

Augmented Reality Mobile Application for Autism Spectrum Disorder Rehabilitation

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Abstract— Autism Spectrum Disorder (ASD) is a neurological disorder in which a diagnosed child may have difficulty communicating socially or may have a repeated or limited set of behaviors. Recently, ASD cases have increased dramatically. This makes scientists interested in finding various drugs or therapies that can be used for children with autism. Social behavior therapy is one of therapy that has shown effectiveness in improving fundamental symptoms of ASD. With the rapid development of technology, social behavior therapy was then expanded by utilizing some of the latest technologies that can be beneficial for children with autism. One of the therapies using the latest technology that can be utilized is making a quiz-based game by utilizing Augmented Reality (AR) to create 3D objects virtually. Spectrum Quiz is an example of an AR-based therapy game. This game is expected to improve the ability of children with autism to communicate socially. In the development of the Spectrum Quiz AR application, several tools are needed such as Adobe Illustrator, Unity, and Blender 3D.

Index Terms— Augmented Reality, Autism Spectrum Disorder, children, software development.

I. INTRODUCTION

OVER the past decade, there has been a significant increase in interest among researchers, physicians, doctors, educators in children's autism spectrum disorders [1]. Autism Spectrum Disorder (ASD) is a neurological disorder in which a diagnosed child may

have difficulty communicating socially or may have a repeated or limited set of behaviours [2]. Usually, children with autism exhibit self-stimulatory behaviors and face challenges in recognizing emotional changes, demonstrating empathy towards others, and responding appropriately to social situations [3]. Indonesian Ministry of Health reports that ASD in Indonesia has increased by around 53.220 children each year and reaches around 2.4 million cases in 2021. While WHO data reports that there are 1 in 100 children with ASD around the world.

When it comes to accessing the healthcare system, autistic people confront significant hurdles. Autism spectrum disorder (ASD) has numerous key characteristics, including trouble with social communication and reciprocal social engagement, limited or repetitive activities and/or interests, and abnormal sensitivity to stimuli [4].

ASD is divided into 2 types of therapy, namely pharmacological and non-pharmacological. Pharmacological therapies, such as methylphenidate and amphetamines, are used to address coexisting hyperactivity and impulsivity in individuals with ASD but offer limited benefits beyond the core symptoms of ASD. Social behavior therapy is one of the non-pharmacological interventions that has shown effectiveness in improving fundamental symptoms of ASD. The Early Intensive Behavioral Intervention (EIBI) is an approach that breaks down complex skills into simpler subskills and teaches them individually. This method has been found to enhance intellectual functioning in 50% of young children with ASD [5].

At the same time as the increase in ASD cases in 2021, Facebook and Microsoft are developing a metaverse world. The emergence of the development of the metaverse world has made the use of Virtual Reality (VR) and Augmented Reality (AR) increase in various sectors, including the healthcare sector. AR and VR in the health sector are commonly used in therapy for people with special needs including ASD [6].

AR allows the design of attractive learning tools that help children with ASD stay focused, promoting engagement with the activities, on-task behavior, motivation, and positive emotions that enhance the

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learning process [7]. These applications may be used to educate and motivate people. AR mobile applications have attracted a lot of attention in recent years owing to their potential to alter several industries, including healthcare. The use of mobile applications to become an exercise therapy for ASD is one use of AR technology in healthcare. These applications can give users with an interesting and interactive approach to learning about everything, leading to greater understanding and better health outcomes [8].

Spectrum Quiz is an example of an AR-based therapy application. Spectrum Quiz will help children with autism who have difficulty interacting with others to learn how to express themselves with 3D human objects that appear on smartphone screens using smartphone cameras. Thus, this application will seem to teach children with autism to be taught individually without involving other people directly. This application can also replace conventional teaching methods because it is more fun and can alter intellectual intelligence.

II. LITERATURE REVIEW

A. Immersive Technology

Immersive technology has been described by some researchers, as a form of technology that provides users with a rich sensory experience, either in terms of quality or quantity of sensory information [9]. It also defined Immersive technology as a technology that blurs the boundaries between the physical and virtual realms, thereby creating a feeling of immersion and heightening the realism of virtual experiences. Virtual Reality, Augmented Reality, and Mixed Reality are the most common examples of impressive technology. These things offer users interactivity, visual engagement, and immersive experiences [10].

B. Augmented Reality

Augmented Reality (AR) is a technology that is able to combine two elements, namely the real and virtual worlds [11]. The AR technology used in this invention is a technique that combines the actual world with virtual items [12]. AR technology consists of hardware and software. Cameras, motion sensors, screens on smartphones, tablets, AR headsets, and smart glasses are common hardware used in augmented reality. Augmented Reality requires software capable of combining real and virtual world elements such as the use of pattern recognition algorithms, position tracking, and 3D rendering [11]. However, these two forms of AR must be able to keep the shape of virtually produced objects that blend with elements in reality, making them compatible with the actual world. Furthermore, the virtual environment's performance should be effective in real time [13].

AR interfaces allow users to interact with digital material such as 3D objects in real time in the user's present surroundings [14]. Some characteristics of Augmented Reality. The first is digital overlay, which allows the technology to insert 3D virtual images accurately into the real environment. The second is interactions in real-time, technology can directly connect

interactions between users and virtual objects such as movement, voice touch, and other inputs [11]. The functioning of Augmented Reality involves several steps. Initially, the sensors within the device examine the physical surroundings, following which the 3D objects embedded in the Augmented Reality (AR) software seamlessly merge with the actual environment. As a result, users can witness the appearance of 3D objects on the device screen and engage with them in real time.

AR's major purpose is to allow direct or indirect interactions between the physical environment and any technology or device-generated information [14]. In AR systems, intelligent interactions are indicated by hardware component interactions, location interactions, tag-based interactions, and other information-based interactions. AR now allows individuals to interact with virtual things in real-world contexts, in addition to overlaying virtual information over real-world surroundings, thanks to advancements in intelligent interaction technology. The goal of this interaction is for people to deliver explicit instructions to the virtual items in the environment, and the virtual objects may engage with feedback that will enhance the audience's experience with the AR application [11].

C. Autism Spectrum Disorder (ASD)

There are numerous definitions of ASD, all of which rely on the idea that ASD can be defined in the most basic terms as an impairment in social communication that develops early in childhood and is triggered by a variety of neurodevelopmental conditions, such as repetitive motor and sensory behaviors with a strong genetic component [13]. This clinical disease has a substantial influence on social life. It can have long-term detrimental effects on a variety of domains including peer social interaction, cognitive ability, daily living skills, academic accomplishment, and mental health [7]. As a result of this diagnosis, children with this neurodevelopmental illness require effective therapies that alleviate not just the core symptoms of ASD but also the disorder's comorbid clinical manifestations.

Although no single accepted treatment for ASD exists at the moment, there is an increasing recognition that effectively targeted personal behavioral and learning intervention strategies [e.g., Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) program, Early Intensive Behavioural program, Applied Behaviour Analytic (ABA) program, Denver model, etc.] have the possibility to improve the lives of people with autism and their families [8]. Some examples include AR applications, computer games, tablet games, video games, or AR interactive books can all help with the therapy of this developmental problem [7].

D. Augmented Realty Applied into Autism Spectrum Disorder (ASD)

Augmented Reality and Virtual Reality have emerged as widely adopted technologies with broad applications across various healthcare needs. Due to their versatility and relevance in numerous industrial sectors, including healthcare, AR and VR technologies have

become increasingly practical and affordable. They have demonstrated potential in enhancing various aspects of clinical practices, such as patient care and management, leading to improved outcomes. The applications of AR in the healthcare area are extensive and encompass various areas such as surgical procedures, clinical practices, education, training, medical rehabilitation, medical diagnosis, and various other domains [15].

In the health area, the patient is the main character in the use of AR and VR therapy applications with the guidance of a clinical. AR applications in the healthcare area may be perceived as a new technology by some people, so the absence of a reference standard for application development is understandable. Nonetheless, even with technological limitations imposed by current or past systems, the application of AR can still prove to be effective [16]. Advances in VR and AR technology also provide the potential for therapists to use the unique qualities of VR and AR to supplement standard psychosocial rehabilitation programs [17].

In terms of ASD, a study shows that AR technology may increase abilities in the academic domains of reading, science, and mathematics, as well as ancillary academic skills, among kids with ASD in grades K-12. This is especially promising to consider the growing emphasis on standards-based education for kids with ASD rather than merely functional skills programs [18]. Research demonstrates the advantages of AR-assistive psychosocial rehabilitation programs, with the majority of studies reporting that participants were able to execute functional activities more accurately or confidently following the treatments [17]. AR technologies seem to have a positive effect on improving different domains such as social interaction, social communication skills, verbal and nonverbal communication, facial emotion recognition procedures, attention skills, or functional life in children and adolescents with autism [7]. These functional responsibilities included everything from everyday living activities, job interviews, and customer service to social contacts and public speaking. The influence on real-world functional outcomes such as community integration, employment retention, and social inclusion, on the other hand, remained uncertain.

E. Tools for developing the app.

In making AR facilities for the therapy of children with special needs, we use Unity. Unity is a widely recognized and popular game engine developed by Unity Technologies that simplifies the rendering, physics simulation, and input processes for developers [19]. The game engine itself is a platform that enables game development for various platforms, including desktops, consoles, and mobile devices [20]. Unity serves as the foundation for creating both 3D and 2D virtual worlds, offering the building blocks required for game development in these immersive spaces [19]. This tool is the main part of making this AR quiz-based application. Unity here is used to unite several cycle projects that will be used as applications, ranging from 3D models to icon buttons, and will use the rear camera to scan flat areas.

III. SOFTWARE DEVELOPMENT

AR is the addition of computer-generated virtual things to a direct or indirect depiction of a real-world

physical environment. These virtual things are represented in the actual world using various technologies and tools [19]. This software employs Ground Plane Augmented Reality, a sort of AR. The marker base has advantages over the marker base, namely in the application case. In general, a marker base is rarely utilized and comes with a hefty marker development charge. Meanwhile, on the ground plane, no use cases are required so that consumers may observe straight from the program without the need for a marker [14].

This study employed agile approaches to effectively complete an AR project. With limited development time, it was critical to detect and fix issues that developed during the project's lifespan as soon as possible. This method made it easier to adjust to change and provided us with the flexibility to meet shifting needs. The agile approach contains a cyclic work process that promotes seamless cooperation and good communication among team members, resulting in mutually acceptable solutions [21].

This quiz-based AR is intended to help children affected by autism spectrum disorder so that they can understand facial expressions and express their interlocutors. In this AR we provide several facial expressions and users can answer them like quizzes, or we can call therapy for children with autism spectrum disorder.

The steps for development are:

1. We'll use Adobe Illustrator to design the button icon along with the font word and background.
2. After creating several icon buttons such as start, setting, exit, etc., we continue the application design stage using Unity.
3. In this step using Unity we start entering code in C# to run the quiz process
4. After the homepage preparation process in Unity has been completed, we develop a 3D model with Blander software.
5. In Blender 3D Character we focus on making some expressions or facial expressions needed in the quiz questions
6. After the 3D character creation process is complete, the model will be imported into Unity to be unified with the initial process.
7. In step 7, the application is ready to be launched to check whether there are still bugs in the application.

If all is done, then the application is ready to be published and used for expression therapy for children with autism spectrum disorder.

IV. RESEARCH RESULT

A. Concept

This application visualizes human organs and serves as a teaching aid to support learning at school and at home. In today's world of gadget dependence, this app is designed to help you learn anytime, anywhere. It has an easy-to-use interface for students, teachers, and

parents. Users can select an organ display, scan the ground plane with the device's camera, and tap the screen to view the selected organ. Additionally, the application provides detailed information about each organ of the human.

B. Design

1. Navigation Structure

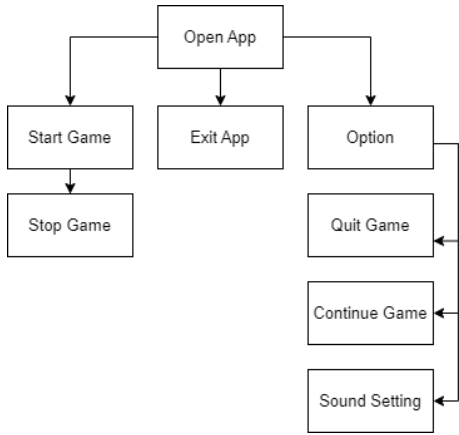


Fig. 1. Flowchart Navigation

In the structure above, there are three options available when the application is started: start game, exit, and option menu. When selecting the start game, the user starts the AR game, and the user can also stop the game. Furthermore, when selecting the option menu, the user can choose between quitting the game, continuing the game, or the sound setting. Users can swipe right to increase the volume and left to decrease it. In this way, users can set sound preferences to their liking.

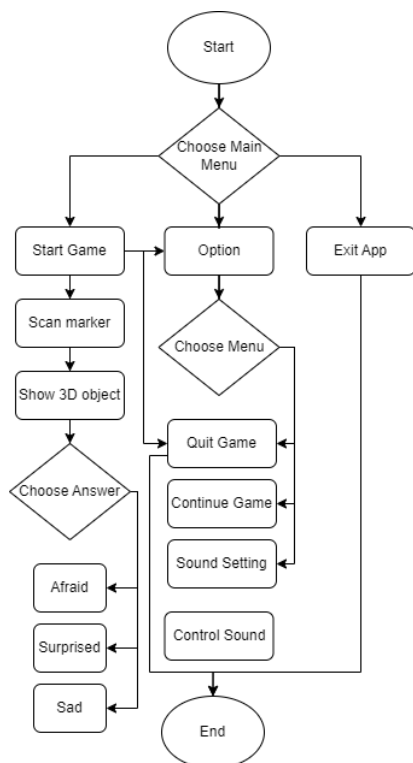


Fig. 2. Flowchart AR process

The flowchart above describes the application process from start to finish. The game starts when the user clicks the start button on the main menu. After that, the user must scan the marker then the 3D object will appear with the quiz options. The next section will provide a complete explanation of the process.

2. Features

The following is an explanation of some of the features of the application:

- Start and end the game.

The function of the starter game is to launch the game within the program. The user can launch the game by clicking the start button at the beginning of the application's run. Once the game is over, try to stop playing the running game. By clicking the pause button followed by the end game button, players can terminate the game at any time.

- Pause and resume the game.

By pausing the ongoing game, users could temporarily suspend its progress. Consequently, users can conveniently resume the game from the point at which it was halted, ensuring continuity, and allowing for uninterrupted gameplay.

- Choose an answer.

A feature called "choosing an answer" enables users to select the best response from a range of options in accordance with the presented 3D model. Users can then provide solutions based on their choices.

- Mute and unmute.

In the application settings, users have the option to enable or disable game sounds. If the user decides to enable the sound, an audible cue will be played when selecting an answer. Conversely, if the user opts to disable the sound, no auditory feedback will be generated upon selecting an answer.

- Exit the application.

The feature of exiting the application enables users to terminate the execution of running applications. When a user opts to log out from the application, it signifies the conclusion of all prior activities within the application.

To use this AR application, the user will be directed to the main menu when the application is successfully opened. In the main menu, users can choose the "Start" button to begin the game or exit the application. If users choose to exit the application, all app activities will be stopped. And if users choose to play, they can enter the game. Upon entering the game, users will be prompted to point the device camera at a flat surface to initiate the game.

Once the sensor successfully analyzes the flat surface, users need to tap on the screen at that flat location to make the 3D object appear, thus starting the game. The game will present random facial expressions, and users can select the correct answer based on the given 3D object. Users will receive notifications when they answer correctly or incorrectly, and their score will

increase by one for correct answers. In the middle of the game, users can briefly pause by tapping the "Stop" button located in the top right corner of the screen. When in the options menu, users are provided with several choices, such as "Quit Game," "Sound Settings," and "Continue Game." If users choose the settings, they can turn the sound on or off, and a checkmark will appear when the sound is active or vice versa. If users select "Quit Game," all game activities will be stopped.

Here are some screenshots of when the application starts.

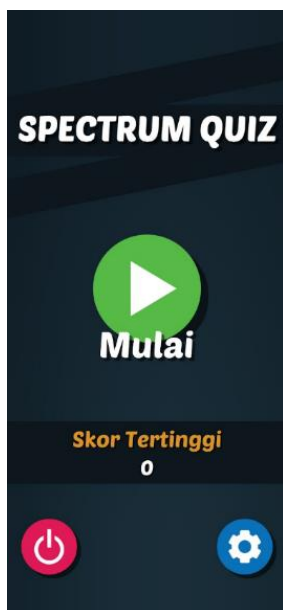


Fig. 3. Main Menu.



Fig. 4. In-game Display.

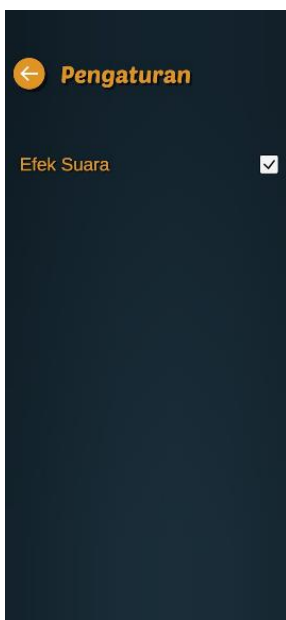


Fig. 5. Setting Display.

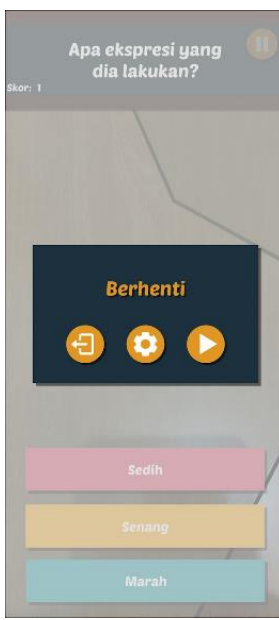


Fig. 6. Display of Options.

Visual Studio Code is a commonly used code editor for designing code. It is used to design and develop the necessary code for application development. Adobe Illustrator is software used to design application icons, backgrounds, and buttons. After this stage is completed, the next step is to integrate it into the software called Unity to create an application. Since it uses Unity, the

application will access the rear camera to display 3D objects. The 3D objects are designed and developed using Blender software. Thus, an application that can be used is created.

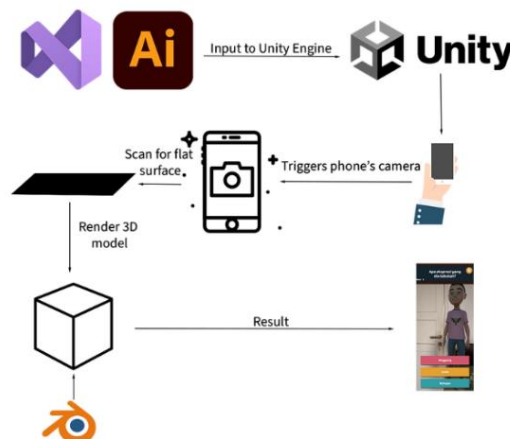


Fig. 7. Spectrum Quiz Structure

V. CONCLUSION

In recent decades, interest in autism spectrum disorders has increased among researchers, clinicians, and educators [1]. Autism spectrum disorder (ASD) is a neurological disorder that causes a person to have difficulty communicating and have limited or repetitive behavior patterns [2]. Globally, especially in Indonesia, there has been a significant increase in cases. Autism spectrum disorder (ASD) has two specific therapies: pharmacological therapy and non-pharmacological therapy. Early Intensive Behavioral Intervention (EIBI) is a social behavioral therapy that has been proven effective [5]. Thanks to the development of the metaverse world carried out by Facebook and Microsoft companies, the number of AR and VR users has increased, especially in the health field including ASD therapy.

Spectrum Quiz is an AR-based application developed to help children with autism interact and understand a person's expression through 3D human objects. Using AR in ASD therapy provides a more enjoyable and effective alternative to conventional teaching methods and has the potential to develop intellectual intelligence.

Based on the information that has been submitted, there are several development recommendations that can be considered. One of them is to increase the interactivity of the application to provide more enjoyable use and reduce the burden felt by users. In addition, it is important to conduct research related to the effectiveness of the application in order to identify existing deficiencies and improve the therapies provided. One of the challenges faced is the difficulty in designing three-dimensional models that are visually appealing and display an aesthetically pleasing appearance.

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