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An Android Augmented Reality Application to Improve Cognitive Skills in Color Recognition for Down Syndrome children

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Abstract
The objective of this research is (1) to develop and construct an educational Augmented Reality game that focuses on color recognition for individuals with down syndrome, using markerless based method. (2) Measure the level of user acceptance towards color recognition educational games with AR technology and the markerless method. (3) Measuring the increase in knowledge of Down Syndrome children in recognizing colors to hone the cognitive skills of early child-hood. Down Syndrome is a common genetic disorder in humans. Children with Down syndrome have three copies of chromosome 21. This condition will cause cognitive disorders in Down Syndrome children which can hinder academic achievement. Apart from that, Down Syndrome children who suffer from this disorder will cause a decrease in attention, metacognition, memory and generalization, so that learning becomes difficult. Therefore, Down Syndrome children aged 0–6 years must be introduced to numbers, letters, geometric shapes and colors to improve their cognitive abilities. In this research, a color recognition educational game was created by adding Augmented Reality (AR) technology which aims to attract children with Down syndrome. This re-search was successfully implemented and approved by 84.8% of parents of Down Syndrome children. The results showed a significant increase in the post-quiz compared to the pre-quiz, indicating an increase in children's grades
Keywords: *Augmented Reality, Cognitive, Color Recognition, Down Syndrome*

Abstrak
Tujuan dari penelitian ini adalah (1) untuk merancang dan membangun sebuah game edukasi Augmented Reality yang berfokus pada pengenalan warna pada penderita down syndrome, dengan menggunakan metode markerless based. (2) Mengukur tingkat penerimaan pengguna terhadap game edukasi pengenalan warna dengan teknologi AR dan metode markerless. (3) Mengukur peningkatan pengetahuan anak Down Syndrom dalam mengenal warna untuk mengasah kemampuan kognitif anak usia dini. Down Syndrome adalah kelainan genetik yang umum terjadi pada manusia. Anak-anak dengan sindrom Down memiliki tiga salinan kromosom 21. Kondisi ini akan menyebabkan gangguan kognitif pada anak Down Syndrome yang dapat menghambat prestasi akademik, selain itu anak-anak down syndrom yang menderita gangguan ini, akan menyebabkan penurunan perhatian, metakognisi, memori, dan generalisasi, sehingga pembelajaran menjadi sulit. Oleh karena itu, anak Down Syndrom usia 0–6 tahun harus dikenalkan dengan angka, huruf, bentuk geometris, dan warna untuk meningkatkan kemampuan kognitifnya. Pada penelitian ini dibuat sebuah game edukasi pengenalan warna dengan menambahkan teknologi Augmented Reality (AR) berbasis mobile yang bertujuan untuk menarik perhatian anak-anak down syndrome. Penelitian ini berhasil diselesaikan dan mendapat penerimaan user, yaitu orang tua anak Down Syndrome sebesar 84,8%. Hasil penelitian menunjukkan adanya peningkatan yang signifikan pada pasca kuis dibandingkan sebelum kuis, hal ini menunjukkan adanya peningkatan nilai anak.
Keywords: *Augmented Reality, Down Syndrome*, Kognitif, Pengenalan warna

INTRODUCTION

Trisonomy 21, commonly called Down syndrome, is a genetic disorder that has existed since birth. According to the WHO (World Health Organization), at this time there are probably 8 million people with Down Syndrome worldwide, and of these, there are more than 3000 cases in Indonesia [1]. Problems regarding children with Down Syndrome are not only about physical and psychological health but also social stigma regarding their condition. In 2017, Marta, a researcher, said that children with Down syndrome have obstacles in their thought processes, for example, slow learning, an inability to solve problems, poor coordination, and a physical appearance that looks different than that of ordinary humans [2], [3]. Down syndrome also has other signs, for example, reading books at close range, having a mouth that is always open to understand something, taking a long time to understand something, and having difficulty speaking [4], [5].

One of the characteristics of children with Down syndrome is a limitation in cognitive abilities that can affect their academics. Children with DS will experience difficulties in matters related to learning due to their slow attention, metacognition,

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remembering, and generalization abilities compared to normal children [6], [7]. This problem can occur due to weak perceptual and judging abilities and weak short-term memory abilities in children with Down's Syndrome. So children with DS at an early age (0–6 years) need to hone their cognitive skills with activities, namely the introduction of numbers, letters, geometric shapes, and colors [2]. According to Permendikbud Number 137 of 2014 concerning PAUD National Standards (Early Childhood Education), early childhood development is within the scope of cognitive development because children can group objects based on color and recognize color patterns [8], [9]. In general, early childhood is very active in playing; to provide parenting or learning methods for early childhood, interactive learning in the form of audio-visuals is required so that children are more responsive. One of the supporting factors for interactive learning for children is the presence of media or learning facilities that use mobile-learning technology [10], [11].

One of the mobile learning tools that can be used for learning is an educational game. Educational Games are perfect for children because they have things that make them happy, active, and easy to understand. However, people are not yet aware of the benefits of games for children and often accuse games of having a negative influence [12], [13]. The negative effects that occur in children can be caused by using a smartphone without parental supervision. However, the influence of the game can be reduced by providing educational games that can have a positive impact on children. And it is also necessary for parents to supervise their children's use of smartphones [14], [15].

Augmented reality, commonly known as AR, is a technology that erases the boundaries between the real and virtual worlds. AR itself was created to improve human performance in the virtual world. AR helps many sectors of life. AR itself is applied to various devices, for example, cellphones or smartphones, glasses, cameras, screens, and various other devices that will function as output devices [16], [17]. Games that use AR have more advantages than games that use traditional ones. There are several case studies proving that the user's ability to perform a particular procedural task increases when there are instructions presented with AR compared to traditional [18], [19], [20]. In AR, there are two methods, namely the marker-based and Markerless methods. The marker-based method is a system that needs to scan a special logo, recognize the logo, and then display 3D objects that we can see in real-time. For the Markerless Method, it will use GPS technology, a digital compass that is in the smartphone device. The difference between these methods is that the markerless method does not need a special logo or symbol, and this method can display 3D objects directly as if they were floating in the air. Also, the markerless method only uses a flat surface that has an angle to serve as a system reference that can display 3D objects [21], [22].

A plan for developing learning activities that can assist parents in providing interaction and instruction to children with Down syndrome was devised based on this context. Color recognition is one of the most fundamental techniques for enhancing cognitive development in individuals with Down Syndrome. This game of color recognition can be connected to objects in the environment that children can recall, such as fruits and vegetables. According to the parents of children with Down syndrome, children are typically more interested in interactive learning activities that can capture their attention so that they can concentrate on learning. Consequently, with markerless-based augmented reality, games can serve as props for interactions between the real and virtual realms. From this, it can be concluded that the purpose of the study was to determine the level of acceptance of parents and children with Down syndrome after helping children play games designed and built using Markerless Based for learning color recognition and to determine whether there is an increase in the knowledge of children with Down Syndrome in recognizing colors to sharpen the cognitive abilities of early childhood, specifically ages 0 to 6 years.

RESEARCH METHOD

2.1. Down Syndrom

Down syndrome is one of the conditions that retard the physical and mental development of children due to chromosomal development abnormalities. John Langdon Down was the first scientist to recognize this malady. According to the results of the study, there was a gene mutation on chromosome 21, where there was an excess number of three (tri) on chromosome 21, whereas normal individuals should have two [23], [24]. Down Syndrome is a physical condition induced by a gene mutation in the fetus during gestation. The failure of gamete cell division, specifically in the egg or sperm cell, is the general cause of Down Syndrome, also known as classic Down Syndrome or non-hereditary Down Syndrome. In Meiosis I or miosis II, there is an excess of chromosome 21 in gamete cells if the gamete cell is fertilized and produces babies with one extra chromosome 21, commonly known as trisomy 21, with karyotypes for baby females 47, X, +21 or baby boys 47, XY, +21 [2], [7], [25]. The chromosomes of a child with Down Syndrome are depicted in Figure 1.

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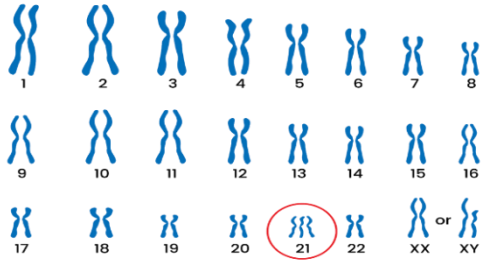

Figure 1. Down Syndrome Child Chromosome Image

People with Down syndrome often look and act much like other people. Most people with Down syndrome have a low to moderate IQ (a measure of intelligence) and are slower to speak than other children. Some of the common physical characteristics of Down syndrome include having a flat face, especially on the bridge of the nose, eyes slanted up and outward, a thick and short neck, small ears, a tongue that tends to stick out of the mouth, small hands and feet, palms that only have one fold, a small little finger that sometimes curves towards the thumb, poor muscle tone or loose joints, and a shorter body size than normal people [2], [6].

2.2. Markerless Augmented Reality

Markerless Augmented Reality, or markerless-based Augmented Reality, is an AR method currently under development. Using Qualcomm's tools for mobile device-based augmented reality development, users can reduce the use of markers to display digital elements, making it simpler for developers to create markerless applications [26]. Total Immersion and Qualcomm are companies that generate motion tracking, face tracking, GPS-based tracking, and 3D object tracking in collaboration [27].

Markerless AR offers high flexibility and ease of use because it does not require physical markers, allowing AR applications to be used in various environments without special preparation. This provides a more natural and interactive user experience; as virtual objects can be placed more seamlessly in the real world [28]. The technology also performs better in varying lighting conditions and is easier to integrate with modern sensors in devices such as smartphones and tablets, supporting a variety of applications from education to gaming to indoor navigation [29]. For this reason, it is hoped that using the Markerless method can make it easier for users to run this application, especially for children with Down Syndrome.

METHODOLOGY

The research steps used in implementing this research are: the first is to identify the problem, where at this stage interviews are carried out with parents who have children with Down syndrome to discuss Down syndrome problems; then proceed with a literature study, where at this stage a search for sources of knowledge that provide rules and facts about Down Syndrome is carried out.

The next step is to design and build the system, followed by testing, where testing is performed on the system that has been created, and then the evaluation stage is carried out, where an assessment is performed on the system that has been created, with parents and children with down syndrome serving as application users. Where respondents with Down syndrome children were recruited from the POTADS (Parents Association of Children with Down Syndrome) community in Indonesia. Whereas the Indonesian POTADS community is an association of parents of children with Down Syndrome whose mission is to empower parents of children with Down Syndrome so that they are always eager to help their special children grow and develop optimally, so that their children can become independent and even achieve accomplishments so that they are accepted by the larger community.

During the application design phase, several flowcharts were created as an initial design for creating the application, as depicted in Figures 2 and Figure 3. Whereas Figure 2 depicts the primary flowchart of the AR Down Syndrome application system.

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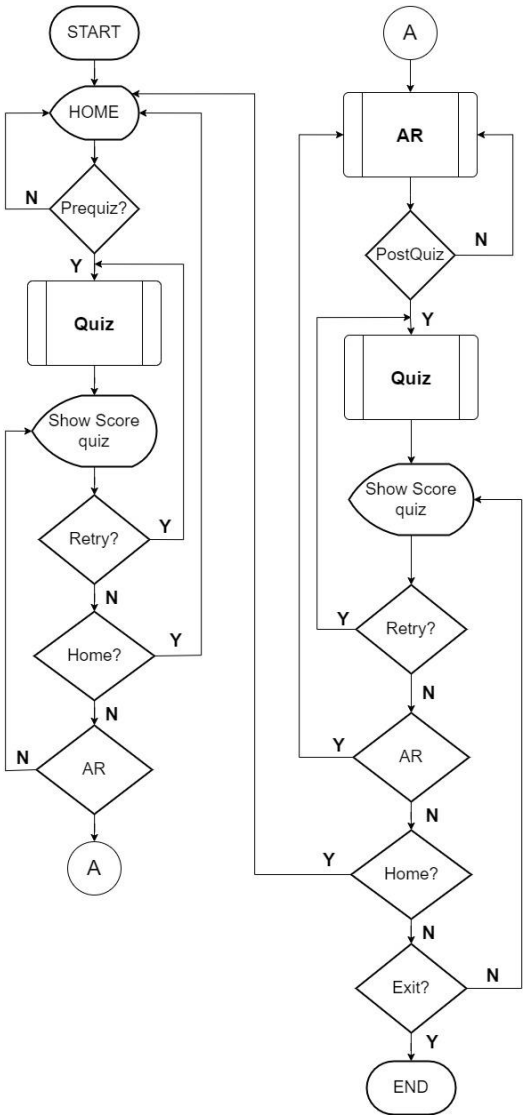

Figure 2. Main flowchart of color recognition AR games for children with Down Syndrome

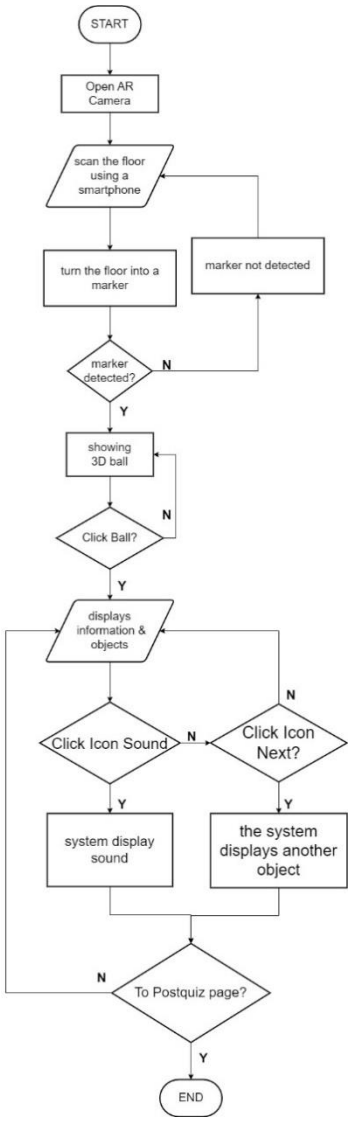

Figure 3. Augmented Reality process in color recognition application for down syndrome

Figure 3 illustrates the predefined process flowchart for AR. The system will initially activate the smartphone's camera and scan the floor using the camera. The system will transform the floor into a marker, and if the marker is correctly detected, it will display multicolored 3D spherical objects. If the user presses a color ball, the system will display information and examples of objects that correspond to that hue. When the user presses the sound icon, the system will play the pronunciation of the color's or object's name. If the user desires to view additional objects, the system will display additional objects with the same color. When the user has completed reviewing the page's content, he or she can proceed to the prequiz page.

RESULT

The next stage, following the creation of the flowchart, is to create the application, the results of which are depicted in Figures 4 through Figure 6. Figure 4a depicts the homepage for the AR color recognition application for down syndrome. Where on the menu there is a "Play" button to play or navigate to the next page and a "Information" icon to display application-specific data. Figure 4b depicts the Prequiz page, which is utilized to access the prequiz question page depicted in Figure 4c. The menu contains a start button to initiate the quiz and a back button to return to the main menu page. After completing the questions, the user will be able to view the quiz results in Figure 4d, which is used to view the pre-test results of the completed Quiz.

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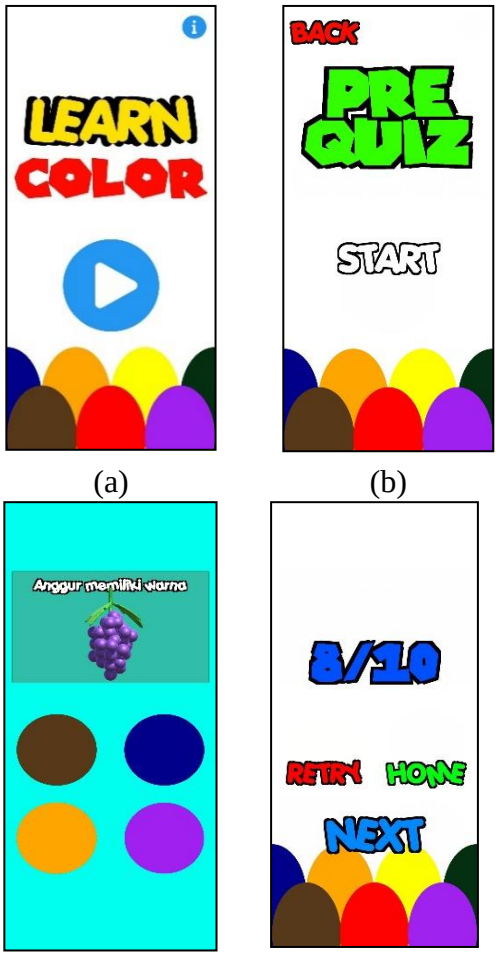

(a) (b)

(c) (d)

Figure 4. Application result with sample pre-test Quiz

After completing the Quiz pre-test, the next exercise will display the color recognition augmented reality menu shown in Figure 5, which includes a voice assistance option for children with Down syndrome who cannot read yet.

Figure 5. Augmented reality results equipped with voice assistance

After the user recognizes the color of the 3D objects displayed with Augmented Reality technology, as depicted in Figure 5, the child will be given a post-test consisting of an exam, as depicted in Figure 6, the results of which will be compared to the results of the pre-test. This measure is taken with the intent of observing the effects of AR technology on child development.

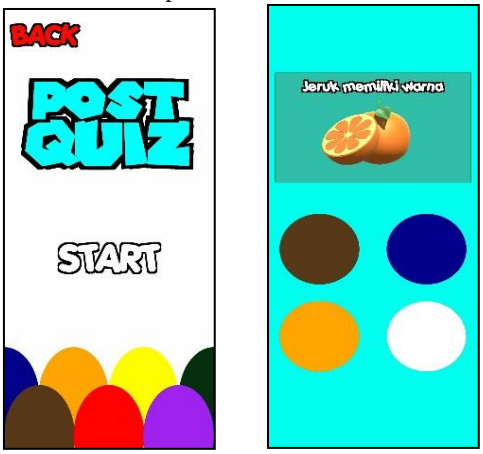

Figure 6. Post-quiz display along with post-test results

According to the results of pre- and post-testing on 30 children with Down syndrome using a color recognition application with augmented reality technology, as shown in Figure 7, post-test scores were higher than pre-test scores, indicating that the user had learned colors by using the color recognition application with AR technology that had been developed.

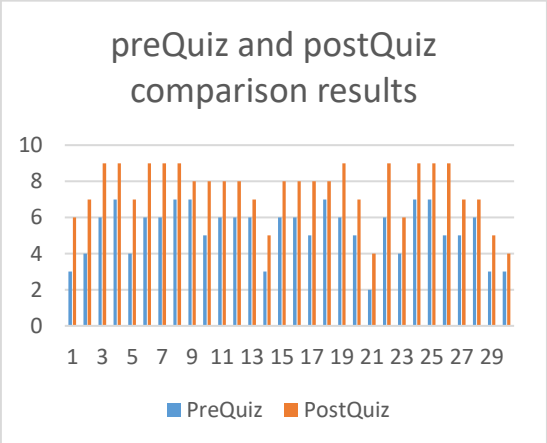

Figure 7. Chart comparison result between preQuiz and postQuiz

According to Figure 7, the average value of the user's pretest is 53, while the average value of the user's posttest is 75,3 points. On the basis of the average pre- and post-test scores, it can be concluded that the value of color recognition has increased by 42.1%.

In addition to testing the increase in color recognition knowledge for children with Down syndrome, a user satisfaction test was also conducted using the user acceptance test (UAT) method with parents or guardians of students with

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Down syndrome from POTADS associations. In Table 1 you will find a list of queries and the outcomes of the user acceptance test.

Table 1. UAT Questionen List and Result

No	Question list	VNA	NA	N	A	VA
1	The design of the color learning game has an attractive appearance	0	0	3	16	11
2	This game based on Augmented Reality is easy to use.	0	0	9	13	8
3	This color learning game has benefits for alternative learning	0	0	5	13	12
4	This Augmented Reality based game is easy to operate	0	0	7	15	8
5	Learning is more fun for children with this game	0	0	7	10	13
6	The excitement of children learning while playing this game	0	0	4	13	13
7	After using this educational game, children will increase their motivation in learning colors	0	0	6	10	14
8	My son enjoys this game	0	0	3	11	16
9	After playing this game, children are interested in playing it again.	0	0	5	12	13
10	After playing this educational game does it improve your child's learning	0	0	3	11	16

Table 1 presents the results of the user acceptance test conducted with 30 parents or guardians of children with down syndrome from the Indonesian POTADS community. Based on these results, it can be concluded that the UAT value for color recognition applications for children with down syndrome using Augmented Reality technology has a value of 84.8%, which indicates that respondents strongly agree that the applications are effective.

CONCLUSION

From the results of the research that has been carried out, it can be concluded that, (1) an Android-based augmented reality color recognition educational game using the markerless Based method has been successfully developed. (2) It was found that the level of user acceptance using the UAT method for color recognition educational games with AR technology and the markerless method that had been created is 84.8%, which indicates that respondents strongly agree that the application created is useful and beneficial to the progress of children with Down syndrome in their color recognition abilities. (3) Based on the evaluation of the results of the pre-test and post-tests administered to children with Down syndrome, it can be concluded that their knowledge of color recognition has increased by 42.1%.

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