

BENTHIX VR: A VIRTUAL REALITY SIMULATION APPLICATION TO PRESERVE A TRADITIONAL GAME

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Abstract - This research aimed to preserve Benthik traditional game using Benthix VR. Benthix VR used the Virtual Reality Interface Design (VRID) development model. The development phase of the VRID model started from High Level to Low-Level phase. The High-Level Design (HLD) phase consisted of identifying data elements and multiple objects, and modeling component objects. The output from the HLD phase would be input to the Low-Level Design (LLD) phase. The LLD phase was a phase of repetition and fine-tunes from the modeling of several component objects thoroughly. Testing of Benthix VR was conducted on 34 respondents with five assessment aspects. Those were enjoyment, realism, interactivity, usability, and impact. The average result of the questionnaire assessment of all aspects is 3,18824. These results indicate that users feel Benthix VR is comfortable, realistic, interactive, and fascinating. Moreover, they are also interested in playing Benthik in the real world after using the application.

Keywords: Benthix VR, Benthik, Virtual Reality (VR), Virtual Reality Interface Design (VRID)

I. INTRODUCTION

The traditional game is a cultural heritage that must be preserved. The traditional game is considered to have benefits for children's psychological development which involves gestures and social activities (Algiffari, 2015). One of the traditional games in Indonesia is Benthik. Formerly, Benthik or Patok Lele or Gatrik has been played by children in various regions in Indonesia such as Central Java, Yogyakarta, West Java, East Java, and others (Wardani & Lutfi, 2014).

Currently, it is rare to encounter children who play traditional games like Benthik in urban areas. This is due to several factors. Those can be acculturation and assimilation of foreign culture, the number of digital games, the small amount of documentation that contains knowledge of traditional games, and the lack of playgrounds (Algiffari, 2015; Setiawan, Kartikadarma, & Haryanto, 2013). Furthermore, there are no researches that directly apply the technology for Benthik game either in digital games or Virtual Reality (VR) applications. In this research, it is proposed to utilize VR technology to preserve Benthik as traditional games.

According to Dionisio, Iii, and Gilbert (2013), VR is an immersive 3D simulation or computer-generated

environment that appears to be real and direct. In other words, it appears to have a physical interaction with the user. With this immersive environment, users can experience the full engagement experience in a virtual world. It is as if the user can feel the similar atmosphere to the real world. Such an immersive environment is required in the manufacture of Benthik game simulation applications as an intuitive learning mechanism.

The previous attempt to achieve the experience was done by Gong and Ning (2016). They tried to simulate the basketball players movement in learning how to shoot the ball. Then, Rietzler *et al.* (2017) simulated airflow to enhance experience in the virtual world. Papagiannidis *et al.* (2016) stated that experience was more associated with engagement and enjoyment.

The use of VR for educational simulations has been widely used in areas such as military, space training, driving simulation, and medical training. In 2008, the US military used VR as a military training and simulation for its soldiers (Wilson, 2008). Moreover, NASA has used virtual reality since 20 years ago. In NASA, VR application is used to simulate zero gravity for astronauts and astronaut candidates (James, 2016).

In-flight simulations, VR is used for pilot training. Furthermore, a variety of VR devices allow pilots to control the aircraft in a virtual world with similar control spaces with real-world aircraft control (Dourado & Martin, 2013). Then, in medical training, VR can be used to simulate surgical procedures (Ahlberg *et al.*, 2007). In another area, Google creates a 3D drawing simulation by utilizing the HTC Vive device called Tilt Brush (Google, n.d.).

VR has also been used for cultural preservation. VR for cultural preservation was first performed in 1994 with 'Interactive Walk-Through'. It is used for museum visitors and made into research. Utilization of VR to make objects in the museum appears more real. It is also done by Beer (2015) with virtuality method. VR for cultural preservation is also applied in understanding areas that have cultural elements (Barreau *et al.*, 2014) and articulating cultural objects in 3D (Tan *et al.*, 2016).

From those related works, it is possible to apply VR as an interactive and immersive simulation technology for Benthik game. Besides that, the objective of using VR technology is to preserve Benthik game. The application of VR for the game simulation of Benthik is expected to provide knowledge about playing Benthik and increase users' interest in the preservation of this traditional game.

II. METHODS

The research stages consist of problem identification, data collection, analysis, design, implementation, and evaluation. The data collection, analysis, design, and implementation stages use the Virtual Reality Interface Design (VRID) development model (Tanriverdi & Jacob, 2001).

Identifying problems start from finding a problem that triggers the lack of interest in playing Benthik. The search is conducted by doing interviews and literature studies. From the result of the interviews and literature studies, the main problems of the low interest in Benthik games are the lack of gameplay information and playing field.

The next stage is the development of VR applications with VRID model. The development phase of the VRID model starts from the High-Level Design (HLD) phase and Low-Level Design (LLD) phase. The HLD phase consists of identifying data elements and multiple objects and modeling some component objects. Its output can be input to the LLD phase. It is a phase of repetition and fine-tunes from the modeling of several component objects thoroughly. Then, the object components to be modeled include graphical components, behavioral components, interaction components, mediator components, and communication components as shown in Figure 1.

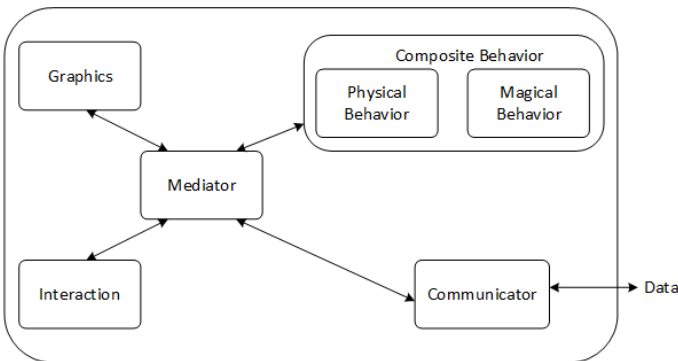


Figure 1 Component Object Architecture of VRID Model (Source: Tanriverdi & Jacob, 2001)

Identification of data elements in this application development is divided into three types of data. There are users, physical devices, and supporting data. Benthik game is usually played by 12 to 17-year-old children. However, Benthik can also be played by adults. Adults' lack of knowledge to play Benthik is the main problem that is previously described. Consequently, this VR application is addressed to adults in the range of 17 to 35 years. The reason why this app is developed for adults is for them to teach children how to play Benthik in the real world by not replacing Benthik game itself.

A physical device used in this research is a set of HTC Vive and a computer unit that supports VR. The set of HTC Vive consists of two base stations, two hand controllers, and one Head Mounted Device (HMD). The computer specifications used to develop this application are 7th generation of Core i5 processor, 16GB RAM, and NVIDIA GeForce GTX 1070.

The last data elements in identification are physical playing tools, game-play procedures, and win-lose system. The main physical tools used to play this game are two pieces of wood. Those pieces of wood are formed to be a long and short stick with the size of approximately 30 cm

and 10 cm. The diameter of both long and short sticks is 3 cm. This game requires high agility when a player goes to hit a short stick with a long stick. The short stick is placed above two brick-like stones (arranged in a line) or hollowed ground. That backrest can be called as 'Wok'.

The game begins with creating two teams. This game has three rounds. It is performed with a turn-base mechanism for every single player in a team (Putra, 2012). The first round is by putting a small stick above the Wok as shown in Figure 2.



Figure 2 The Benthik Playing

Then, the player is assigned to hit a small stick with a long stick until it crosses the predetermined line. The opponent's job is to keep the thrown short stick. If the opponent fails to capture that short stick, the other player can throw the short stick again. When the opponent catches the short stick, it will end the team's turn.

The second round is done by a player who is holding both long and short sticks. It is important that the player stands above the Wok. The player will throw the short stick upward, over the long stick, and hit the short stick until it crosses the predetermined line. The opponent must catch the thrown short stick.

The final round is to put a short half stick on the side of the Wok. Thus, the player can hit some part of the short stick to float in the air. Then, the player will hit that short stick quickly before it falls to the ground. The game rules for each region in Indonesia are slightly different. Nevertheless, the game rules and mechanism used in this research are as described previously. After the game ends, the win-lose system is done by calculating the distance score for every single player on the team in all rounds. The distance score is obtained from a distance between the short stick's end positions with the Wok position.

The next stage in the HLD phase is the identification of the object. Objects that have been identified are presented in Table 1.

Table 1 Objects Identification

No	Code	Object name	Quantity	Object Type
1	B1	Hand control	2	Physical objects
2	B2	Long stick	1	Physical objects
3	B3	Short stick (thrown)	1	Physical objects
4	B4	Wok	1	Physical objects
5	B5	Predetermined line	1	Logical objects
6	B6	Opponent character	3	Aggregate Objects

Table 1 Objects Identification (Continued)

No	Code	Object name	Quantity	Object Type
7	B7	Guiding robot	1	Aggregate Objects
8	B8	Head-Up Display (HUD)	1	Aggregate Objects
9	B9	Playing environment	1	Aggregate Objects
10	B10	Laser pointer	1	Aggregate Objects

There are three types of object as shown in Table 1. First, physical objects are directly related to the user’s physical environment. Second, logical objects are logically based on game rules. Third, aggregate objects contain a combination of several objects. Some objects may not be included in the game directly, such as HUD, guiding robot, and laser pointer. HUD contains player name information, current score, score accumulation, and quest score. Meanwhile, guiding robot only appears at the beginning of the game to let players know how to play descriptively. Then, the laser pointer can tell the name of virtual objects around the player. This can be activated by pressing the grip button on the HTC Vive controller.

After identifying multiple objects in the game, it is followed by object components modeling. The first step in object components modeling is graphical component modeling. The graphical component modeling is applied to objects in Table 1 by using 3D objects modeling. 3D modeling also includes animation and texture painting. The second step is behavioral modeling. Each object has different behaviors according to its function. The behavior is classified as physical behavior and magical behavior.

A physical behavior includes migrating, colliding, moving, and having another physical simulation. Meanwhile, a magical behavior is a virtual behavior which can be made irrationally. Physical behavior is present in almost all identified objects except HUD and laser pointer objects.

Then, interaction modeling aims for multiple objects to be involved in forming or changing behavior. Table 2 shows the interaction between objects. When the hand control holds another object, the user or player must press and hold the trigger button on the HTC Vive controller.

Table 2 High-Level Interaction Objects

No	Object Code	Interaction
1	B1 and B2	Holding and Swinging
2	B5	Triggering
3	B1 and B4	Holding
4	B2, B3, B6, and B9	Colliding
5	B3 and B4	Supporting
6	B8 and B10	Pointing

Modeling of communication component consists of two parts. There are internal (mediator) and external communication. Modeling of internal communication components aims to prevent interaction conflict between

objects directly. Interaction conflicts occur between the hand control object, long stick, wok, and short stick.

In Benthik game rules, it is mentioned that three rounds require different interactions. For instance, in the first round, the small stick must be placed above wok, and the player can hit that with a long stick (lifting). In the second round, small stick is placed in the left hand with the control and the right hand is holding a long stick. There is a conflict in changing the round from the first round to the second round. This kind of conflict can be dealt by making a turn-based mechanism for each round.

Then, external communication modeling aims to determine the need for control and coordination of some objects. Coordination of multiple objects occurs when a long stick hits a short stick and causes it to pass the predetermined line and fall to the ground. As long as it is not exposed to the opponent, the game can continue. When short stick hits the ground, the user must wait for one of the opponents to throw back the short stick within wok’s target.

The next phase of VR application development with VRID model is LLD phase. This phase explains more detail about graphics modeling, behavior modeling, interaction modeling, and communication modeling. Graphic modeling in LLD is done by adding physics engines such as gravity effects, density, and colliding simulation with 3D objects. The tools or apps used to create 3D models are 3D Blender. Meanwhile, for animation and physics effects, it uses Unity 3D. All these effects exist on all objects identified in this Benthik game, except for the HUD object. Figure 3 depicts the 3D models of Wok, long stick, and short stick.

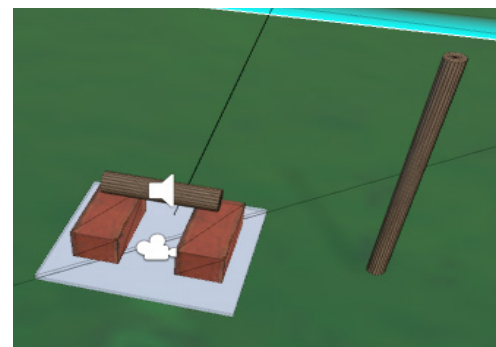


Figure 3 The 3D Model of Wok Object, Long Stick, and Short Stick

The LLD modeling of behavior includes a detailed description of the behavior that exists on the object. In this research, there are some behaviors that need to be described more thoroughly. It can be the behavior of short stick and the behavior of the opponents. The behavior of the short stick is represented by the state diagram in Figure 4. Meanwhile, Figure 5 represents the state diagram of the mental behavior of each opponent.

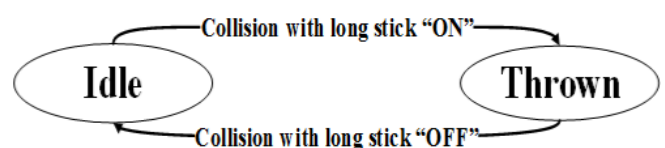


Figure 4 Behavior Short Stick (Thrown)

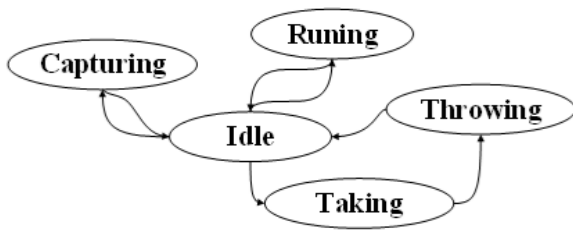


Figure 5 The Mental Behavior of Opponent

Capturing state occurs when the short stick collides with the opponent directly. Then, the transition from the state of taking to throwing occurs if the short stick has touched the ground.

The overall steps of the game in interaction sequence are successfully completed by implementing program code in Unity editor. The program code to make this application uses C# programming language with the help of SteamVR SDK. It is software development kit developed by Valve for supporting VR application using HTC Vive device on Steam platform. Modeling of low-level internal communications is already shown in Figure 2. Since the hand control touches and hits, there are differences in flow of steps by adjusting to Benthik playing rules in each round.

The steps are divided into three rounds. First, hand control touches long stick and hits short stick which is placed on the right and left of Wok (for brick-like Wok). Second, right-hand control touches long stick and hits the short stick controlled by the left-hand. Third, the right-hand control touches the long stick and hits the short stick that

is propped up in one Wok until the short stick is thrown upwards. When the short stick floats in the air, players can hit again until it is thrown.

The flow diagram of low-level external communications modeling, which is related to the game interaction, is presented in Figure 6. There are two game conditions which will be completed. There are lose and win in each round. This Benthik VR game app is temporary. It can be played in single-player mode as it focuses on the knowledge of the game itself. Thus, it requires an external communication mechanism that can meet the single-player game mode.

The storyline in this app is based on game-play rules that have been described at the beginning of this research. Assuming that the opponent is finished with the turns, the value of the accumulated score is symbolized with S_q . The target player can get an accumulated score S_p earned at each of the player's turn on each round. If S_p is bigger than S_q , the target player will win this game. If that condition is not met, the player will lose. The accumulation calculation is presented in equation (1).

$$S_p = \sum_{i=1}^3 \sum_{j=1}^N P_{ij} \quad (1)$$

Moreover, the value of P_{ij} is the score of players who play in the round of - i with players of - j , and has a limitation on the number of - N players. Maximizing each existing players' turn is necessary.

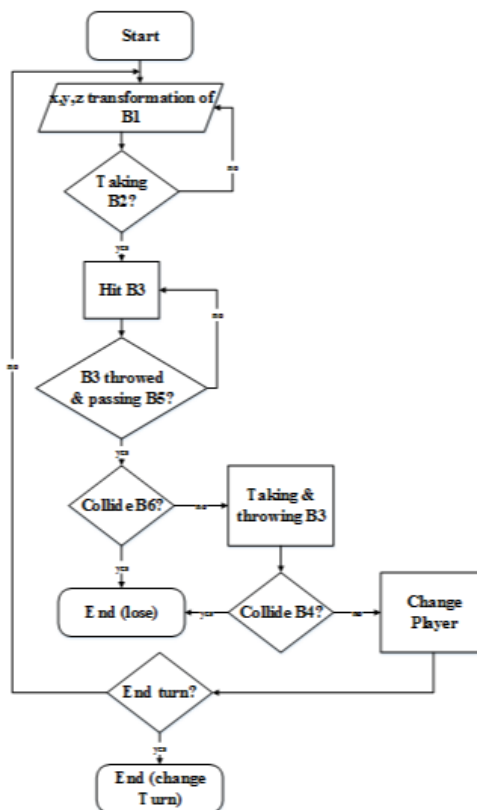


Figure 6 Flow Chart of Benthix VR Game Interaction

Moreover, there are two losing conditions. Firstly, losing condition can occur directly when the short stick collides with the opponent. Opponents will spread randomly to keep the short stick from falling. Secondly, it can happen when the opponent throws the short stick back and collides it with at least one Wok.

III. RESULTS AND DISCUSSIONS

After completing the analysis, design, and implementation steps with the VRID model, the virtual reality application for Benthik is named as Benthix VR. Benthix VR is implemented directly on users who have or have never used VR with HTC Vive. To make the experience of users distributed equally, simple training is done first by using the steam VR tutorial application from HTC Vive.

Figure 7 shows the comparisons of playing Benthik using Benthix VR and the traditional way in the real world. There is no significant difference in the game either traditionally or with Benthix VR. To get haptic feedback on the user, when a long stick hits the short stick, there is

a vibration for approximately three seconds and a sound effect.

The guiding robot on this application can help a new user to play Benthik in general. However, if the user wants to feel a real sensation in playing Benthik, the user still has to finish every round in Benthix VR. Figure 8 depicts the action of the guiding robot with a transcript of the dialogue with the robot's sound.

To make the application more realistic, one of the opponent characters can approach a short stick that has been thrown and has touched the ground. When the opponent comes to the short stick, it uses the feature called 'NavMesh' on Unity. Navmesh feature is a path-finding algorithm that it uses the A* algorithm. After approaching the short stick, the opponent will throw a small stick object to the Wok, as shown in Figure 9.

In the last stage, there is an evaluation of Benthix VR. The tests are conducted on 34 respondents with a questionnaire after playing this Benthix VR application. The respondents are male and female students with age range from 17 to 24 years.

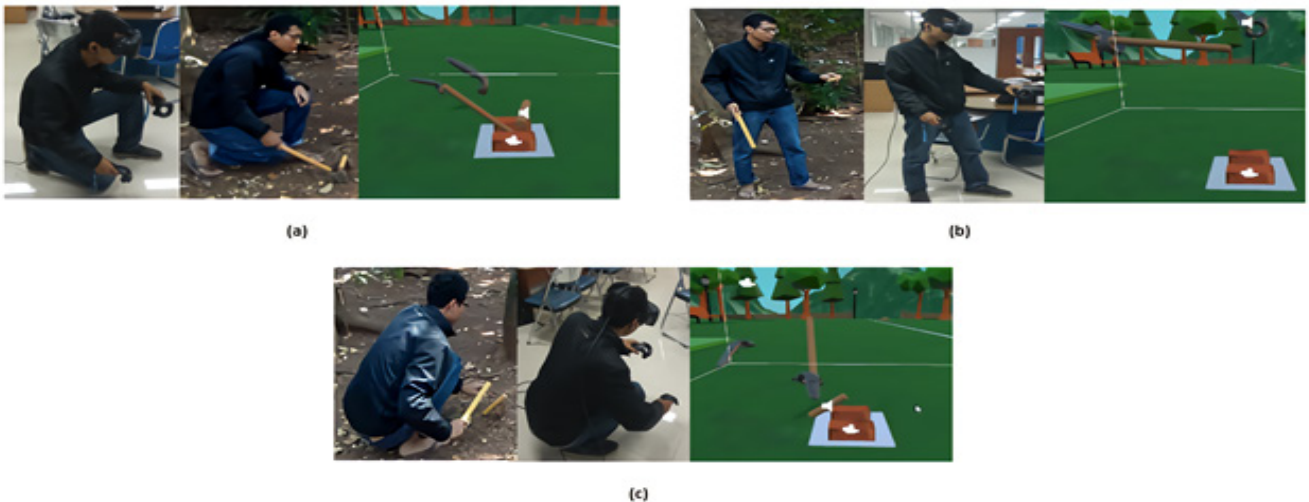


Figure 7 Comparisons of Traditional Game Play and VR Game Play at (a) First Round, (b) Second Round, and (c) Third Round



Figure 8 The Virtual Guiding Robot in Benthix VR



Figure 9 Opponent Characters in Benthix VR

The contents of the questionnaire include several aspects. Those aspects are enjoyment, realism, interactivity, usability, and impact. Assessment for each question in this questionnaire falls within the range of rating results from 1 to 5. First, the questions on the enjoyment aspect have a result of 1 for uncomfortable to 5 for very comfortable. This aspect consists of four questions. Second, the answer to the questions of realism range from unrealistic to very realistic. It is an assessment of how realistic Benthix VR applications are when played by the user. There are four questions for this aspect. Third, to assess how interactive Benthix VR applications are there is an interactivity aspect. The questions on the aspect have answers from non-interactive to highly interactive. In this aspect, there are only two questions. Fourth, the questions on the usability aspect have the answers of do not understand to very well-understood. This aspect of usability is very influential in how useful Benthix VR application is and understood by the users. It consists of three questions. Fifth, the last one is the impact aspect. This aspect assesses how influential Benthix VR is to attract users to preserve the traditional Benthik game. There are two questions on this aspect. The answers to questions ranging from not interested to very interested. The questions are shown in Table 3.

Table 3 List of Questions

Aspect	Question
Enjoyment	Are you comfortable to play Benthix VR?
	Are you comfortable with the design of objects or virtual environments within Benthix VR?
	Are you comfortable to use VR Controller (HTC Vive Controller)?
	Are you comfortable when looking at virtual objects on this Benthix VR?
Realism	Does it feel realistic (like in the real world) when you play Benthix VR?
	Do the objects in Benthix VR look realistic?
	Does it feel realistic when a physics effect occurs (the influence of gravity and density) in this Benthix VR?
	Does the NPC movement or the opponent look realistic when walking, stopping, and throwing?
Interactivity	Does the sensation of the haptic effect of Benthix VR make the game more interactive?
	Does the opponent work properly and interactively (including when throwing a short stick to wok)?
Usability	Can you understand the rules of Benthik game by playing Benthix VR?
	Do you know how to throw a short stick in all rounds of Benthik game after playing Benthix VR?
	After playing Benthix VR, do you understand the process of player substitution (turn) in every round?
Impact	After playing Benthix VR, are you interested in playing Benthik game in the real world?
	Are you interested in teaching Benthik game in the real world to friends/ colleague/children?

The result of the questionnaire that has been answered by 34 respondents is shown in Figure 10. P1 represents enjoyment. P2 and P3 are realism and interactivity respectively. Then, P4 is usability and P5 is impact.

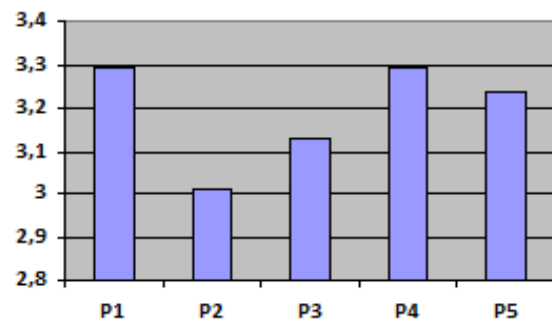


Figure 10 The Result of Five Aspect Evaluation

In Figure 10, it is seen that the aspect with the highest result is enjoyment and usability with an average result of 3,29412. These results indicate that the users understand the rules of Benthik and feel comfortable playing with Benthix VR application. Then, the third highest average score is the aspect of impact with an average result of 3,23529. Although the average result of impact aspect is not very high, users are still interested in telling others about Benthik game or playing it in the real world.

The worst average achievement is the aspect of realism and interactivity with the average result of 3,00735 and 3,13235 respectively. However, the average results do not have a significant difference compared to other aspects. Users still feel that Benthix VR application is a realistic and interactive application. Conclusively, if the average results of every aspect are taken, Benthix VR application has an overall average result of 3,18824.

IV. CONCLUSIONS

The application to preserve Benthik traditional game, Benthix VR, has been successfully developed with VRID model. Benthix VR is tested on 34 respondents and evaluated by a questionnaire on five aspects. There are enjoyment, realism, interactivity, usability, and impact. From the five aspects, there are no distinctive results on the aspects. Users mostly agree that Benthix VR is comfortable, realistic, interactive, useful, and impactful. In addition, the high interest from questionnaire answers on impact aspect implies that users also want to preserve Benthik game.

Nonetheless, there needs to be an improvement on all aspects of the assessment for Benthix VR application so it can be more valuable for users. In a subsequent development, Benthix VR application can be made with Mixed Reality technology to increase users' interest in Benthik game.

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