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Development of Home-based Rehabilitation Mobile App for Autism Spectrum Disorder

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ABSTRACT

Autism Spectrum Disorder (ASD) children experienced postural balance disorders that significantly affects their quality of life. It is believed that poor gross motor development leads to the bare social interaction which is the core weakness of ASD. However, treatment expenses for ASD children such as movement therapy requires high cost. This may be due to the limited access to the rehabilitation facilities and medical professionals to evaluate the patient well-being. In this study, Android-based mobile application of home-based therapy intervention for ASD children as the main user where mainly monitored by the therapists and caretaker is developed. This mobile app includes movement modules which intended to conduct the therapy routine via the character animations and audio. Users can evaluate motor performance and psychological well-being of the patients which designed for both in-house and clinical settings. Based on the qualitative measurements, it is shows that the average System Usability Scale (SUS) score is 86.25% which indicates good usability.

INTRODUCTION

More than 5 million Americans were statistically affected by Autism Spectrum Disorder (ASD), with a frequency of 1.7% in kids (Hyman et al., 2020) and at least 214 million children worldwide were affected with ASD, with 1 million of those under the age of 10 living in the United States (Penev et al., 2021). ASD is related to postural and balance disorders that could interfere with gross motor development and lead to slow development of social interaction. Therefore, the ability to maintain good posture is thought to be one of the requirements for the performance of gross motor skills (Mache and Todd, 2016) that allow the human body to carry out daily tasks and engage in social contact.

Rehab sessions for ASD patients are crucial to overcome these issues. However, the existence of rehabilitation facilities for autistic children and those with ASD was extremely low in Saudi Arabia (Hajjar et al., 2021). Meanwhile, in Africa, the research shows there is a lack of understanding and awareness, poor mental health facilities, and a serious lack of educated professionals (Bakare and Munir, 2011). In addition to this, the expense of the treatment may be higher even though the parents can give their ASD children appropriate care.

Therefore, to overcome the aforementioned issues, a home-based mobile application therapy is developed to assist therapists as well as caretakers in evaluating the condition of people with ASD. In this study, this mobile application will help the caretaker to assist the ASD patients in their therapy sessions via movement module through character animation and voice. The therapy routine applies to both home and clinical settings that improve motor performance and psychological well-being. This mobile application was developed using Android Studio where the functional testing was carried out on the target communities and adjusted based on the community feedback.

In this journal, project methodology related to mobile application development will be further discussed in Section 2. The result of the developed mobile application will be portrayed

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in Section 3. In Section 4, the discussion of the obtained results will be further explained, and Section 5 will describe the conclusion of this project at the end of this journal.

MATERIALS AND METHOD

An interview session was conducted prior to the prototype development with the occupational therapist. This was to ensure that the prototype of the mobile application was designed and developed accordingly based on the clinical requirement. It was mentioned that the design of the mobile application must be layman-friendly. So that, the therapists and caretakers can easily assess during the therapy session. It is highlighted by the occupational therapist that cartoon animation as well as audio should be included in the application design which could help the attention span of ASD children to focus.

Mobile Application Development

The system workflow of the mobile application development is summarized in Figure 1 where the mobile application will be started with the User's Login layout. Registration was acquired for the first-time user before login to the mobile application. Once logged in, the user needs to fill up the patient's information which then the information was saved to the Firebase.

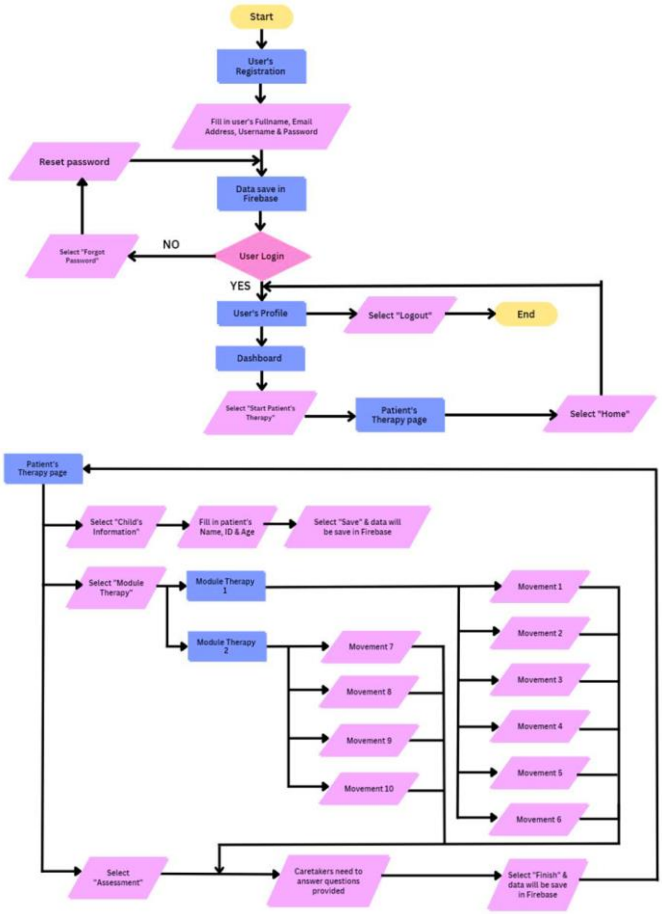

Fig 1 Application system workflow

After all the information was filled up, the user got back to the Module Therapy section. In this section, there are two module therapies displayed namely Module Therapy 1 and Module Therapy 2. In Module Therapy 1, there are six basic movements were included in the module while in Module Therapy 2, there are four movements that were included. Once the therapy sessions are done, the user needs to fill up the patient's assessment on the Assessment page based on the patient's performance during the movement therapy session. Once the assessment is done, the data of the assessment will be saved to the Firebase. By selecting the "Finish" button, the user will be navigated to the Patient's Therapy section and the "Home" button will navigate to the User's Profile, and the user can log out from the mobile application.

The layout of the prototype of the mobile application was designed using Adobe XD version 56.1.12.1 to foresee the flow of the real mobile application. The complete linked prototype of the designed layouts in the Adobe XD. Meanwhile, the movement modules that will simulate the cartoon animation were created using Adobe Animate. In this module, a cartoon character is selected and each of the keyframes is selected and adjusted to create a complete animation movement. The layouts of the mobile application as well as the animation were then merged into the Android Studio IDE using Java.

Performance Testing and User Experience Analysis

The usability of the mobile application is then evaluated using System Usability Scale (SUS). This qualitative survey includes ten questions that consist of five statements which positively worded and five statements which negatively worded. Each of the questions consists of five response options, ranging from strongly agree to strongly disagree. The functional testing involved two stages where in the first stage the respondent is requires to test the first mobile application prototype. In the second stage, the respondent needs to test the modified prototype. The respondents are then required to fill up the SUS, questionnaire with ten items. Table 1 summarises the items that were included in the questionnaire survey.

Table 1 Statements to evaluate the usability of the mobile applications.

Items	Statement
1	General favorable opinion of the system or product
2	Evaluate the complexity of the product
3	Analyse the usability of the system itself
4	Evaluate the perceived difficulty of utilizing the system or the perceived requirement of system training
5	Evaluate the consistency of the system or user interface elements perceived
6	Evaluate the complexity of the product
7	Measure the simplicity of the system based on the participants' point of view
8	Evaluate the complexity of the system based on the participants' point of view
9	Evaluate the usability and simplicity of the system based on the participants' point of view
10	Assess the participants' satisfaction and the usability of the system

RESULT AND DISCUSSION

Mobile application is integrated with the therapy modules according to the product requirements based on the interviews conducted with the therapist. The mobile application prototype was then tested with the user experience and improvements were made based on the feedback of the users. This will be further discussed in the next subsections.

Mobile Application Integration

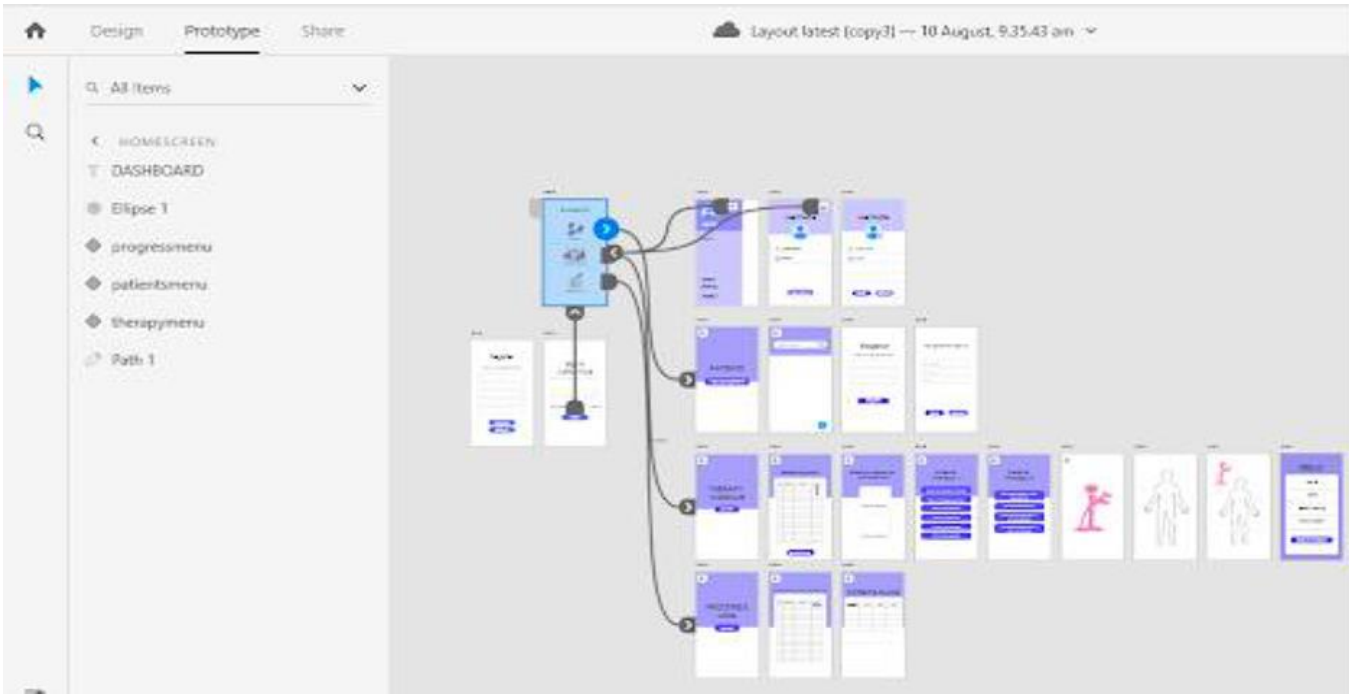

Fig 2 Mobile application layout prototyping

The mobile application is designed in a layman-friendly layout which could assist the user easily in using the application at home without the need for aid from professionals. The layout of the mobile application was designed in the Adobe XD as illustrated in Figure 2. Based on the designed layouts, an Android-based mobile application is then designed as in Figure 3.

Fundamental movements of the therapy modules were done based on interviews with the occupational therapist. Ten different movements were made up of two therapeutic modules. Figure 2 shows the movement therapy modules that were integrated with the mobile application. Module Therapy 1 consists of six movements that involve fundamental movement that requires one limb each time. Meanwhile, the remaining four movements were included in Module Therapy 2 which has been

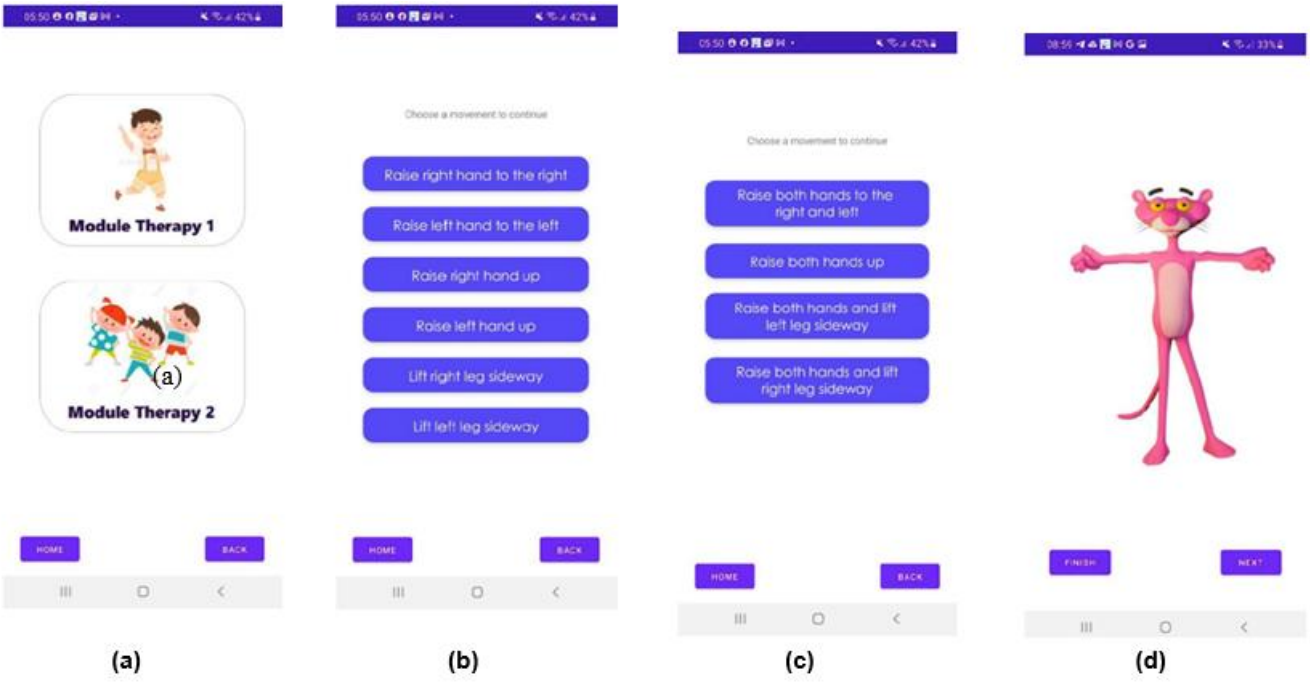

Fig 3 (a) Therapy Modules Menu Screen, (b) Movements involve one limb in Module Therapy 1, (c) Movements involve two or more limbs in Module Therapy 2, (d) Animated avatar in assisting therapy module.

improved where it involved a combination movement of two or more limbs. These ten basic movements that involve both upper and lower limbs can be practiced by ASD patients which could be aided the posture and balance control issues. After the therapy session, the caretaker or therapist can access the progress of the patient through the assessment section in the mobile applications. This assessment will help to see the progress of the gross motor, postural, and balance control development of the ASD patients. The example of the assessment is shown in Figure 4.

Fig 4 Assessment for ASD patients

Findings of Performance Testing and User Experience

The performance of the mobile applications of this study is evaluated through the SUS. A survey was done by collecting responses from 10 respondents in Stage 1 and Stage 2. The findings of both stages are tabulated in Table 2.

Table 2 Results of average SUS score for Stage 1 and Stage 2

Stage	Average SUS score (%)
1	79.95
2	86.25

The testing result in Stage 1 did not satisfy the passing requirement of average SUS score which may be due to the glitches that occur during the intended activity in the integrated mobile application. Based on the users' feedback on Stage 1, modification has been made to ensure that the user will have a positive experience and the functionality has been improved in Stage 2. Therefore, the average SUS score in Stage 2 is greater than 80% which indicates that this mobile application prototype has decent usability.

CONCLUSION

The development of the mobile application enables home rehabilitation as it provides an alternative for caretakers to monitor and evaluate their autistic children. This also could be a digital intervention for postural and balance control issues faced by ASD children. Besides, the implementation of the cartoon animation and audio which mimics the instructions of the therapist could increase the attention span of the patient during home therapy. Consequently, this mobile application can help caretakers ensure that their autistic children receive therapy treatment by undergoing therapy sessions from home as well as save their time and penny from the need to go to any medical center.

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