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Design Numbers-Recognizing Game with Interactive Projection for Young children

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A B S T R A C T

Early Childhood Education (PAUD) requires an interactive and attractive learning system. The PAUD learning method is also capable of stimulating the knowledge development of the students, especially in the cognitive aspect. Such an aspect enters into an educational game where there is an element of education obtained from something that exists and is inherent as well as being part of the game itself. The activities that have these educational elements can stimulate and train the development of the child's brain and stimulate the creativity of children's thinking. The use of technology has a strong influence on the development of education in children of PAUD age. Interactive Projection is one of the learning media for students to understand numbers easily and fun. Target kids are there at the age of three to five, with introductions starting from physical numbers, how to write numbers, counting some objects and matching numbers. Numberpedia uses blackbox method as a testing method. From the blackbox method, some several questions were carried out to support functional testing, a percentage value of 90% was obtained.

A R T I C L E I N F O

1. INTRODUCTION

Early Childhood Education (PAUD) is one of the educations that can be obtained before entering the level of primary school education. In the School Act No. 20 of 2003, it was stated that early childhood education is a constructive effort aimed at providing educational incentives to children from birth to six years of age.

In Permendiknas 58 of 2009 it is also explained that the standard rate of achievement of cognitive development of children at the age of 3-6 years is on the concept of numbers, symbols of numbers and letters, with details of numbers 1-10, able to match numbers and symbols, as well as recognize various vocal letters and consonants (Putra & Ishartiwi, 2015).

The golden age in early childhood is one of the important factors of an education. It's because the whole function and ability of a child is developing rapidly. But this golden age only happens once in his life. Therefore, there is a need for an education that can develop the child's potential comprehensively. (Siti Farikhah, Hesti Ariestina, 2020).

There are several major advantages of educational games, one of which is on the visual appearance. The Massachusetts Institute of Technology (MIT) has proven that games are useful for improving logic and user understanding of a problem in a game project called Scratch. Moreover, educational games are superior in some respects to conventional learning methods. (Anik, 2016).

Educational games are one of the developments of games that entered the academic field for early childhood, how to arouse children's interest in learning something new. Early childhood interest in studying something developed in this research by creating a prototype wall projector. The results of this interactive game design will detect any movement with external targets to PAUD children in order to develop the child's motor sensor in learning (Paulo Dias, Jõao Silva, Rafael Castro, Antʹonio J.R. Neves, 2015)

This model of educational games can also address a common problem that is often complained by many parents, i.e. the addiction (gadget) that often complains many parents or known as Screen Dependency Disorder (SDD). Around 70% of parents say they allow their children between the ages of 6 months and 4 years to play gadgets while they are doing their homework, and about 65% do the same thing to calm their children when they are in public. A quarter of parents admit to leaving their own children with gadgets before they go to bed, while the brightness of the screen on the gadget can damage their eyes and disturb their sleep at night.

The process of developing a game model may use several media gadgets, but each gadget has almost the same negative impact. The projector became the main device used in this research. The use of projectors is expected to reduce the child's direct interaction with the gadget used, as some adverse effects may occur, such as the use of a TV with a touch screen, allowing for excessive interaction from child to screen and the magnitude of radiation from the screen due to too close use. On the psychological side, it is also concluded that the overuse of gadgets will have a negative impact on the social and emotional development of the child, such as; the child becomes closed personality, sleep disturbances, liking to be alone, as well as reduced self-creativity. From the development using the projector implementation, it is expected that there will be no possibility of damage to the player's eyes.

Multimedia interactive learning becomes one of the alternatives to enhance the interest of children in learning to know numbers and letters. In a study conducted by (Lovandi Dwanda Putra & Ishartiwi., 2015) Multimedial Development of Interactive Learning to Know Numbers

and Letters for Early Childhood, is judged to be very effective in applying interactive learning. Besides, in the development of this research there are interesting visual and audio, as well as a variety of games that combine numbers and letters.

In the PAUD curriculum, the research carried out by (Siti Farikhah & Hesti Ariestina., 2020) in the title Menelisik Curriculum PAUD: Fenomenological Study Against Learning Tendencies of Early Childhood Calistung, requires learning strategies, contexts and situations that affect learning. Some of the strategies for implementing Calistung include understanding the linguistic, cognitive, physical and motor and emotional aspects. In learning Calistunga is also not allowed to engage in coercion because it can affect the emotional level of the PAUD child.

Improving interpersonal interaction skills among children as pupils, carried out by (Issey Takahashi, Mika Oki, Baptiste Bourreau, Itari Kitahara, Kenji Suzuki., 2018) in FUTUREGYM: A Gymanasium with Interactive Floor Projection for Children with Special Needs, explains the improvement of interpersonal interaction abilities between children as students. Interpersonal interaction is one of the fundamental factors for the success of inclusion in the education of every child, especially children with special needs. On the other hand, the research has produced a product that contains projectors and cameras in high range for the size of PAUD children. Interactive technology is created and used to support children with neurodevelopmental disorders. Many applications are already using interactive technology, such as robotics, augmented reality, virtual reality, mixed reality and a variety of other applications. Furthermore, FUTUREGYM was created with the aim of providing learning opportunities for children with special needs. Visual highlighting from the projector to the floor becomes one of the main keys and becomes an effective tool to support child activity. The resulting projection will help and direct the movements of the children to a particular situation.

Current learning methods are closely related to the gamification model. Gamification is an approach to learning using a variety of elements that are in the game or video with the aim of giving motivation to the child PAUD so that the learning process can run maximum and enjoy. According to Gabe Zichermann (Giang, 2013), using game mechanics increases the ability to learn new skills by 40%. In the world of education, it can also be listed that gamification is the process of changing existing activities or learning activities and making content playable. The basic idea behind gamification is to increase the motivation of an activity. There are several gamification features, among them:

- Points, is a calculation of the score the user gets in the game
- Badges, it is a form of reward that a user gets, in exchange for the user's points. Badges are also earned when a user successfully completes a challenge
- Levels, is the difficulty level of the game
- Leaderboards, as a representation of the rankings of each user
- Challenges, or a challenge that may always appear in every level of the game
- Rewards, Challenges that may always appear in every game
- OnBoarding, Objective of the mission achieved or target in the game
- Engagement Loops, a form of game process experienced by any user where this process runs repeatedly.

2. RESULTS AND DISCUSSION

Projection mapping is a digital technology that can provide visual results that can be projected to other fields or media. This technology has undergone some quite significant developments, where we can interact directly with previous projections.

Interactive Projection Mapping is also a solution for any application developer that aims to produce an application that is impressively more futuristic and capable of attracting more attention than any user.

In this research, developed a game application for children of early age. The application has been developed into two main applications, the Hand Tracking application and the NumberPedia application. The Hand tracking application is used as a way of detecting the position of the hand on the player, to enhance interaction. Hand tracing runs with several configuration options such as the detection type, the orientation of the display of the webcam screen capture, and some of the available webcam options. Once the user can open the webcam view.

In the NumberPedia application contains core games to introduce to PAUD kids about numbers and interesting games in them. When the game is running, the user will be faced with two main features, namely learning and playing. The learning feature contains some game techniques that support the learning atmosphere, such as recognizing numbers, counting objects, matching numbers. In the play feature, the mechanics of the challenge contains bubbles of numbers. Users are required to select bubbles according to the instructions given. Both of these features are intended to enable young children to learn to recognize numbers or to sharpen their skills in numerical knowledge.

In this game, there are 3 game modes, namely the introduction of numbers 1 to 10, where in this mode there is only audio and visual without any challenges or missions. In the second mode, the user will be given 2 numbers with one audio as a question.

In the play feature, the user will be given several choices. The appearance of several characters that indicate the number in which the player will count the object and guess the number corresponding to the number of characters. In counting the number of characters, the player is given a time limit in carrying out the counting. There will be a reward for the player in this case is the PAUD kids.

This number recognition game is shown to children of early age, from 3 to 6 years of age. Some of these considerations are due to the presence of early childhood educational curriculum materials on number identification. As for the description of the application support system and the workflow, there are the following feature plans:
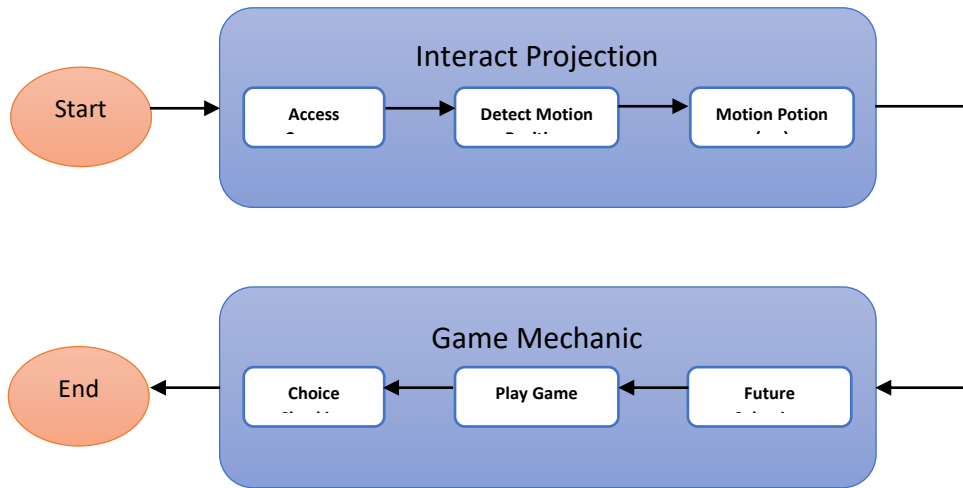
Figure 1. Application drawing diagram

Overall, the needs analysis results have been taken to the next stage by developing the main feature of motion detection for the interactive projection technology system. Designing a workflow diagram of how interactive projection can work with some hardware as support.
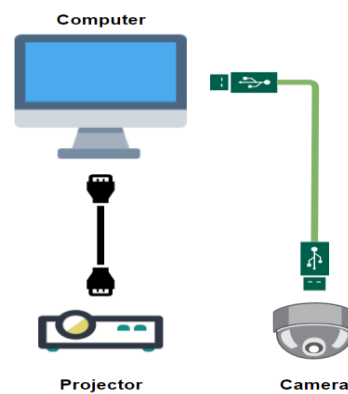

Figure 2. Interactive Projection Workflow

Gamification is the use of game design techniques, ranging from how to think to using mechanical games to improve the outer quality of learning. The game recognizes numbers for early childhood by using "interactive projection" Numberpedia uses several elements of the game namely the narrative. The narrative aims to explain the role of each character that will adventure by giving variable numbers. Users will have a chance to get acquainted and make friends with every number they encounter.

The game mechanics present in this game have repetitive or repetitive properties. This mechanical game recurrence is limited to the level in each stage. Levels and challenges are also set based on the stage process and the level reached by the player. The higher the stage and level achieved, the higher the level and the challenge the user gets.

At this stage, the mockup design will describe how interactive projection technology can run and be implemented in real life.

In the development of the mechanical concept of the game Numberpedia, divided into 4 stages and 3 levels and entirely using the concept of numerical identification specific to the child PAUD.
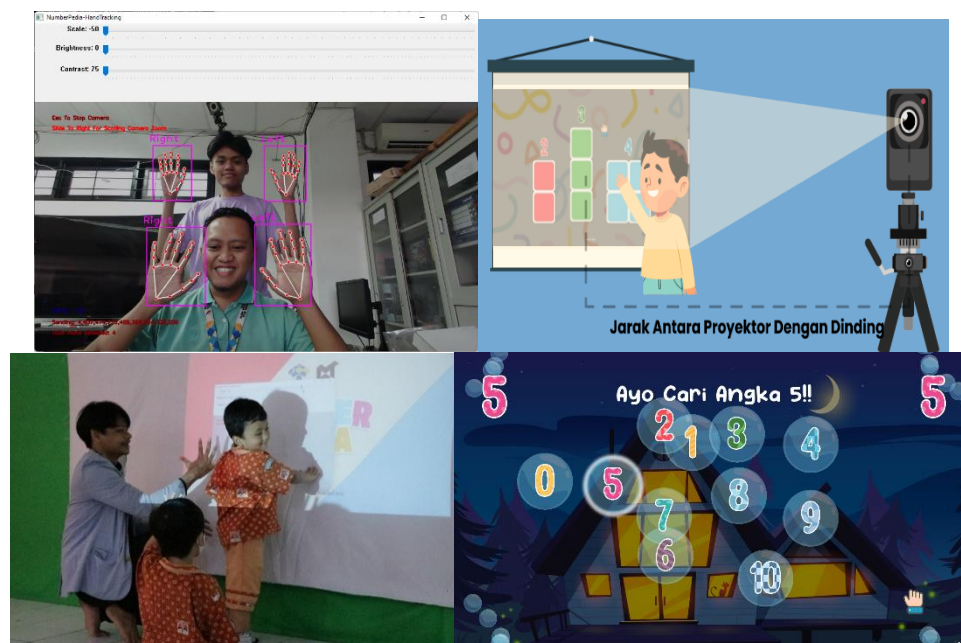
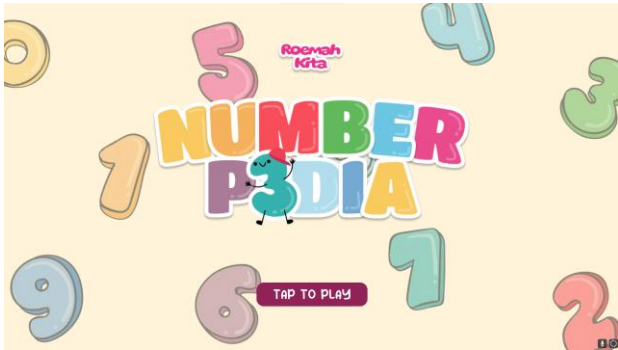**Figure 3.** Numberpedia game system implementation

The player will be faced with several bubbles of numbers. There is a supporting audio running and at the same time, the player is required to be able to choose one of the bubbles that matches the audio. In levels and challenges adjusted to Table 1.

**Table 1.** Levels and Challenges by Stage and Level

Stage	Level	The number taught	Core Mechanic
1	1	0 and 1	Identification of numbers 0 and 1 in the user. An interaction occurs in which the user selects only one of the numbers in the game view.
	2		Count the objects on the screen, where the number of objects is adjusted to the number identified.
	3		A visual match between 1 number as a question with the visual number 0 and 1 as the answer to which the user has to choose one.
2	1	2, 3 and 4	The identification of numbers 2, 3 and 4 on the user, where the user interaction in this case, only chooses one of the numbers on the game's display.
	2		Count the objects on the screen, where the number of objects is adjusted to the number identified.
	3		The visual matching of 1 number as a question with the visual numbers 2, 3 and 4 as the answer to which the user has to choose one.
3	1	5, 6 and 7	Identification of numbers 5, 6 and 7 on the user, where the user interaction in this case, only chooses one of the numbers on the game's display
	2		Count the objects on the screen, where the number of objects is adjusted to the number identified.
	3		The visual matching of 1 number as a question with the visual numbers 5, 6 and 7 as the answer to which the user has to choose one.

Stage	Level	The number taught	Core Mechanic
4	1	8, 9 and 10	The identification of numbers 8, 9 and 10 on the user, where the user interaction in this case, only chooses one of the numbers on the game's display.
	2		Count the objects on the screen, where the number of objects is adjusted to the number identified.
	3		The visual matching of 1 number as a question with the visual numbers 8, 9 and 10 as the answer to which the user has to choose one.

**Table 2.** User Interface view on the NumberPedia application

No	Aset User Interface
	Splash Screen View
1	
	In this splash screen display, there are 3 PENS Campus logos, Game Technology Studies Program and NumberPedia. The colors on the logo are made varying with the purpose of attracting attention, as well as supported by the use of pastel colors on most background images that can make the look more comfortable to look at.
	Game Start View
2	
	After the splash screen, go to the application's start view. In this view, there is the NumberPedia logo and the Tap to Play button.

No	Aset User Interface

Play Menu View

3
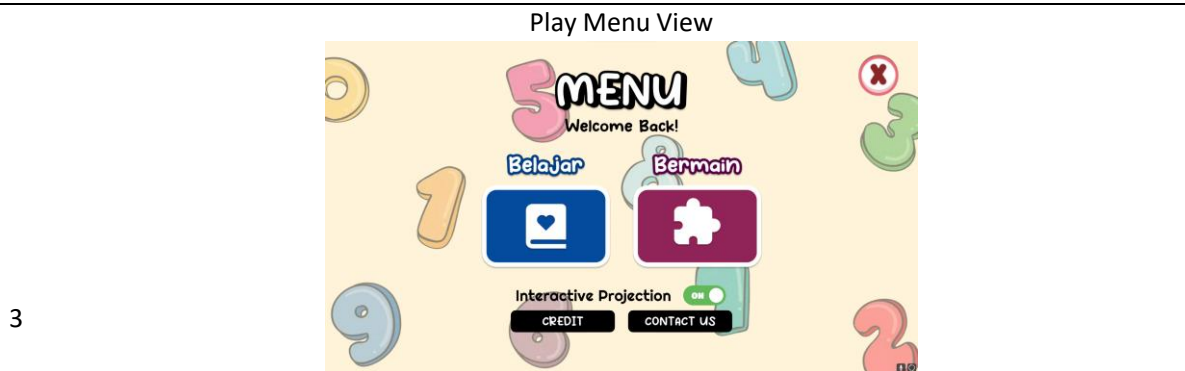
Terdapat beberapa tombol pada tampilan menu sebagai berikut:
1. Learn, when the button is clicked then the user will be faced with a stage selection display
2. Play, used to unlock the mechanics of the bubble-number challenge game
3. *Interactive Projection*, used to enable or disable the hand detection feature
4. *Credit*, digunakan untuk menampilkan informasi-informasi terkait pengembang
5. *Contact Us*, used to display contact information related to the developer that can be contacted
6. *Exit*, used to exit the application

Stages View

4
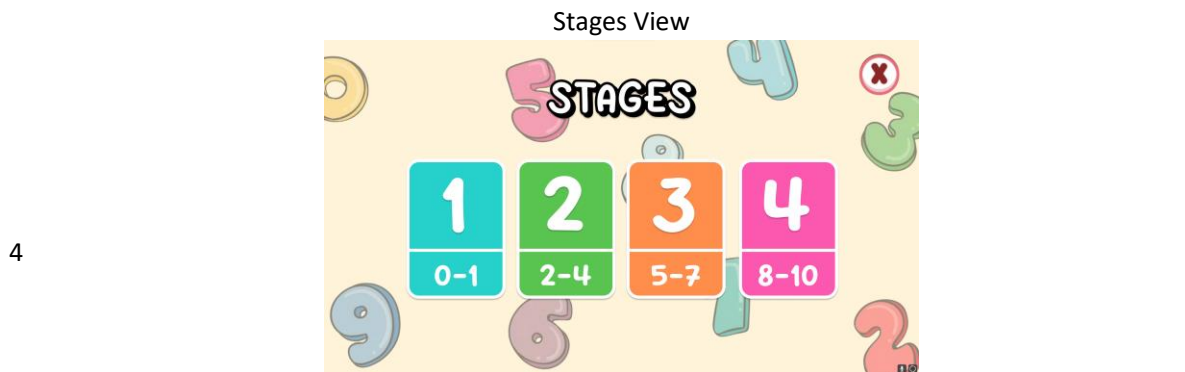
When the user selects Play, the next view is Stages. In this view, there are several stages with a description of the numbers to be taught (located at the bottom). For example, in the first stage, which teaches the numbers 0 to 1.

Learning Feature View, Level 1

5

No	Aset User Interface
	In the first stage of each stage of the Learning feature, the player will recognize the numbers by the number bars. When the numbers bar is touched by the player, they will be confronted with a video of how the numbers are written and audio how to pronounce the numbers being taught.
6	Learning Feature View, Level 2
	Next, in the second stage, the player will be asked to count one by one, the entire object displayed. The number of objects is adjusted to the number taught on the selected stage.

No	Aset User Interface
	Learning Feature View, Level 3
7	
	The last stage of each stage is the mechanics of matching numbers. At the same time, the player must match each pair of objects.
	Play Feature View
8	
	In the Play feature, the player will be faced with several bubbles of numbers. Then, there is an audio challenge running, and at the same time the player is required to be able to select one of the bubbles that matches the audio.

No	Aset User Interface
	Notification View
9	

Whenever a user successfully completes the game, a reward notification display will appear. In this view, there are Retry and Home buttons. This view will always appear on the Learn or Play feature.

Testing the functionality of the game using the blackbox method is done by running the application with the aim of finding errors as well as checking whether the system can run properly and as needed. Additionally, inter-assessment reliability in the test phase is also used to ensure that the application runs properly. In addition, reliability at this test stage is used to make sure that the app runs correctly.

Analysis performed in the game feature functionality test phase includes: Hand Tracking feature test analysis, Game learning feature test analyses, Game play feature testing analysis, Light intensity test analysis in the room, analysis of distance testing between projector and supporting device, and analysis of projector magnification relationship testing with hand size difference.

In the test of the Hand Tracking feature, there are two stages of testing, namely the Test of the hand tracking feature and the NumberPedia play experiment with synchronization between the player's hand position and the virtual hand position in the game application. Hand tracking features are tested with 2 hands and 4 hands. The results of this test show whether the HandTracking feature is running well and can be integrated with the player hand as seen in Figure 3.

The test of learning features in the Numberpedia is divided into three stages namely recognizing numbers, counting objects, and matching numbers. In the number recognition section, players will encounter game mechanics such as choosing a number, and are coupled with audio pronunciation (voice over) stating that the numbers have their respective descriptions. In the process of counting objects, the mechanics of this game is to count according to the number taught, for example if the number to be taught is 8, then the object in the display will be 8 objects and the player will count the objects on the screen.

Room lighting is also a factor in the game, which requires testing. The room used has a length of 7.8 meters and a width of 4.8 is done during the day. Here are the results of the experimental intensity of room light found in Table 3.

Table 3. Room Light Intensity Test

Trial Fourth-	Number of lights on	Light Intensity Percentage	Results
1	5	100%	✅
2	4	80%	✅
3	3	60%	✅
4	2	40%	✅
5	1	20%	✅
6	0	10%	❌

The experiments were repeated, and the result was that the light intensity in the playroom should be sufficient, at least by turning on one light source so as not to interfere with the light highlighting from the projector.

Other tests were also performed on measuring the distance between the projector and the wall several times with the distance as the primary parameter. The system will detect a player's hand with a projector distance of 1 to 6 meters, with a percentage success rate of up to 100%. When the distance between the projector and the wall is over 6 metres, then the system reads the hand's movement not so well that the success rate is low.

The testing at this stage continues with a projector distance to the wall of 3 meters, and the fabric height is adjusted to the children's height of about 150cm. The fabric heights are adjusting so that the player can reach the screen illustrated in Figure 4.

Figure 4. Illustration of Projector Distance Test with Wall

Test analysis performed by more than one person, in this test there are still some impediments among them:

1. Some of the higher children's bodies potentially cover the projector's appearance. This can cause the player's hand not to be detected by the webcam as seen in Figure 5.

Figure 5. Condition at the time of testing more than one player

2. Sometimes when there is more than one player, in this game triggers a quarrel between one child and the other child. It's because of the moving animation that makes the kids curious and want to try.

In other trials, the spread of the questionnaire was also performed in children of early age. The scenery of the dissemination of the questionnaire is done by giving two large papers (which are held by an adult) and the children attach the stars that have been held before. There were 50 students who took the test with the following questions and answers in detail:

Table 4. Question and Answer

No	Question	Answer (Number of Respondents)	
		Yes	**No**
1	Is the game easy to play?	45 children	5 children
2	Is the entire image shown by the game visible clearly?	50 children	0 children
3	Can all the audio in the game be heard clearly?	47 children	3 children
4	Is all the writing in the game clearly readable?	50 children	0 children
5	Do you like the game?	48 children	2 children
6	Are you interested in playing games that use similar technology?	50 children	0 children

3. CONCLUSION

The NumberPedia Number Recognition Game can be an interactive and attractive learning medium, with a 90% survey spread giving the answer that the game has a positive impact. The results of the percentage can be inferred from the features and gameplay. All the educators and pupils were given more space to be able to pay attention to the pupils' ability to understand numbers while playing.

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