly.

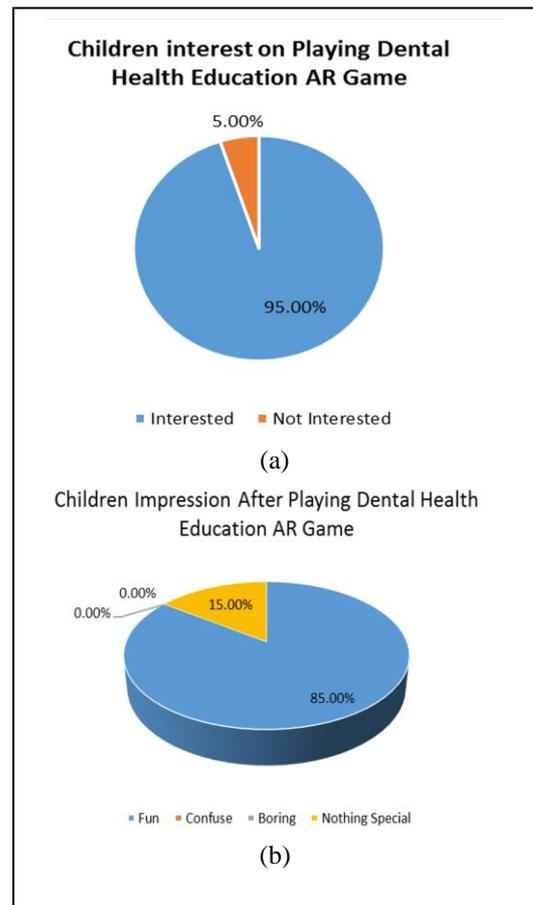


Fig.11. The percentage of: (a) children interest and (b) children impression

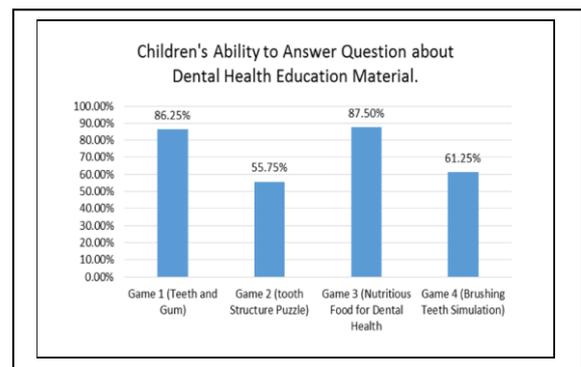


Fig.12. The percentage of Children understanding

IV. DISCUSSION

The result concluded that the Dental Health Education AR Game could help counsellors convey dental health materials to the children. Besides that, the material is easy and more comfortable to deliver to the children. Dental Health Education AR Game should be developed further, especially regarding the ease of use of dental material health the ease of use. The interaction in the game should be enhanced and can further help the children to understand the dental health materials.

The results stated that the most children could accept and understand all the materials on the dental

health education AR game. Besides, 3D objects on each game need to be improved, especially in the teeth and the gums (G1) game, since the anatomy of the teeth and gums is still not approaching the actual physical form.

According to the result, the children can enjoy with dental health education process. Most children are interested and enjoy playing the Dental Health Education AR Game. However, the understanding of material depends on the children's maturity since the users are aged below seven years old. At this point, the minimum age to understand the material is seven years old.

The result of children's understanding indicates that game 2 and 4 still requires development, especially on the material thing implied in the game, the 3D object of counseling tools, and the type of interactions.

V. CONCLUSION

Dental health education AR games can be used as an application aid to give information about dental health to children. Implementing this application can make the dental health education process more enjoyable and fun, and the delivery process and the content becomes easier. Most children respond to this game well, enjoying the dental health education process.

Based on the test results, it can be concluded that the game is easy to play by children, quite interesting, and fun for children. Besides that, this application can make the children more understand the content material with an average understanding score of about 72.69%. However, this application still requires improvement and development especially in the material content, 3D Object of counseling tools, and interaction type implied in the game.

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