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Utilization of Augmented Reality Technology in Independent Speech Therapy Applications

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Abstract

One of the uses of information technology is augmented reality technology in the health sector. Augmented reality is used in the development of applications that are used for speech therapy for children with autism or children with speech delays. The method used for the development of speech therapy applications is the extreme programming method. This method can adapt to the development of an application in a short time and quite a lot of changes. The stages in the extreme programming method include identifying system requirements, planning activities during system/application development, system development process, iteration for system improvement until the final iteration, and no more user feedback, system/application production, and system maintenance with data backup and system recovery. After testing the system, it was concluded that three iterations occurred during the development of the speech therapy application. The last test showed that the user accepted the speech therapy application with a percentage of 77,14%. The output of this research is an augmented reality-based speech therapy application that is useful for independent speech therapy for children with speech delays.

Keywords: *Extreme Programming Method, Speech Delay, Augmented Reality, Autism Spectrum Disorder, Therapy*

1. Introduction

Autism is a developmental disorder in children that attacks them mentally and causes difficulties in interacting with their social environment [1]. Usually, the child's signs will be seen before the child reaches three years of age [2]. Parents can detect this autistic disease by observing the child's daily behavior, especially how the child communicates with his close family [3]. Handling children with autism can be done in consultation with experts such as psychologists, pediatricians, pediatric neurologists, nutritionists, and therapists [4]. Some therapies that can be given to children with autism include physical therapy, speech therapy, sensor integration therapy, visual therapy, occupational therapy, biomedical therapy, and others, depending on the child's condition [5].

Therapy that can be done for people with autism to treat communication disorders is speech therapy [6]. Speech therapy is given to children with autism who have problems regarding the ability to speak, understand, and express language [7]. The initial examination to determine the cause of the child's speech delay includes first examining the mechanism of the mouth, which serves to ascertain the cause of speech disorders, not from the structure of the mouth, tongue, and surroundings [8]. The second is an examination of the child's pronunciation/articulation. The purpose of this examination is to assess a child's ability to pronounce consonants and vowels. The third examination is the child's understanding ability and verbal disclosure to determine how the child expresses something he understands [9].

However, due to the Covid-19 pandemic, sufferers experience difficulties in carrying out therapy. Information technology is proliferating, especially in the health sector; this is evidenced by the emergence of special computer applications/programs for handling health problems, both website-based and Android-based [10]. The use of health applications, better known as mobile health, is easy and fast to help users access information about various health disorders, one of which is child development disorders, better known as autism spectrum disorder (ASD) [11], [12]. Currently, many applications for health purposes have been developed using augmented reality technology [13]. In this study, AR technology is used for self-therapy for people with autism through smartphone applications. Augmented reality is a technology that combines visualization in the virtual world, equating with visualization in accurate and real-time [14].

Several previous studies have been conducted by Kamran et al. This study discusses using augmented reality (AR) to improve the skills of children diagnosed with ASD. The results showed that AR was beneficial in supporting learning skills for children with ASD. Subsequent research discusses the effectiveness of AR among more participants, the sharing of technologies that support AR for intervention, generalization and maintenance of learning skills, and evaluation in inclusive classroom environments and other guaranteed settings [15]. Subsequent research by Syahputra et al. produced 3D animation of social stories by detecting markers located in a particular book and some simple games designed for children with autism that were carried out using a motion controller jump, helpful in reading hand movements in real-time. The implementation of augmented reality technology for social therapy by packaging the story uses virtual techniques to increase the intrinsic motivation of children with ASD because the child has difficulty focusing. Based on the Likert scale, with an average percentage of 71.18%, respondents agree that the system can support visualizing social story therapy for children with Autism Spectrum Disorder (ASD) in interpreting and understanding the surrounding social situations [16]. The following research by Liu et al. has resulted in smart glasses that use augmented reality technology, which has a vital role in helping to overcome the therapeutic needs of children with ASD. This app trains children and adults for emotion recognition, face-to-face gaze, eye contact, and behavioral self-regulation. The data collection method in this study is quantitative, where data is obtained from a system that allows digital phenotyping and social improvement, construction, and communication from the research domain criteria. In conclusion, this study provides evidence about the feasibility, usability, and tolerability of smart glasses [17].

The difference between this research and previous research is optimizing the extreme programming method at each stage, especially in the iterations before producing speech therapy systems/applications. The iteration that occurs is optimized to extract feedback from the end user to improve speech therapy applications. This research is also helpful in monitoring the communication development of children with ASD by using an augmented reality-based application developed by implementing the extreme programming method. The first reason for choosing the extreme programming method for developing speech therapy applications based on augmented reality is that this method can adapt to many changes with the application/system processing time not too long. The second reason is that in the extreme programming method, there are helpful iterations to find feedback from end users, and from that feedback, the shortcomings of the developed application can be seen. The data used in this study is student data at SLB Putra Mandiri Kawunganten and SLB Putra Mandiri Gandrungmangu from January 2021 to March 2022. The objects of this research were children or students at SLB aged Kawunganten who experienced speech delays between the ages of 7 years and 17 years. Meanwhile, the level of success of therapy is determined through several things, namely discipline in carrying out treatment, meaning that therapy will be successful quickly when every child with ASD regularly does speech therapy, and secondly, support from the people around the child to carry out speech therapy to increase the success of speech therapy. This support comes from parents, family, and the environment of children with speech delays. The output of this research is a mobile-based application that can be used by people with autism spectrum disorder (ASD) or their families to guide and self-administered speech therapy.

2. Research Methods

This study uses extreme programming to develop mobile-based speech therapy applications with augmented reality technology. The stages in the extreme programming method include identifying system requirements, planning activities during system/application development, system development process, iteration for system improvement until the final iteration and no more feedback from users, system/application production, and system maintenance with data backup and system recovery [18], [19].

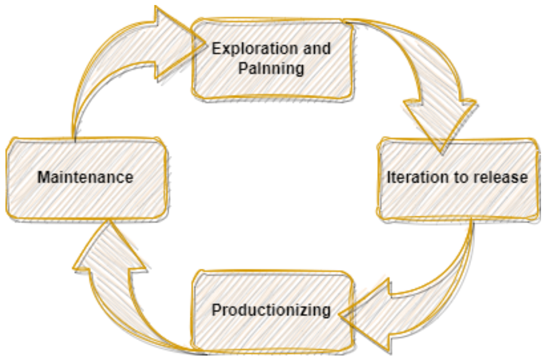

Figure 1. Stages of the Extreme Programming Method

The stages in this method are as follows:

a. Exploration and planning of system requirements and research data.
This stage begins with the identification of functional and non-functional requirements needed for the development of applications that children with autism can use to perform speech therapy independently. Non-functional requirements are related to equipment and materials such as cameras, storage devices, and computer devices [18].

b. Activity planning
Planning for speech therapy application development activities begins with determining the iteration to be carried out in the application development process [20]. Iterations are carried out based on end-user input on speech therapy applications. These processes are consulted with end users to capture the functional requirements of the system, such as the design of the speech therapy application interface, the modules that will be displayed, and the buttons on the speech therapy application are made as simple and easy as possible so that the end user does not feel confused when using speech therapy applications [19].

c. System development process
The augmented reality method implemented in application development for speech therapy is the marker-based tracking method, shown in Figure 9 point e. At this stage, coding is carried out for application development using software such as Unity, vuforia, and software for designing 3D object designs which will later be displayed on mobile-based speech therapy applications using augmented reality technology. At this stage, it is also done by rendering an image or object recorded to produce reality as a three-dimensional object [21]. Followed by designing the character of the therapist and autistic child patient and the background of the place used for therapy. Then, organize HIPO (Hierarchy Input Process Output), create storyboards from AR applications, and create 3D animations.
   1) The design of the therapist's character design, the patient's character, and the speech therapy process

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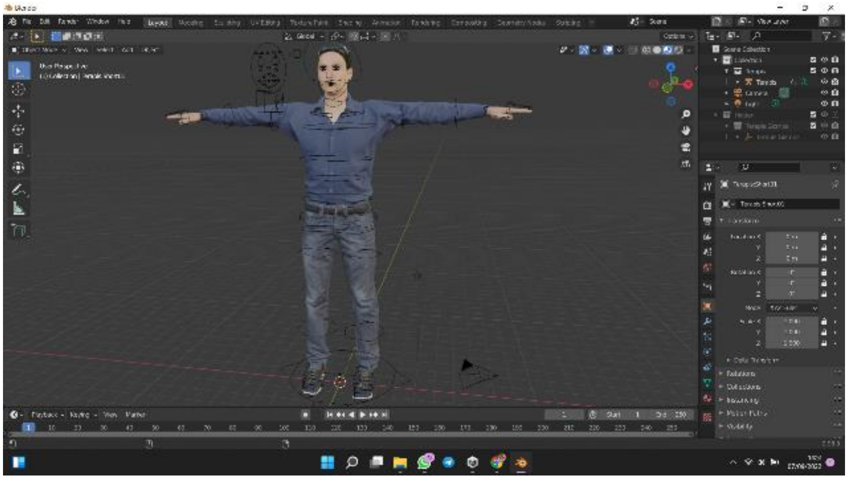
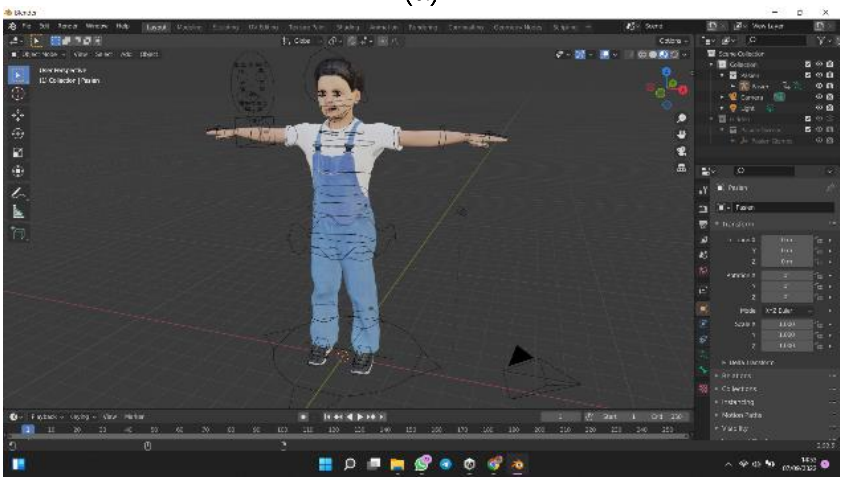


(a)



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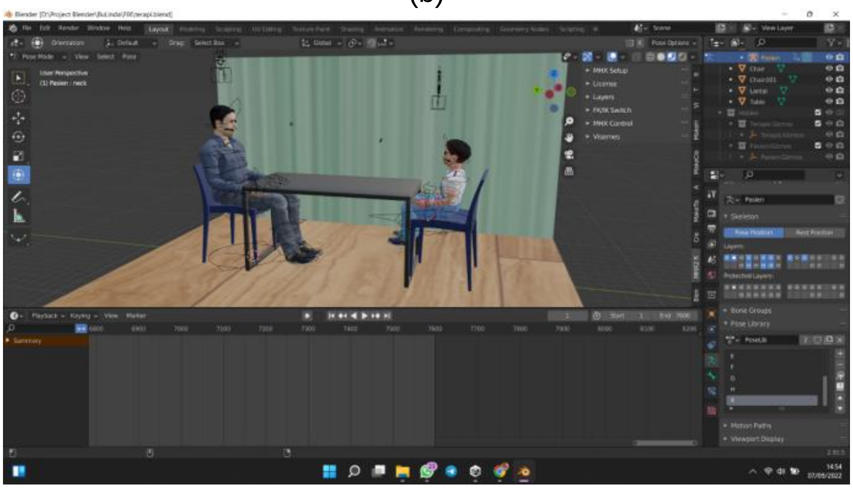


(c)

Figure 2. (a) Therapist Model Design, (b) Patient Model Design, (c) Speech Therapy Model Design

2) HIPO Design

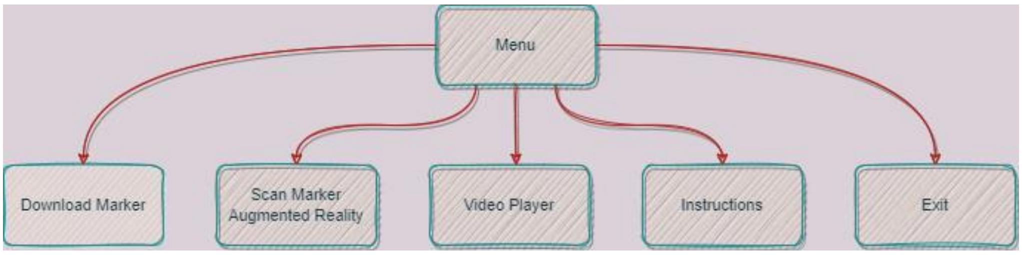


Figure 3. HIPO Speech Therapy Application

HIPO (Hierarchy Input Process Output) AR application consists of a main splash screen menu in which there are five sub-menus, each of which can be used to:

a) Download Marker
The menu serves to download markers that can later be scanned. The marker is already available on the drive link.

b) Scan AR
The menu can be used to scan/detect marker images that have been previously downloaded. The scanned marker will display a 3D animation of speech therapy performed on autistic patients.

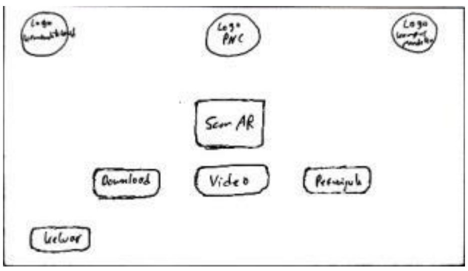
c) Video Player
The video player menu contains speech therapy videos for children with autism that have been made into 3D animations.

d) Hint
This menu contains instructions for using the AR application, starting from how to download a marker image/target image, how to scan a marker image, how to play a video player about speech therapy sessions, and how to exit the AR application.

e) Exit
The user will exit the AR application if this menu is pressed/clicked.

3) Storyboard Design

Table 1. Storyboard

No.	Sketch	Description
1.		The splash screen display design of the speech therapy AR application, when opening the application with the display of the Kemendikbudristek logo, the PNC logo, and the Merdeka Campus logo, lasts 3 seconds.
2.		The main menu display design contains the display of the Kemendikbudristek logo, the PNC logo, the Merdeka Campus logo, and the AR scan menu, Download, Video, Instructions, and Exit, with a duration of 3 seconds.

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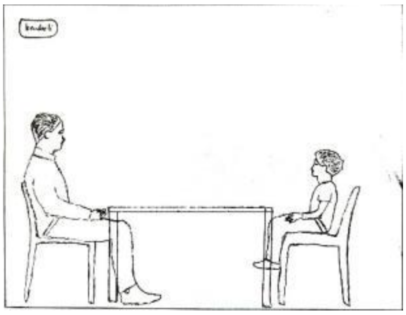
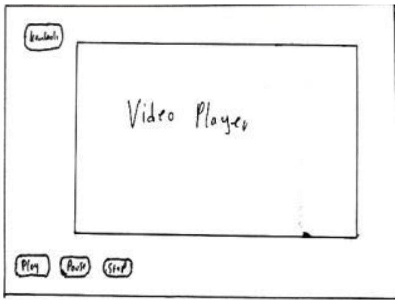
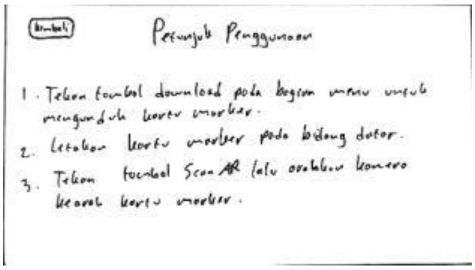
3.		The design of the AR scan display contains a menu to return to the main menu and a 3D animation showing a speech therapy session for autistic patients by a speech therapist; the duration is not specified.
4.		The video player menu display design contains a back menu to return to the main menu, a play menu to play videos, a pause menu to pause the video, and a stop menu to stop the video; the duration is not specified.
5.		The display design of the pointer menu contains instructions for using the AR application, and there is a back menu that can be used to return to the main menu, with a duration of 8 seconds.

4) Splash Screen Menu Flowchart
The flowchart of the splash screen main menu on a mobile-based speech therapy application with augmented reality technology is shown in the image below.

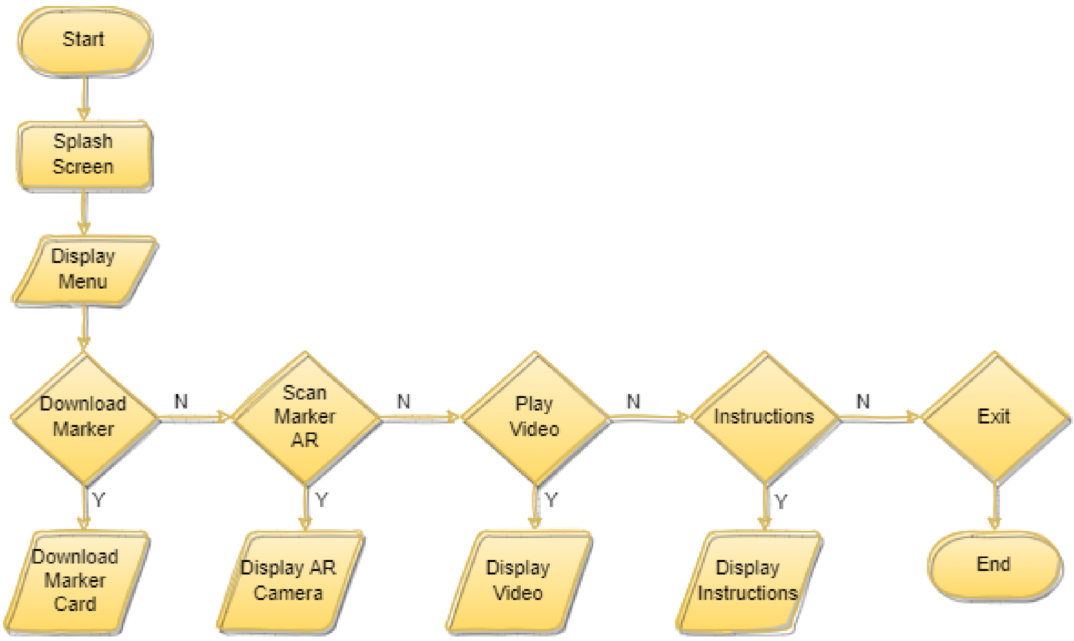


Figure 4. Flowchart of the Main Menu of Speech Therapy Applications

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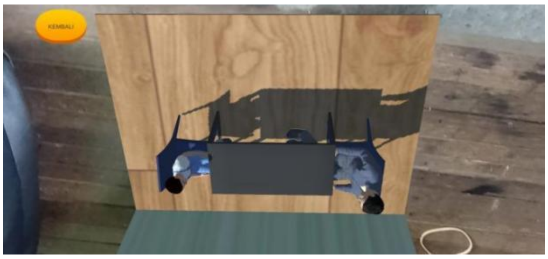
In Figure 4 above, it is explained that the speech therapy application menu has five menus, each of which is a download marker menu, AR scan menu, instructions menu, video player menu, and exit menu.

d. Iteration process
   1) First Iteration
      The improvement in the first iteration is that the speech therapy session should have therapeutic objects displayed on the table, like the words spoken by speech therapists to children with autism or children with speech delays. Feedback from end users is done as an improvement in the first iteration [22].
   2) Second Iteration
      The improvement in the second iteration is that there is no 3D rotation for speech therapy sessions in the video. End users provide input that 3D rotation should exist to make it easier for end users to watch speech therapy sessions without rotating the device.
   3) Third Iteration
      The third or final iteration process improves the speech therapy session. In speech therapy sessions, the patient's voice should be removed so that only the therapist's voice can be heard, and the therapist's voice can be followed by patients doing independent speech therapy at home.
      After this third iteration and the repair of the end user is done, the entire iteration process has been completed. The stages of system development using the extreme programming method can be continued to the next step, namely, the production process of speech therapy applications [18].

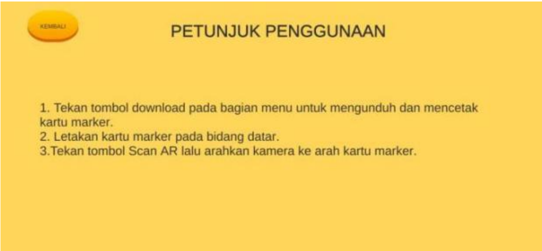
e. Production process system
   This stage begins with coding/production applications using the Unity software and creating a speech therapy application database using the Vuforia programming language, as well as implementing the user interface design for the main page of the speech therapy application, as shown in Figure 5 below. The speech therapy application consists of 4 menus, namely (a) the main application menu, (b) the AR scan menu, when the marker is scanned, a speech therapy video will appear, (c) a marker that can be scanned on the AR scan menu, (d) the video menu. , in which a speech therapy video can be played, (e) a menu that shows the use of speech therapy applications.

(a)



(b)

(c)



(d)

(e)

Figure 5. (a) Splash Screen Menu, (b) AR Scan Menu, (c) Video Menu, (d) Instructions Menu, (e) Application Marker

3. Result and Discussion

From all stages of research using the extreme programming method that has been carried out, it can be tested using performance measurement techniques and retrospective think-aloud. The process carried out in this technique is to analyze several aspects such as efficiency, effectiveness, difficulties, or problems faced by respondents/end-users, and these aspects provide a more detailed explanation of the meaning of the data and information that has been obtained to conclude these measurements [23].

The effectiveness and efficiency of speech therapy applications were measured using performance measurement techniques [24]. The success of the given task and the failure of the task carried out by the respondent are measured to calculate effectiveness [25]. Effectiveness is calculated by setting a value of 1 if the task performed is successful and a value of 0 if the given task fails [26]. The equation for calculating the failure rate and the success rate is shown in Equation (1) and Equation (2) below [27].

$$\text{Succeed} = \frac{\text{Number of successful tasks}}{\text{Total number of tasks}} * 100\% \quad (1)$$

$$\text{Fail} = \frac{\text{Number of failed tasks}}{\text{Total number of tasks}} * 100\% \quad (2)$$

Meanwhile, the measurement using the retrospective think-aloud technique was carried out by interviewing respondents during the iteration process. Respondents practice their way of using speech therapy applications using the respondent's smartphones. To find out the respondents' opinions while using the speech therapy application, interviews were carried out to obtain information about the level of usefulness of the application according to the respondent's version. The results of the questionnaires that have been filled out by the respondents representing the respondents' thoughts are then collected to conclude how practical the speech therapy application developed is. These results represent the impressions, benefits, and difficulties experienced by respondents, as well as the feedback given during testing [28]. The questionnaire used to obtain data using this technique is shown in the table below.

Table 2. Speech Therapy Application Questionnaire

No	Question
1	I think that this system makes it easier for me to do independent speech therapy.
2	I find that this system should not be made this complicated.
3	I think this system is easy to use
4	I think that I will need help using this system.
5	I find the various functions in this system well-integrated

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6	I found many things in this system that were inconsistent.
7	I imagine that most people can quickly learn to use this system.
8	I think that this system is complicated to use
9	I am very confident in using this system.
10	I need to learn many things before I can use this system.

Respondents involved in this test were 35 respondents consisting of 23 guardians of children with autism and children with speech delays, eight special school teachers, and four speech therapists. The results of measuring the performance measurement of a mobile-based speech therapy application with augmented reality technology that implements the extreme programming method are shown in Table 3 below.

Table 3. Results of Speech Therapy Application Performance Measurement

Respondent Code	Successful (%)	Failed (%)
R1	82,05	17,95
R2	74,36	25,64
R3	79,49	20,51
R4	87,18	12,82
R5	74,36	25,64
R6	71,79	28,21
R7	79,49	20,51
R8	69,23	30,77
R9	87,18	12,82
R10	79,49	20,51
R11	66,67	33,33
R12	74,36	25,64
R13	82,05	17,95
R14	74,36	25,64
R15	84,62	15,38
R16	76,92	23,08
R17	79,49	20,51
R18	66,67	33,33
R19	71,79	28,21
R20	66,67	33,33
R21	66,67	33,33
R22	87,18	12,82
R23	82,05	17,95
R24	79,49	20,51
R25	76,92	23,08
R26	84,62	15,38
R27	69,23	30,77
R28	71,79	28,21
R29	87,18	12,82
R30	71,79	28,21
R31	74,36	25,64
R32	84,62	15,38
R33	79,49	20,51
R34	76,92	23,08
R35	79,49	20,51

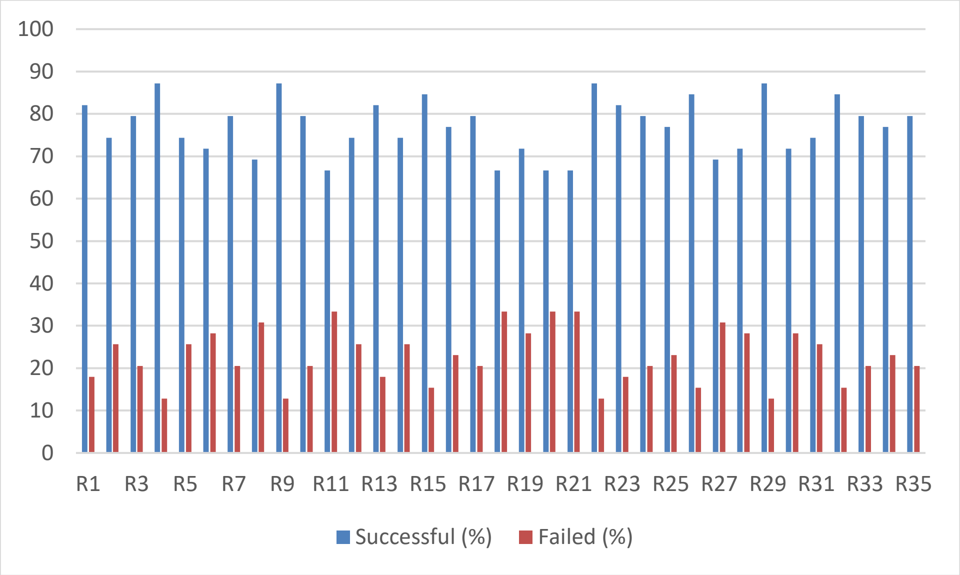

Figure 6. Testing Results of Speech Therapy Applications

Figure 6 above shows that testing using performance measurement techniques and retrospective think-aloud produces an average for all tasks that respondents have done, and the results of questionnaires that respondents have filled out are 77.14%. The user's failure when using the augmented reality-based independent speech therapy application is that the camera on the smartphone device has different resolutions, and the angle when scanning the marker does not match the marker. This value indicates that the application of speech therapy is well received by respondents and can be used as a guide for independent speech therapy for children with autism or children who have speech delays [29].

4. Conclusion

Based on all the activities carried out at the speech therapy application development stage, it was concluded that the extreme programming method has been successfully implemented in this application development process by performing three iterations until the application can be produced. All improvements from 35 respondents have been successfully carried out to advance speech therapy applications. In addition, all the processes carried out in this research, starting from the development of a mobile-based speech therapy application with augmented reality technology that implements the extreme programming method and the stages of testing carried out using performance measurement techniques and retrospective think-aloud, the results obtained that speech therapy applications are acceptable by respondents with a value of 77.14%. This value means that the application of speech therapy has been successfully used to guide independent speech therapy under the supervision of a speech therapist.

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