



Physio

IT 497: Graduation Project Report Product Release-2

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Physio

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Abstract (English):

The Physio project is poised to revolutionize physiotherapy services in Saudi Arabia by tackling the long-standing challenges associated with appointment scheduling and limited access to therapy centers. To overcome these barriers, we propose the development of a cutting-edge, specialized physiotherapy application that seamlessly integrates advanced virtual reality (VR) technology.

Our software development process followed a meticulous, iterative approach, where we systematically broke down the complex problem into manageable tasks. Each task was expertly addressed, and individual solutions were seamlessly integrated to comprehensively address the overarching problem and incrementally construct the final product.

Following user acceptance testing (UAT), it was evident that the software's primary objective is clearly defined and remarkably user-friendly. Comprehensive evaluations revealed that the physiotherapy application exhibits exceptional performance, unparalleled usability, robust error handling, seamless availability, and stringent security measures. In conclusion, we are confident that this transformative platform will effectively facilitate seamless connectivity between patients, administrators, and therapists, significantly enhancing the accessibility and convenience of the physiotherapy process.

Abstract (Arabic):

يهدف مشروع ("Physio") إلى إحداث ثورة في خدمات العلاج الطبيعي في المملكة العربية السعودية من خلال معالجة التحديات المتعلقة بجدولة المواعيد وصعوبة الوصول إلى مراكز العلاج. ولتجاوز هذه الصعوبات، نقترح تنفيذ تطبيق متخصص حديث يدمج بسلاسة تقنية الواقع الافتراضي المتقدمة.

تم تطوير البرنامج باستخدام نهج تكراري دقيق، حيث تم تفكيك المشكلة المعقدة إلى مهام صغيرة ومدارة بسهولة. تم التعامل بمهارة مع كل مهمة ودمج الحلول الفردية بسلاسة لمعالجة المشكلة الرئيسية وبناء المنتج النهائي تدريجيًا.

وبعد إجراء اختبار قبول المستخدم، تبين أن الهدف الرئيسي للتطبيق واضح وسهل الاستخدام بشكل ملحوظ. وأظهرت التقييمات الشاملة أن التطبيق يتمتع بأداء استثنائي وسهولة استخدام، ويتعامل مع الأخطاء ويوفر سلاسة وتدابير أمان صارمة. في النهاية، نحن واثقون من أن هذا التطبيق الثوري سيسهم بشكل فعال في تسهيل التواصل المستمر بين المرضى والمسؤولين والأخصائيين، مما يعزز بشكل كبير إمكانية الوصول والملاءمة لعمليات العلاج الطبيعي.

Keywords:

1. **Physiotherapy:** Specialized medical services aimed at restoring physical function and mobility through targeted exercises, manual therapies, and other interventions.
2. **Appointment scheduling challenges:** Obstacles and difficulties associated with efficiently managing and organizing physiotherapy sessions and allocating suitable time slots for patients and therapists.
3. **Admin:** Administrative personnel responsible for overseeing and managing the operations and logistics of the physiotherapy app.
4. **Therapist:** A qualified professional who provides physiotherapy treatments and interventions to patients.
5. **Virtual reality (VR) technology:** State-of-the-art technology that creates immersive and interactive virtual environments, utilized to enhance the effectiveness and engagement of physiotherapy sessions.
6. **Iterative approach:** A systematic development methodology involving breaking down complex problems into smaller, more manageable tasks, addressing them individually, and progressively integrating the solutions.
7. **User acceptance testing (UAT):** The process of evaluating software performance, ease of use, and adherence to user requirements through testing conducted by end-users.
8. **Patient:** An individual seeking physiotherapy services to address physical impairments or injuries.
9. **Convenience:** The state of being convenient, providing ease and comfort in accessing and utilizing physiotherapy service.

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CHAPTER 1: INTRODUCTION

1. Introduction

1.1 Introduction

In today's world, the necessity for physical therapy extends far beyond athletes, encompassing individuals from various walks of life. There has been a notable global increase in physiotherapy patients spanning all ages in recent years. The adoption of technology has played a part in driving this surge. For instance, people who spend hours working on their computers at their desks can suffer from neck, shoulder, and arms pain. Technology can also play a solid transformative role in physical care and rehabilitation.

As the demand for physical therapists is expected to increase yearly [1], we aim to develop a new application utilizing Agile methodologies infused with Virtual reality technology to help patients and therapists save time and reduce costs.

This document will address the main problem and how we are willing to solve it. Moreover, we will present our system design and requirements. Also, we will delve into our data design along with the interface design and implementation.

To summarize, we will present the conclusion and the future work we intend to make. Any external references used will be cited at the end of this document.

1.2 The Problem

Many physiotherapy patients encounter challenges in the regular process of their physical therapy sessions, such as scheduling appointments due to the shortage of therapists and the limited access to therapy centers in Saudi Arabia, as shown in Figure 1 below [2]. This high demand for physical therapy sessions and appointments can result in extended waiting periods, exacerbating such conditions.

Moreover, patients who live in remote areas confront some difficulties and limitations in transportation and its expenses. Patients with severe mobility constraints and people who can suffer from physical strain go to the clinics every session. This might even dissuade them from seeking the essential care they require.

Additionally, through our research, we engaged in a valuable discussion with a physiotherapist (Dr.Noura Alnajim). She pointed out that most of the exercises are repetitive. We believe these

are burdens for the therapists as it's time-consuming to keep repeating the same exercises for every patient and ultimately impacts the treatment journey inefficiently.

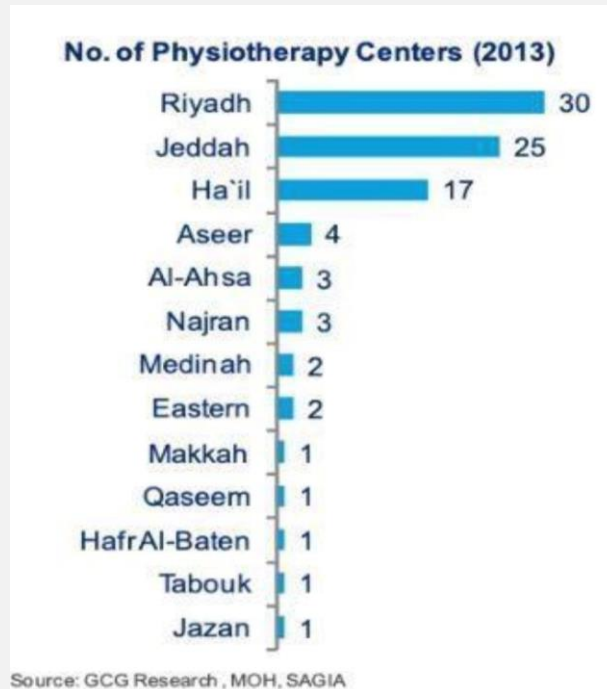


Figure 1 [2] (Number of physiotherapy centers (2013))

1.3 The Main Contribution And Solution

The proposed solution presents an advanced physiotherapy application integrated with a virtual reality (VR) system, offering a cutting-edge and interactive approach to address upper body pain and the need for physical therapy. Illustrated in Figure 2[4] below, this specialized application combines personalized treatment plans, instructional videos, and virtual reality-based exercises, all within a single platform.

The application caters to three key user roles: patients, therapists, and admins. The process begins with admins registering therapists and patients in the system, assigning each patient to a specific therapist. Subsequently, patients undergo assessments by therapists, who then design customized treatment plans for them. Upon logging in, therapists gain the ability to create therapeutic plans for their assigned patients, while patients can access their personalized plans tailored to their specific conditions, such as thoracic outlet syndrome, cervical bulging discs, stiff shoulder, tennis elbow, golfer's elbow, carpal tunnel, shoulder compression syndrome, and recurrent shoulder dislocation [3], as depicted in Figure 3[5] below.

Patients are granted access to instructional videos developed in collaboration with therapists, demonstrating the correct execution of prescribed exercises. These videos provide guidance on proper form and technique and are replayed multiple times to ensure patient comprehension. Once patients have learned the exercises from the instructional videos, they can skip ahead and actively engage in virtual reality-based practices resembling video games. This interactive approach ensures engaging therapy sessions, allowing patients to apply what they have learned and perform the exercises within a virtual reality environment. During these exercises, patients are presented with specific targets to hit or interact with, ensuring proper practice, and contributing to their overall score.

The application incorporates a scoring system that records exercise completion, tracking and measuring patient performance. This scoring data is securely stored in the application's database, enabling patients to monitor their progress over time. Additionally, this data provides valuable insights to therapists, enabling them to evaluate the effectiveness of the treatment.

Physiotherapists have login access to the application, empowering them to monitor patient progress, review exercise performance, and make necessary adjustments to treatment plans based on the collected data. Exercise data will also be collected by the developers in collaboration with the physiotherapist mentor, Dr. Noura Al Najim.

Furthermore, an administrative role is assigned to manage various administrative tasks within the system. These tasks include registering patients and therapists, assigning each patient to a suitable therapist, and overseeing account management. During the registration process, the system gathers relevant data about patients and therapists. Additionally, exercise videos are designed with the assistance of Dr. Noura Al Najim.

On a global scale, this solution effectively addresses the issues of accessibility and affordability in physiotherapy. By leveraging virtual reality technology, it enables patients to receive remote therapy regardless of their geographical location. This proves particularly beneficial for underserved areas with limited access to physiotherapy services. Overall, the proposed solution has the potential to revolutionize physiotherapy by providing a novel and effective approach to managing upper body pain. It significantly enhances the lives of individuals locally and globally by offering accessible, engaging, and personalized rehabilitation options.



Figure 2 [4] (targeted area)

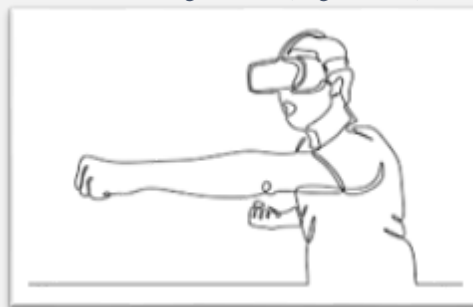


Figure 3 [5] (the use of VR)

The benefits of our application are:

Increased accessibility: Patients can access home therapy sessions, eliminating the need for frequent visits and overcoming transportation limitations.

Personalized Treatment: Physiotherapists can customize exercises to suit each individual's condition, ensuring targeted and effective therapy programs.

Enhanced engagement: VR experiences make therapy sessions interactive and enjoyable, motivating patients to participate actively in rehabilitation.

Progress tracking: Patients can track their progress in real-time, providing a sense of accomplishment and motivation to continue their treatment journey.

Effective monitoring: The app's database allows therapists to easily access and review patient information, allowing for effective monitoring and adjustment of treatment plans.

1.4 Objectives

In the physio mobile application, we are developing for individuals suffering from upper body pain, the focus is on providing valuable assistance and benefits to users. The application aims to address the following objectives:

1. **Personalized Treatment Plans:** Therapists can design customized treatment plans for each patient based on their specific condition and needs.
2. **Therapy Session Notifications:** Patients will receive reminders and notifications through the app to help them stay on track with their therapy sessions.
3. **VR-Integrated Video Games:** The application will offer virtual reality-based exercises and activities that resemble video games, making therapy sessions more engaging and enjoyable.
4. **Scoring System:** A scoring system will be implemented to track and measure patient performance during exercises, providing a quantifiable measure of progress.
5. **Patient Progress Tracking:** Therapists can monitor patient information and track exercise progress through the app, enabling them to evaluate the effectiveness of the treatment plan and make necessary adjustments.

1.5 product vision

Product Vision:

For physical therapists and patients suffering from upper body pain.

Who are seeking a transformative and immersive physical therapy and rehabilitation experience.

The "Physio" application is a Virtual Reality Physical Therapy and Rehabilitation Application.

That provides personalized treatment plans and guided exercises and leverages virtual reality capabilities for enhanced engagement and pain management.

Unlike the "Physical Therapy Pros" application.

Our product offers tailored treatment plans customizable therapy sessions and maximizes recovery through virtual reality technology.

1.6 Scope

Physio is a mobile application that supports the English Language. The Physio application aims to create an immersive virtual reality (VR) system that aids patients suffering from upper body pain in receiving physical therapy in rehabilitation and recovery. The program will assist patients from ages 20 to 55, both male and female, by providing a simulated environment that enables patients to engage in therapeutic exercises and movements through interactive games within a controlled VR environment. The games are specifically designed for physical therapy purposes. These games will leverage VR technology to create an immersive and engaging environment that encourages patients to perform therapeutic exercises and activities, facilitating rehabilitation and recovery. It allows patients to receive a custom treatment plan designed by the patient's therapist. The VR system can track and record the patient's performance data over time based on the patient's game score. It can provide visual representations of progress, such as graphs or charts, showing improvements in therapy goals. Physio will enable therapists to customize exercise programs for each patient by selecting specific game exercises, setting repetitions and durations, and incorporating variations, which ensures that therapy plans align with each patient's goals and progression. The application allows therapists to access patient records and review their progress quickly.

1.7 Brief Description of the Approach

Physio System was developed using the Agile methodology [6], an iterative and flexible software development approach. The team utilized the Dart language and Flutter framework to create an Android mobile application, as well as C# for the VR exercise game.

Firebase was selected as the real-time NoSQL database for efficient user data management. Before the design phase, an extensive requirement elicitation process was undertaken, involving interviews with patients and therapists. This ensured a comprehensive understanding of their needs and informed the identification of essential system features and functionalities.

The development phase was carefully planned, and an incremental Agile approach was adopted. This allowed the team to adapt to challenges and make necessary changes during the development process. Acceptance testing and integration testing were conducted at the end of each sprint to assess team performance and application functionality.

Various tools were employed, including Android Studio IDE for coding, Unity and GitHub for version control, and Jira software for project management. The combination of the Agile approach, robust tools, and technologies resulted in the creation of a responsive, user-friendly, and feature-rich Physio System. Its versatility and adaptability make it suitable for meeting the changing needs of patients and therapists, providing an advanced solution for virtual reality-based physical therapy.

1.8 Report structure

1. Introduction: This section provides an overview of the problem Physio addresses and the domain area it operates in.

2. Background: Here, the report explains the key aspects encountered during the development of Physio.

3. Literature Review: This section conducts a comparative analysis between Physio and its competitors.

4. System Design and Development: This section covers the methodology, system requirements, system design, data design, interface design, and implementation aspects of Physio.

5. System Evaluation: This section includes user acceptance testing, assessment of quality attributes, and a discussion on the evaluation results.

6. Conclusion and Future Work: The report summarizes the software development process, highlights the significance of the developed technology and its impact on the world, discusses encountered challenges, outlines the system's limitations, emphasizes the main contribution of Physio, and suggests avenues for future development.

7. Acknowledgments: This section acknowledges the individuals or organizations that contributed to the development of Physio.

8. References: This section lists the sources cited throughout the report.

9. Appendix: Additional supporting information that enhances the understanding of the report but is not crucial to its comprehension.

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CHAPTER 2: BACKGROUND

2. Background

2.1 Physical Therapy

Medical treatment includes physical therapy. Used to regain functional motions, including standing, walking, and manipulating various body parts. Injuries or illnesses that cause discomfort, dysfunctional movement, or restricted mobility may be successfully treated with physical therapy. For instance, if you enjoy jogging and begin to have knee discomfort [7], a physical therapist may assess your range of motion and create a treatment plan to help you run without pain.

Physical therapists, physiotherapists, or PTs—all terms for the same group of medical professionals— deliver this therapy. For each patient, these professionals provide education, provide personalized therapies, and recommend exercises to increase function, strength, and mobility.

Physical therapy can be both preventive and corrective. Physical therapists can adopt measures to avoid injury, enhance performance, and correct functional movement abnormalities in patients with injuries or medical disorders.

Physical Therapy is Customized. Physical therapists are specialists with education and expertise in successful rehabilitation techniques. They work directly with your referring medical professional and have extensive knowledge about surgical techniques and treatment targets to develop individualized rehabilitation programs. Physical therapists combine their understanding of surgical techniques and rehabilitation with what they learn about your body to provide the highest individualized treatment. They'll look at your movement patterns, habits, and limitations, evaluate how well you're recovering, and devise a plan to help you return to your regular activities.

2.3 Virtual reality (VR)

Advanced virtual reality (VR) technology produces a virtual environment that resembles actual or imagined events. VR applications typically involve wearing a head-mounted display (HMD) that provides a 360-degree view of a virtual world. Users can use controllers or other input devices to interact with the virtual world [8] of VR technology (gaming, education, and healthcare). It offers unique opportunities for simulating real-life scenarios and providing immersive experiences.

2.3.1 Virtual reality in Physical Therapy

Virtual Reality (VR) has developed into a valuable tool in physical therapy. VR-based interventions offer engaging and immersive experiences that complement traditional physical therapy techniques. By creating virtual environments, patients can perform therapeutic exercises see figure 4, practice functional movements, and receive real-time feedback in a safe and controlled setting. One of the critical advantages of VR in physical therapy is that rather than going to the clinic, the patient can continue their exercises at home, reducing the need for frequent visits to the clinic. VR technology allows therapists to remotely track and analyze patient progress, customize treatment programs based on individual needs, and provide virtual supervision and guidance. VR's motivational and distraction aspects make therapy sessions more enjoyable, improving patient adherence to treatment plans.



Figure 4 [9] (Creating virtual environment by VR)

2.4 Sensors in VR-based Physical Therapy

Sensors are crucial in enhancing the VR experience and enabling precise interaction in VR-based physical therapy applications. Various sensors can be integrated into VR systems to capture and track user movements and actions [10].

2.4.1 Motion Tracking Sensors

Motion tracking sensors measure the user's body's real-time orientation, position, and movement. These sensors capture the user's head and upper body motions (see figure 5), allowing them to navigate and interact in the virtual environment. Motion tracking sensors enable the system to provide accurate and responsive feedback, ensuring a seamless and immersive VR experience. Tracking the patient's movements allows the therapist to customize a treatment plan based on the patient's needs. The data captured can inform the design of personalized exercises and interventions tailored to the patient's condition and rehabilitation goals.

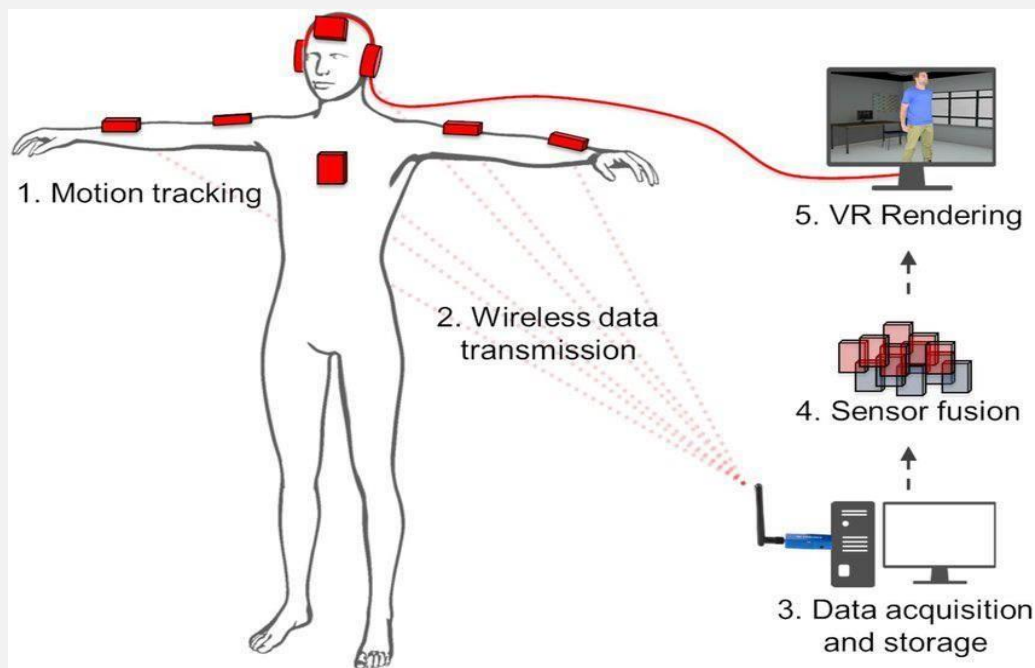


Figure 5[11] (how motion tracking sensors work)

2.5 Scoring System

Scoring systems are widely recognized as valuable tools across various domains, including healthcare, sports, education, and more. They offer a standardized and objective approach to evaluating and quantifying performance, progress, or outcomes. By establishing predefined criteria and metrics [12], scoring systems overcome the limitations of subjective assessments, such as personal biases or variations in interpretation.

In domains like healthcare, sports, and education, scoring systems play a crucial role by providing a framework for assigning scores or ratings based on specific measurements, observations, or evaluations. This enables individuals or organizations to make informed decisions, monitor progress, and compare performance across different individuals or groups.

One of the primary advantages of scoring systems is their ability to introduce objectivity and standardization into the evaluation process. By eliminating personal biases and relying on quantifiable criteria, scoring systems offer a more reliable and consistent assessment method [13]. This enhances the credibility and fairness of the evaluation process as it is based on measurable factors rather than subjective interpretations.

Additionally, scoring systems facilitate easier comparison and benchmarking. Using a common scoring framework makes comparing performance or outcomes across different individuals, teams, or periods feasible. This enables the identification of strengths, weaknesses, and areas for improvement.

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CHAPTER 3:

LITERATURE REVIEW

3 Literature Review

3.1 PhysiApp

PhysiApp is a healthcare technology application that allows physiotherapists to create customized programs for their patients and let patients complete their exercise program smoothly at any place.

Main features for patients:

- Each patient can view and access their customized exercise plan with a video for each exercise even without Wi-Fi.
- Patients receive real-time feedback as well as both patients and physiotherapists can track the progress.
- Patients can communicate with their therapists via video and chat.
- Patients can rate each exercise.
- Patients receive daily/weekly reminders regarding their programs. Each patient needs an access code from their physiotherapist to access the app.

Main features for therapists:

- generate access code for patients
- customize exercise plans for their patients

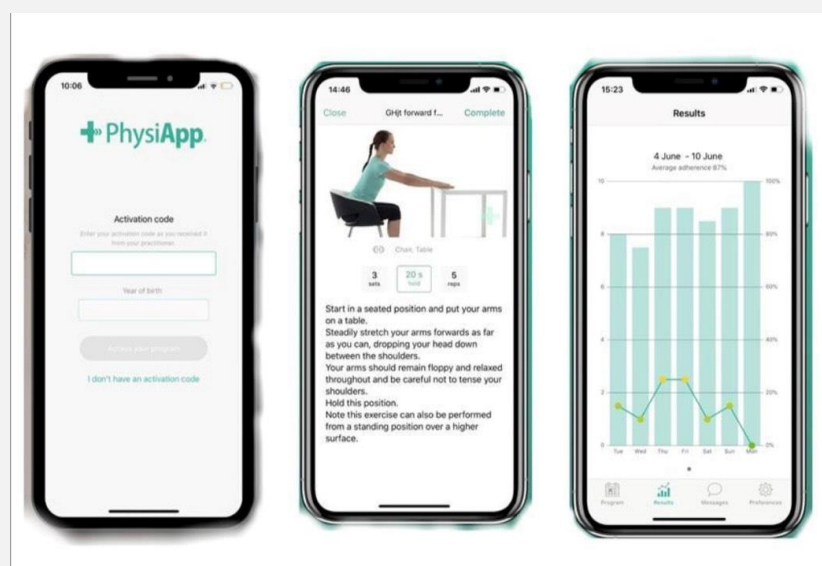


Figure 6[14] (PhysiApp)

3.2 Luna Physical therapy

Luna physical therapy is a healthcare technology app that offers dual applications, one is designed for patients and the other for therapists. Luna app features a wide range of licensed expert therapists withing its platform.

Main features for patients:

- book in-person or at-home appointments.
- rate their therapist.
- view, schedule and manage their appointments.
- access their prescribed exercise plan.
- reminders to stay on track.
- pay online.

Main features for therapists:

- publish their weekly availability for appointments.
- view their total earnings.
- define their personal profile including their specialties and area of coverage
- message their patients.
- prescribe exercise plans to their patients and monitor their progress.
- view their calendar including their upcoming appointments.
- view appointments details and patient's details.

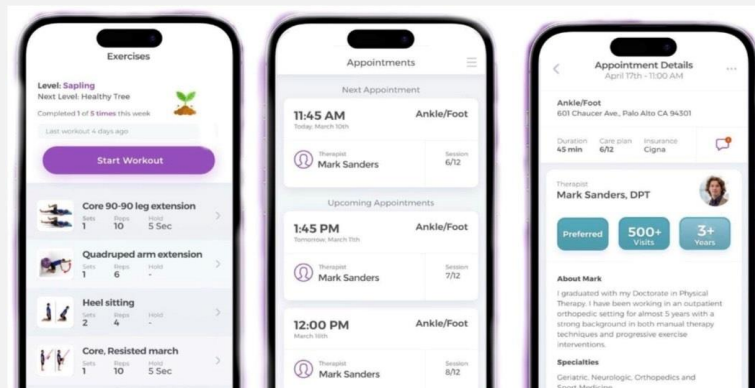


Figure 7[15] (Luna Physical therapy)

3.3 KinesteX

KinesteX is an AI-powered app that powers high quality healthcare in person and at home by providing assessments and exercises plans for Physical therapy and fitness. There is no real therapist nor coach associated with this app, only AI.

Main features:

- Users can view their personalized exercise plan.
- Users receive real-time AI-based motion coaching including posture correction, automated rep counts, motion tracking and real-time graphical/vocal feedback by using the front camera of their device.
- Users can choose between many suggested workouts.

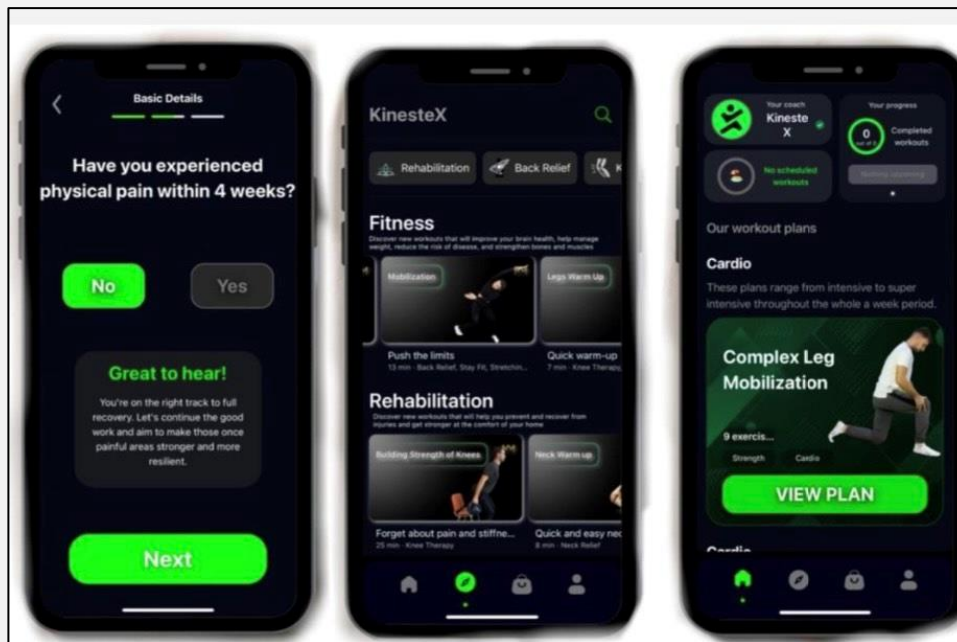


Figure 8 [16] (KinesteX)

3.4 Exer Health

Exer Health is an AI-powered app that revolutionizes the management of musculoskeletal conditions. It offers personalized care, empowering users to track their progress and achieve optimal recovery outcomes. With advanced technologies and a focus on convenience and privacy, Exer Health revolutionizes healthcare experiences.

Main features for patients:

Motion-AI digital health app for assessing range of motion, mobility, and strength.

Measures and tracks progress of musculoskeletal (MSK) conditions, pre- and post-surgery.

Automatically counts reps and offers real-time form correction and coaching during exercises which can be visual or audio.

No need for sensors or extra hardware; uses physical biomarkers on the body by using the phone camera.

Provides accurate measurements remotely, without the need for in-person visits.

Daily pain level reporting via SMS prompts.

Provides insights to care teams for a comprehensive approach to recovery.

contains a library with 200 exercises that the patient can follow.

Main features for therapists:

keep track of the patient's performance from the report.

customize a plan for his patient.

generate access code for patients.

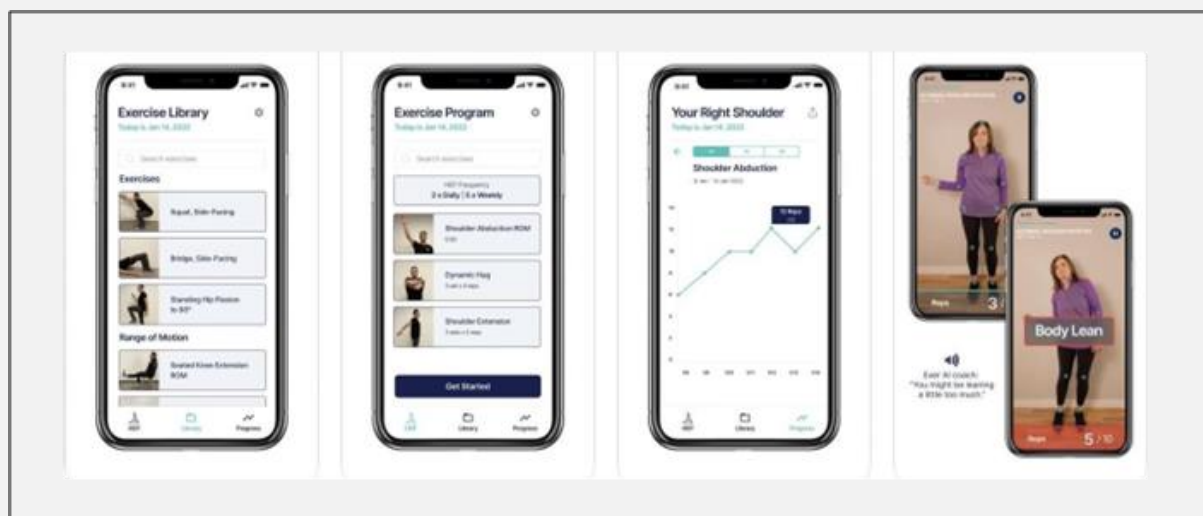


Figure 9 [17] (Exer Health)

3.5 Pappas Physical Therapy now

Pappas Physical & Hand Therapy is a patient-focused app that simplifies your therapy experience. It provides convenient access to personalized care plans and seamless communication with your physical therapist.

Main features:

- Clear and concise instructional videos for correct exercise execution.
- Progress tracking by checking off completed exercises.
- Seamless communication with your physical therapist between visits.
- Access to educational materials for better understanding of your care plan.
- Ability to share your care plan with friends, family, or other care providers.
- Reminders to help you stay on track with your recovery.

- Customizable notification settings to fit your schedule.
- Exclusive access by invitation from your personal physical therapist.
- Main features for therapists:
 - generate access code for patients.
 - message their patient

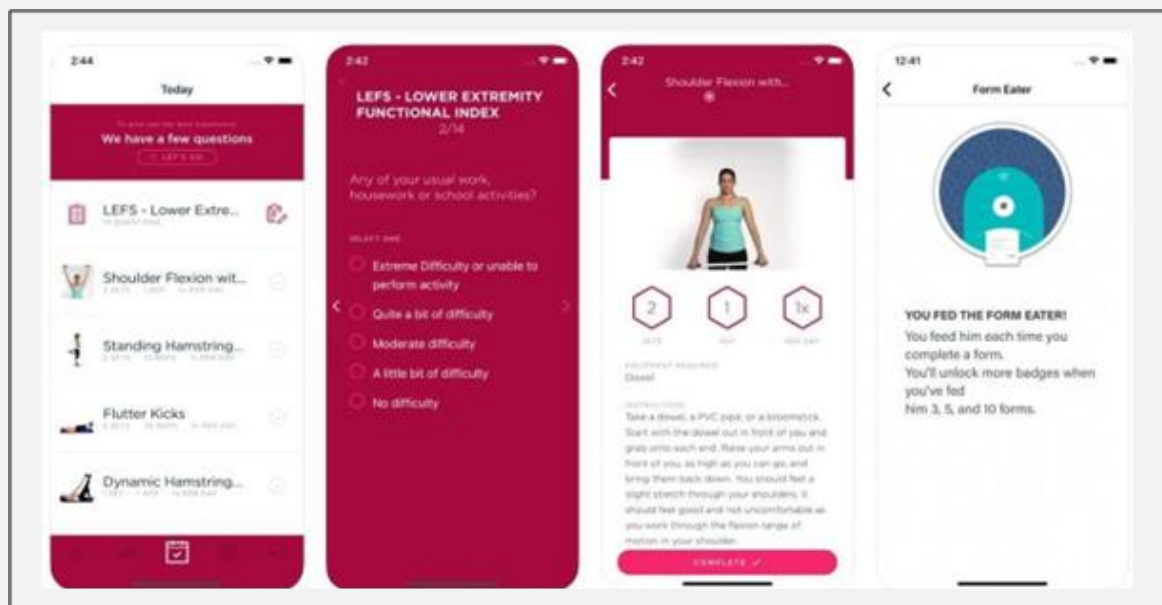


Figure 10 [18] (Pappas Physical & Hand Therapy app)

Table 3.1: COMPETITIVE ANALYSIS

App name/feature	PhysiApp	Luna	KinesetX	Exer Health	Pappa s Physical Therapy Now	Physio (our app)
Live chat with the therapist	Yes	Yes	No	No	Yes	No
Customize d exercise plan	Yes	Yes	Yes	Yes	Yes	Yes
Progress tracking	Yes	Yes	Yes	Yes	Yes	Yes
Supports multiple Languages	Yes	No	No	No	No	No
Reminders for sessions	Yes	No	No	No	Yes	Yes
Enhanced by VR or other special equipment	No	No	No	No	No	Yes
Patients can register through email	No	No	Yes	No	No	No



3.6 Summary

In this section, we've conducted a review and an analysis of similar apps. Physio, our physical therapy app, stands out by utilizing VR technology to simulate a real-life environment. Even though some of our competitors share some similar features to ours, and some of them are even AI-powered, none of them delivers a realistic environment and an enjoyable therapy experience the way Physio does. The integration of VR technology adds significant therapeutic value to the whole journey and provides an enjoyable experience for both the patient and therapist.

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CHAPTER 4:

SYSTEM DESIGN AND

DEVELOPMENT

4 System Design and Development

4.1 Methodology

4.1.1 Agile Approach

Physio was developed using the agile software development process. Agile is a flexible and iterative approach that enables developers to deliver value to users gradually, rather than in a single large launch. These tasks are divided into sprints, each within a specific time frame. Physio was developed over five sprints.

4.1.2 Scrum framework

The Scrum Framework is an agile project management and software development methodology that promotes collaboration and iterative development. It involves a small, cross-functional team working in short iterations to deliver a high-quality product. The framework consists of three key roles: the Product Owner, the Scrum Master, and the Development Team. These roles have specific responsibilities that contribute to the success of the project.

The Product Owner is responsible for creating and prioritizing the product backlog, which is a list of features, improvements, and problem fixes. They represent the stakeholders and ensure that the team delivers value to the client. The Scrum Master facilitates the Scrum process and ensures that the team adheres to Scrum principles and ideals [19]. They support the team in achieving their goals and removing any obstacles. The Development Team is responsible for delivering a potentially shippable product increment at the end of each sprint.

The Scrum Framework also includes five events that provide structure to the team's work. The Sprint Planning meeting is held at the beginning of each sprint to discuss and plan the work that will be completed. The Daily Scrum is a brief daily meeting where the team coordinates their activities, discusses progress, and identifies any obstacles. The Sprint Review meeting is conducted at the end of each sprint [20], where the team presents the completed work to stakeholders and gathers feedback. The Sprint Retrospective is a meeting where the team reflects on the previous sprint and identifies ways to improve their processes. A sprint is a time-boxed period during which the team works on items from the product backlog.

In addition to roles and events, the Scrum Framework involves three objects that help manage the project [21]. The Product Backlog is a prioritized list of all the features, improvements, and problem fixes for the product. The Sprint Backlog is a subset of items from the product backlog that the team commits to completing during the current sprint. The Increment is the sum of all the completed items from the sprint backlog that are potentially shippable.

As a team, we embraced the agile concepts by collaborating, communicating, and being responsive to change. We diligently followed the Scrum Framework, engaging in regular sprint planning, daily scrum, sprint review, and sprint retrospective sessions. Throughout the sprint, we held weekly stand-up meetings to monitor progress, address any challenges, and make necessary adjustments to our plan. At the end of each sprint, we conducted a sprint review meeting to showcase the completed product and gather feedback from stakeholders. To manage our work and ensure value delivery, we utilized the product backlog, sprint backlog, and increment as effective tracking mechanisms. Our Scrum Master played a vital role in supporting the process and ensuring adherence to Scrum principles and ideals. This framework empowered us to work efficiently while consistently delivering a high-quality product within the designated timeline.

Overall, the Scrum Framework and Agile principles foster an adaptive, collaborative, and iterative approach to software development. This approach allows teams to adapt quickly and effectively to changing needs, resulting in successful project outcomes.

4.1.3 Jira and GitHub

During the development process, we used Jira as our project management tool and GitHub for version control and collaborative development.

Jira helped us manage the project by creating and organizing user stories, assigning tasks, tracking progress, and maintaining a backlog of features and requirements. It provided a visual representation of the project's status [22], allowing the team to prioritize and plan our work effectively.

GitHub facilitated collaborative development by providing version control for the source code. It allowed multiple team members to work simultaneously on different features, merge their changes [23], and maintain a clean and up-to-date codebase. GitHub also enabled efficient bug tracking and issue management.

By using Jira and GitHub, we streamlined our development process, ensured effective collaboration, and maintained transparency throughout the project. These tools helped us embrace Agile principles and practices, enabling us to deliver a high-quality physiotherapy application with VR integration.

4.2 System Requirements

4.2.1 System Users

The physio app's users are admin, physical therapists and patients suffering from upper body pain. The general characteristics of Users:

Physical Therapists:

Educational Level: Physical therapists typically own a bachelor's or master's degree in physical therapy, or an area connected to physical therapy. They have received professional training and education in the field of physiotherapy.

Experience: Physical therapists have practical experience providing rehabilitation and therapeutic services to patients. While they may have limited experience with using VR technology specifically, they are well-versed in the principles and techniques of physical therapy.

Technical Expertise: Physical therapists may require training on how to use the VR technology and the specific features of our application.

Patients:

Educational Level: There is no specific educational requirement for patients. Users may have varying academic backgrounds.

Experience: Patients may have varying experience levels with physical therapy and VR technology. Some may be familiar with traditional physical therapy methods, while others may be new to physical therapy and VR.

Technical Expertise: Patients may have diverse technical expertise and familiarity with VR technology. The application should be user-friendly and provide clear instructions to accommodate users with different levels of technical proficiency.

Admin:

Educational Level: The admin owns a bachelor's or master's degree in computer science, or in area connected to computer science. They have received professional training and education in the field of computer science.

Experience: The admin should have experience in system administration, user management, and application maintenance. They are responsible for overseeing the functioning of the application and ensuring its smooth operation.

Technical Expertise: The admin should possess technical expertise in application administration, database management, system configuration, and security. They need to understand the application's functionalities and administration procedures well.

4.2.2 Requirements Elicitation and Analysis

We decided to employ interviews, a questionnaire, and focus groups for requirements elicitation since questionnaires are quick, inexpensive and may help us cover a large portion of the audience (patient and therapist) in a short period of time. In terms of interviews, we will be able to gather more information, and there will be less potential for misinterpretation because confusion may be corrected promptly by asking further questions. This will help us better understand our consumers' knowledge and needs. In addition, we have included focus group sessions as an additional way of eliciting requirements. Focus groups offer a unique opportunity to elicit insights from a diverse collection of participants, allowing for a more in-depth investigation of their points of view.

Interviews [see **Appendix A**]

For the patients:

- Comfort in using technology for healthcare purposes.
- Expectations of pain relief, improved mobility, and enhanced well-being
- Personalized exercise plans are crucial for addressing specific conditions.
- High interest in gamified exercises for motivation and engagement
- Value visual progress charts and precise feedback mechanisms for tracking improvement
- Recommend including visual demonstrations or videos for exercise guidance.
- Suggestions: personalized plans, gamified elements, demonstrations/videos, clear therapy session notifications

For the therapists:

- Positive views on incorporating virtual reality technology into physiotherapy sessions.
- Acknowledge benefits for patients unable to visit the clinic due to distance or disabilities.

- Emphasize customization in exercise plans and treatment protocols for individual patient needs.
- Value access to analytics and insights from exercise data for tracking patient progress
- Belief that integration of application and virtual reality systems improves therapy session efficiency.
- Anticipate enhanced patient engagement and adherence through gamification.
- Suggestions: outcome measures, notification reminders, specifying repetition numbers for exercises

Questionnaires [see **Appendix B**]

information about patient expectations, preferences, and therapist perspectives on incorporating technology in healthcare.

For the patients:

- Age range: 84.4% fell within the age range of 20-55, 9.4% were aged 12-19, and no responses from individuals aged 56 and above.
- Frequency of Smartphone/Tablet Usage: 78.1% reported frequent usage, 15.6% reported occasional usage, and no responses for rare or no usage.
- Openness to Using Technology for Healthcare: 87.5% expressed openness to using technology for healthcare purposes.
- Difficulty in Visiting the Clinic Daily: 96.9% found it challenging to visit the clinic daily for therapy sessions.
- Interest in Interactive Game-Based Exercises: 81.3% expressed interest in participating in therapy exercises presented in interactive games.
- Importance of Personalized Therapy Plan: 87.5% considered it important to have a customized therapy plan tailored to their needs and goals.

For the therapists:

- Years of Experience: 60.5% had 6-10 years of experience, 18.4% had 11 or more years of experience, 15.8% had 1-5 years of experience, and no responses for less than one year.
- Thoughts on Incorporating Game-Like Format: 94.7% believed incorporating a game-like format into exercises could make therapy sessions more engaging.
- Importance of Patient Progress Data: 92.1% considered access to patient progress data and analytics essential.
- Interest in Virtual Reality (VR) Therapy: 84.2% expressed interest in incorporating Virtual Reality (VR) therapy into their practice.
- Impact of VR Therapy on Engagement and Outcomes: 81.6% believed that VR therapy could enhance patient engagement and treatment outcomes compared to traditional approaches.
- Efficiency with App Integration: 86.8% believed that incorporating a physiotherapy application into their workflow would enhance their ability to manage patients more efficiently.
- Customization of Exercise Plans: 97.4% believed that the ability to customize each patient's exercise plan within the physiotherapy application would be helpful.
- Addressing Challenges of Therapy Attendance: 94.7% believed that the physiotherapy app would assist patients in overcoming challenges related to attending every therapy session.

Focused groups:

After gathering the results of the interviews and surveys, we conducted a focus group session to gain further insights into participants' opinions regarding Physio app.

- Participants had a positive outlook on incorporating VR technology into physiotherapy sessions, recognizing its potential benefits for patients who face challenges visiting the clinic due to distance or disabilities.
- Therapists highlighted the significance of tailoring exercise plans and treatment protocols to suit each patient's need.
- Therapists highly valued the ability to access analytics and progress data gathered from exercise sessions, enabling them to monitor and track their patients' progress effectively.
- Therapists believed integrating Physical therapy and virtual reality systems could improve therapy sessions' efficiency, saving patients and therapists' time.
- The application and virtual reality system were expected to improve patient involvement and treatment adherence plans through gamification techniques.
- Therapists suggested additional features, including outcome measures, notification reminders, and specifying repetition numbers for exercises. These suggestions aimed to enhance patient care and treatment outcomes further.

Overall, the feedback from participants and therapists indicated a positive reception towards incorporating VR technology into physiotherapy sessions, with an emphasis on customization, efficiency, patient engagement, and improved treatment outcomes.

4.2.3 User Interactions

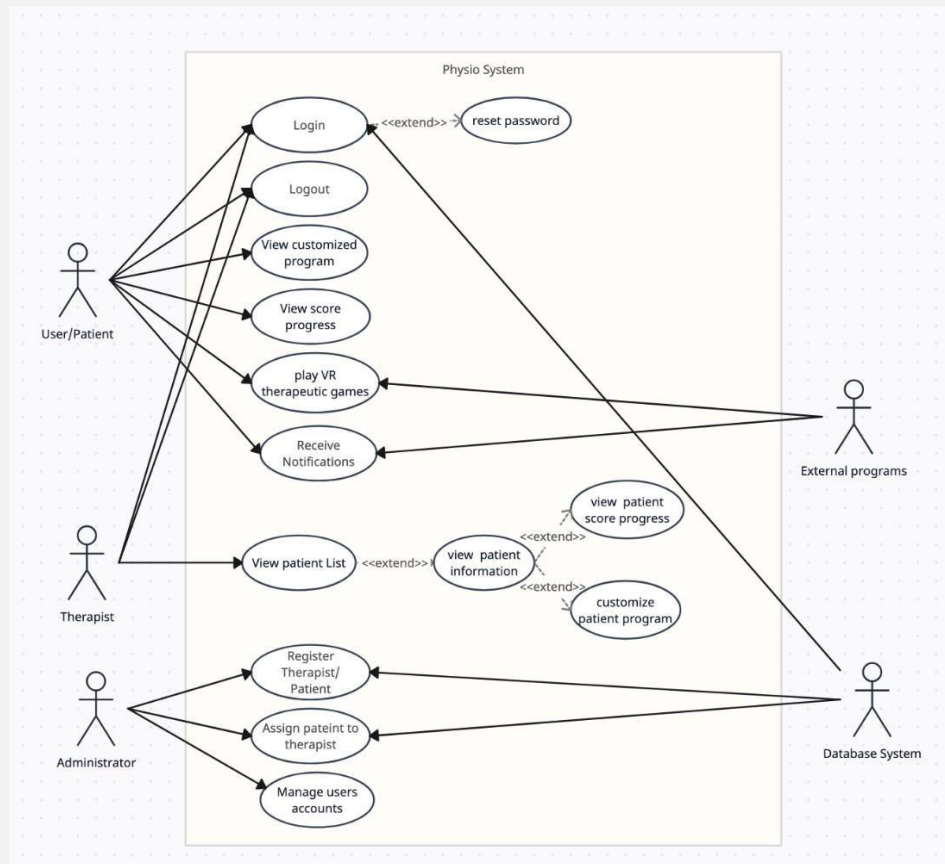


Figure 11(Use Case Diagram)

4.2.4 Roadmap and Product Backlog

• Roadmap

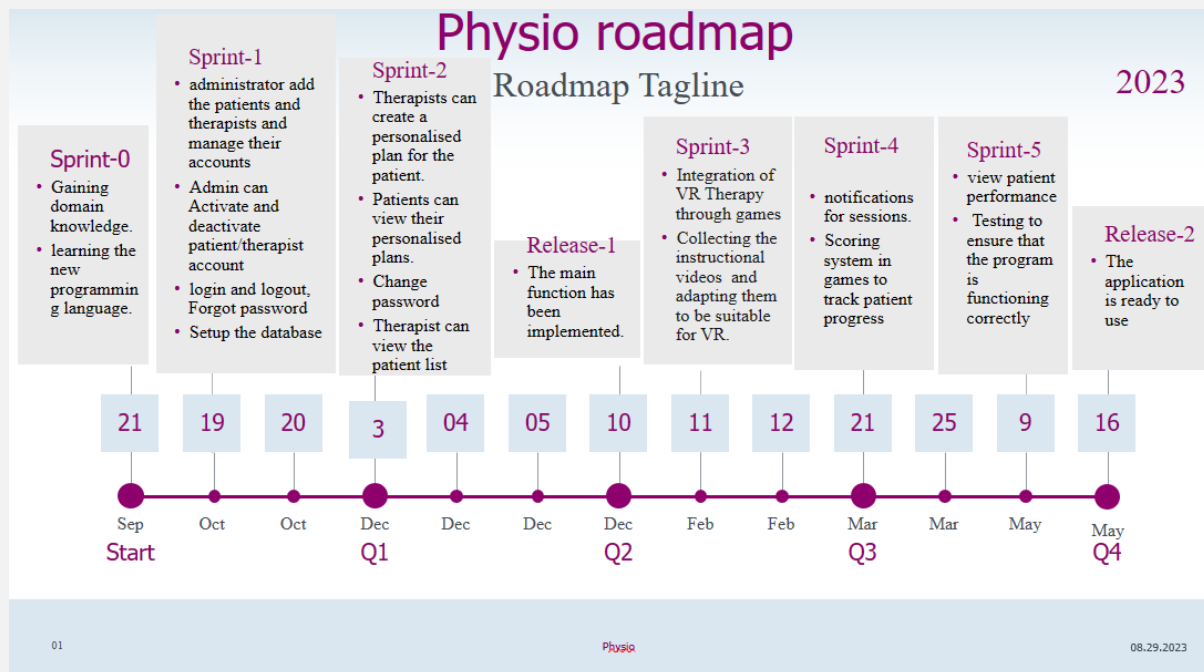


Figure 12(roadmap)

• Product Backlog

TABLE 4.2.4: Product Backlog Table

PBI (user story)	ID	Size (Story points)	Type (Feature, defect, technical work, knowledge acquisition)	Status (To do, in progress, or done)	Acceptance Criteria The conditions of satisfaction that must be met for that item to be accepted.

As an admin, I want to log in into my account so that I can access the application and use my account.	1	2	feature	done	As an admin, if I go to the sign- in page and enter my email and password then I should be logged in into my account in Physio application.
As an admin, I want to be able to reset my password when I forget it so that I can access my account.	2	2	feature	done	directed to a page to enter my email and receive a link through my email to reset my password. As an admin, if I entered an invalid email or unregistered email then an error message should be displayed, and I won't receive the link.
As an admin, I want to add patients so that they can use the app.	3	5	feature	done	As an admin, if I choose to add a patient then I should be able to fill a form and register him/her,

					As an admin, if I click on the profile icon the patient will receive a randomly generated password through their emails to login.
As an admin, I want to add therapists so that they can use the app.	4	5	feature	done	<p>As an admin, if I choose to add a therapist then I should be able to fill in a form and register him/her.</p> <p>As an admin, if I click on the profile icon the therapist will receive a randomly generated password through their emails to login.</p>

As an admin, I want to activate therapists and patients accounts so that they can sign in.	5	5	feature	done	<p>As an admin, if I click on 'therapists' or 'patients' in the navigation bar and flick the button then I should be able to activate a therapist.</p> <p>As an admin, if I add a patient or a therapist that I previously deactivated then a pop-up message will appear informing me that the email belongs to an inactive user and if click on yes then I can re- activate his/her account.</p>
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As an admin, I want to be able to deactivate a patient or a therapist so that I can make sure the process goes well.	6	3	feature	Done	As an admin, if I click on 'therapists' or 'patients' in the navigation bar and click the button then I should be able to deactivate a therapist or a patient from the list and they can't access their account until I reactivate them.
As an admin, I want to be able to update some of the patient's info so that I can make sure the info is accurate in case there are any changes or updates required.	7	2	feature	Done	As an admin, if I click on a specific patient from 'patients' page then I should be able to update some of his/her info and a confirmation message will be displayed.

As an admin, I want to be able to update some of the therapist's info so that I can make sure the info is accurate in case there are any changes or updates required.	8	2	feature	Done	As an admin, if I click on a specific therapist from 'therapists' page then I should be able to update some of his/her info and a confirmation message will be displayed.
As an admin, I want to manage accounts so that I can make sure the app is functioning properly.	9	3	feature	Done	As an admin, if I click on 'Manage' then I should be able to assign therapists to patients.

As a registered patient, I want to log into my account so that I can access the application and use my account.	10	2	feature	Done	<p>As a registered patient, if I go to the sign-in page and enter my email and the password given to me that was generated by the admin then I should be signed into my account in Physio Application.</p> <p>As a registered patient, if I go to the sign-in page and enter an email and a password that doesn't match then an error message should be displayed, and I wouldn't be able to login into my account.</p>
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As a registered therapist, I want to log into my account so that I can access the application and use my account.	11	2	feature	Done	<p>As a registered therapist, if I go to the sign-in page and enter my email and the password given to me that was generated by the admin then I should be signed into my account in Physio Application.</p> <p>As a registered therapist, if I go to the sign-in page and enter an email and a password that doesn't match then an error message should be displayed, and I wouldn't be able to login into my account.</p>
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As a registered patient, I want to be able to reset my password when I forget it so that I can access my account.	12	2	feature	Done	<p>As a registered patient, if I open the login page and click on ‘forgot my password’ then I should be directed to a page to enter my email and receive a link through my email to change my password.</p> <p>As a registered patient if I entered an invalid email or unregistered email then an error message should be displayed, and I won’t receive the link.</p>
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As a registered therapist, I want to be able to reset my password when I Forget it so that I can access my account.	13	2	feature	Done	<p>As a registered therapist, if I open the login page and click on 'forgot my password' then I should be directed to a page to enter my email and receive a link through my email to change my password.</p> <p>As a registered therapist, if I entered an invalid email or unregistered email then an error message should be displayed, and I won't receive the link.</p>
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As a registered patient, I want to be able to log out of my account so that I can make sure no one else access my account after I've finished using it.	14	1	feature	Done	As a logged in patient, if I click on 'log out' button from the drop-down menu that appears when clicking the menu icon on the top of each page then the system should log me out of the application.
As a registered therapist, I want to be able to log out of my account so that I can make sure no one else access my account after I've finished using it.	15	1	feature	Done	As a logged in therapist, if I click on 'log out' button from the drop-down menu that appears when clicking the menu icon on the top of each page then the system should log me out of the application.

As an admin, I want to be able to log out of my account so that I can make sure no one else accesses my account after I've finished using it.	16	1	feature	Done	As an admin, if I click on 'log out' button from the drop- down menu that appears when clicking the menu icon on the top of each page then the system should log me out of the Application.
As a registered patient, I want to be able to change my password so that I can make sure it's more secure.	17	1	feature	Done	<p>As a logged in patient, if I click on the menu icon at the top of the home page and choose 'change password' then I should be redirected to the change password page and fill the fields my old password and my new password.</p> <p>As a logged in patient, if I tried to change my password and entered a password that doesn't match my old password or a password that's less than 6 characters or left a field empty then an error</p>

					<p>message should be displayed.</p> <p>As a logged in patient, if I changed my password successfully then a confirmation message should be displayed.</p>
<p>As a registered therapist, I want to be able to change my password so that I can make sure it's more secure.</p>	18	2	feature	Done	<p>As a logged in therapist, if I click on the menu icon at the top of the home page and choose 'change password' then I should be redirected to the change password page and fill the fields my old password and my new password.</p> <p>As a logged in therapist, if I tried to change my password and entered a password that doesn't match my old password or a password that's less than 6 characters or left a field empty then an error</p>

					<p>message should be displayed.</p> <p>As a logged in therapist, if I changed my password successfully then a confirmation message should be displayed.</p>
As a registered therapist, I want to able to view my patients list so that I can know which patients are assigned to me.	19	2	feature	Done	<p>As a logged in therapist, if I click on 'my patients' in the navigation bar then I should be able to see my patients list.</p>
As a registered therapist, I want to Personalize an exercise plan for each patient so that each one of them can achieve their goal and match their needs.	20	5	feature	Done	<p>As a logged in therapist, if I go to 'my patients' page 'and choose one of the patients from the list then click on customize plan' page then I should be able to choose exercises for the patient.</p>

					<p>As a logged in therapist, If I pick invalid dates such as finish date before start date or left a field empty then an error message should be displayed.</p> <p>As a logged in therapist, If I customized the plan for my patient successfully then a confirmation message should be displayed.</p>
As a registered therapist, I want to update each exercise duration for my patient so that I can make sure he benefits from the exercise to the fullest.	21	3	feature	Done	<p>As a logged in therapist, if I click on a specific patient then I navigated to customize plan page and clicked on a specific exercise then I should be able to update the finish date for that exercise.</p> <p>As a logged in therapist, If I pick invalid dates such as finish date before start date or left a field empty then an error</p>

					<p>message should be displayed.</p> <p>As a logged in therapist, If I updated the exercise successfully then a confirmation message should be displayed.</p>
As a registered patient, I want to be able to view my customized exercise plan so that I can start my therapy journey correctly.	22	2	feature	Done	As a logged in patient, if I go to my 'my plan' page then I should view my own personalized exercise plan.
As a registered patient, I want to be able to use VR so that I can have a guide through my prescribed exercises.	23	13	feature	Done	As a logged in patient, if I put on my VR then I should see instructional videos in interactive VR games for my exercises.
As a registered patient, I want to	24	3	feature	Done	As a patient, If I have logged in into my Physio

receive notifications to remind me of my therapy sessions so that I can keep on track					account, then notification messages to remind me of my sessions should be displayed on my phone
As a registered patient, I want to have a scoring system in the VR integrated video games so that my therapist can track my progress	25	13	feature	Done	As a registered patient, If I use VR and started my session through the game then a score should be displayed on the top.
As a registered patient, I want to be able to view my progress in 'Physio app' so that I can see and track my performance	26	2	feature	Deleted	As a logged in patient, If I click on 'Progress' in Physio app, then I should be able to see my performance.

As a therapist, I want to view my patient's progress so that I can keep track of his/her progress to evaluate him/her periodically.	27	2	feature	Done	As a logged in therapist, If I go to 'my patients' page and I select a specific patient and click on report from the bottom navigator and select the plan, and it's date then I should be able to view his/her performance.
As a user, I want the application to respond quickly within 5 seconds to my interactions, so that I can have seamless and immersive experience.	28		feature	Done	As a patient, if I click to open the progress page, then the page should load within 5 seconds.
As a user, I want the application to have a user-friendly interface with clear instructions, so that it	29		feature	Done	As a user, if I go to any of my pages, then the page should be clear and

becomes easy for me to navigate and understand the therapy exercises.					understandable for me to navigate through it.
As a user, I want my password to be stored securely in the database, so that no one can access my account.	30		feature	Done	As a therapist, if I receive a password during registration, then it will be securely stored in database, and if I changed my password the new password isn't showing in the database. As a patient, if I receive a password during registration, then it will be securely stored in database, and if I changed my password the new password

					isn't showing in the database.
As a patient, I want my personal medical data to be secure and protected within the application, so that no one can access it other than my therapist.	31		feature	Done	As a patient, If I play therapeutic games, Then I would like my progress to be stored securely in the database so no one can access it other than my therapist.
As a user, I want the application to be available 97% of the time when I try to access it, so that I don't get discouraged during my treatment process.	32		feature	Done	As a user, If I desire to access the application, then I will be able to access it 97% of the time.

As an admin, I want the application to be scalable, capable of accommodating a growing number of patients and therapists, so that it doesn't compromise performance or user experience.	33		feature	Done	As an Admin, If I registered accounts of multiple patients and therapists working at the same time, then the application's performance shouldn't change.
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After reconsideration, User Story 26 has been deleted. We believe it's sufficient for patients to view their scores immediately after playing in VR. However, a detailed report in the app is only necessary for the therapist's assessment; it's not necessary for the patient to view it, as the score alone is sufficient

4.3 System Design

4.3.1 Architectural Diagram

The proposed system design for our physio application is layered architecture see Figure 13, which allows for clear separation of concerns and facilitates modularity and scalability. The architecture consists of three main tiers: the Presentation Tier, the Application Tier, and the Data Tier [24]. Each tier handles specific responsibilities and interacts with other tiers to provide the desired functionality.

The Presentation Tier serves as the system's user interface, providing interfaces such as the Admin Interface, Physiotherapist Interface, and Patient Interface. These interfaces allow users

to perform specific actions based on their roles within the system, such as administrative, physiotherapist, and patient actions.

The Application Tier is responsible for processing and handling the system's business logic. It consists of the Controller and Model components. The Controller component is an intermediary between the Presentation Tier and the Model component. It receives requests from the interfaces in the Presentation Tier and directs them to the appropriate members for processing. The Model component represents the core logic of the system and interacts with the VR device for VR interactions. It also accesses the Database and to retrieve and update user and exercise data.

The Data Tier serves as the storage and retrieval layer for persistent data. It includes the Users and Exercises, which store user and exercise-related data. The Model component interacts with these databases to access and modify the required data for the system's functionalities.

The system architecture follows the principle of separation of concerns, where each tier has distinct responsibilities and interacts with other tiers through defined interfaces. This architectural design promotes modularity, reusability, and maintainability. Additionally, the layered approach allows for easier scalability and future enhancements by adding or modifying components within a specific tier without affecting the other tiers.

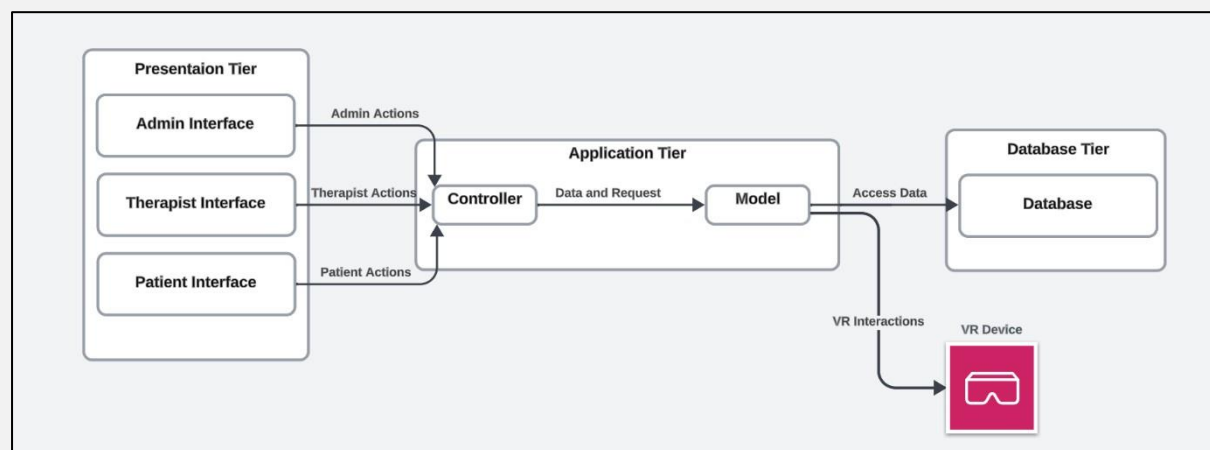


Figure 13(layered architecture for physio app)

4.3.2 Class Diagram /DFD

The main Figure 14 illustrates the relationships and dependencies among the main classes in the UML representation of the physio app within this context. Each class defines variables and methods that contribute to the app's functionality.

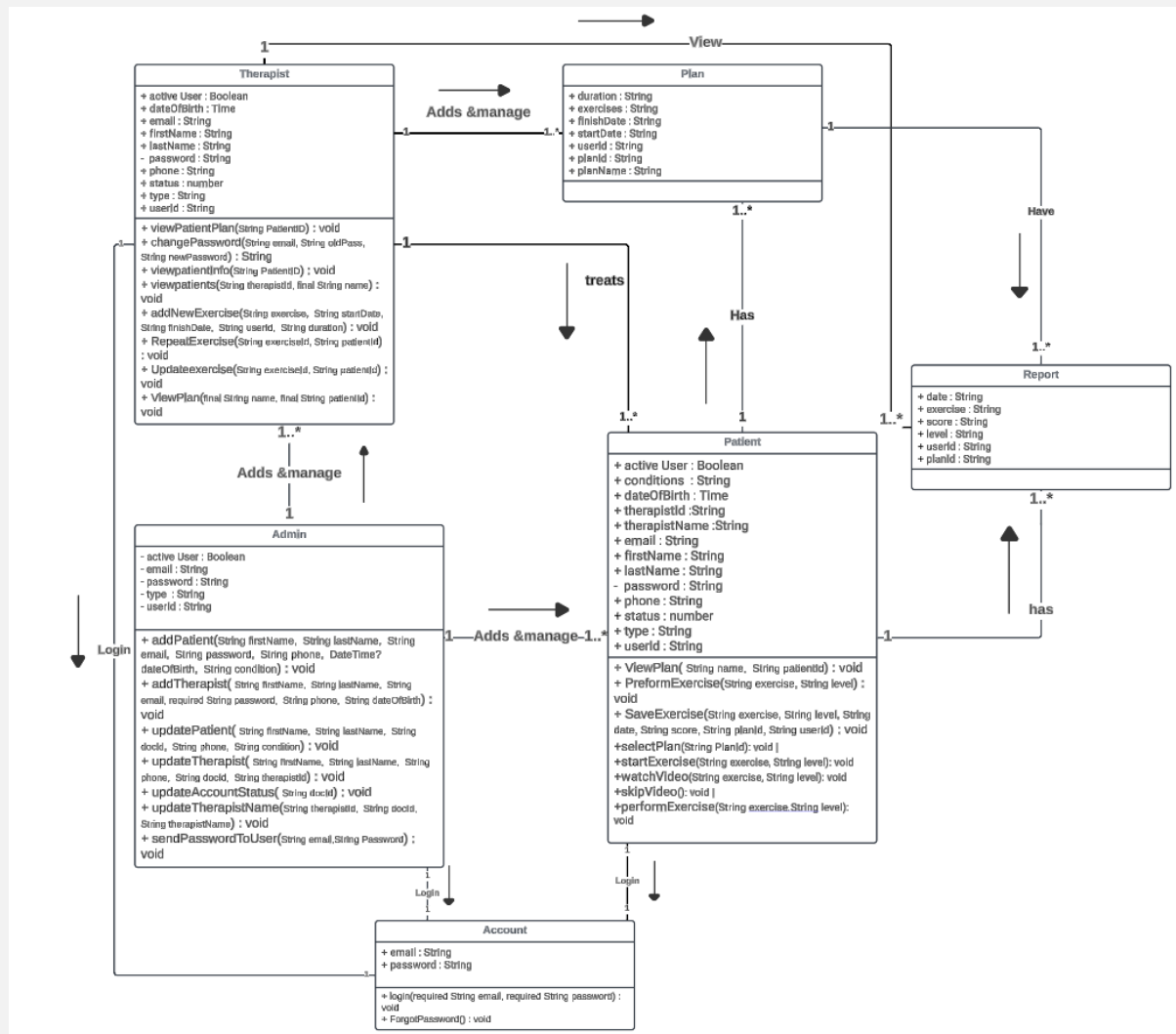


Figure 14(class diagram)

4.3.3 Component Level Design

This section will illustrate the design of three components of Physio app such as manage accounts, change password, and personalized plan.

- **Manage Account**

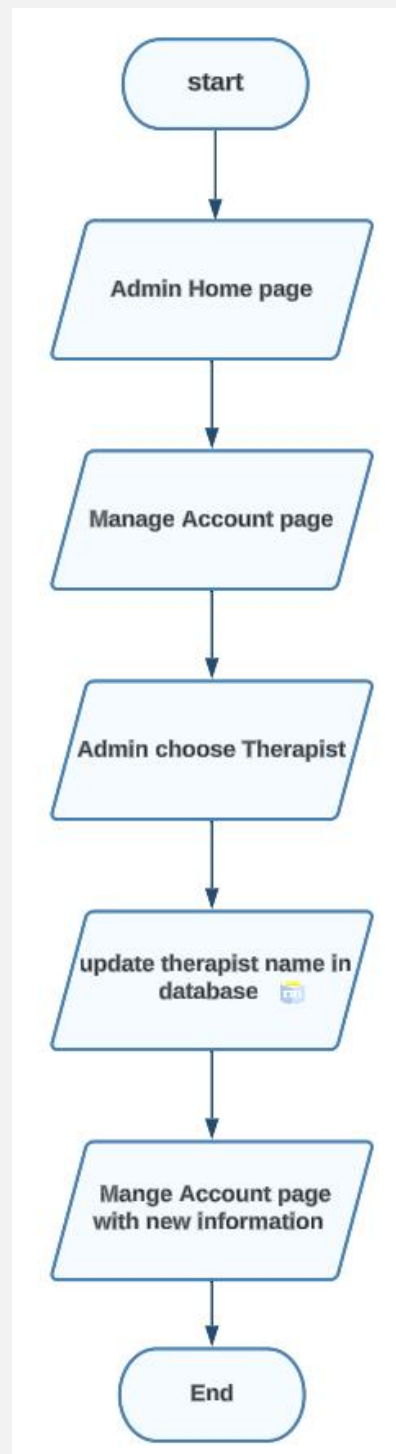


Figure 15(Manage account(user story:9) flowchart)

- **Change Password**

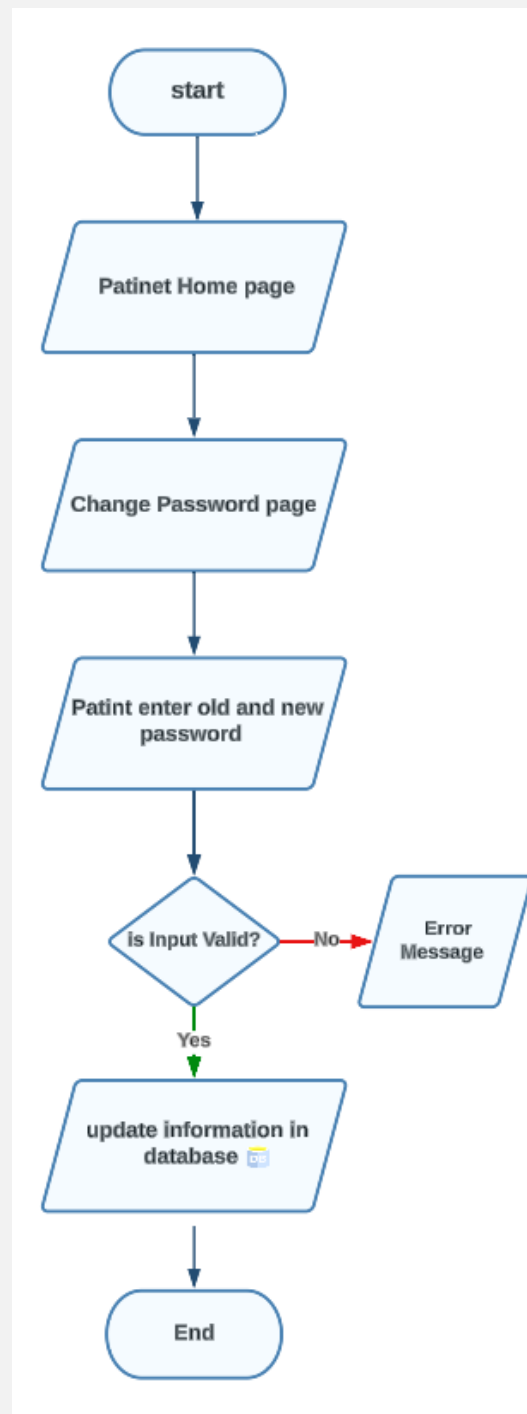


Figure 16(change password (user story:17) flowchart)

- **Personalized Plan**

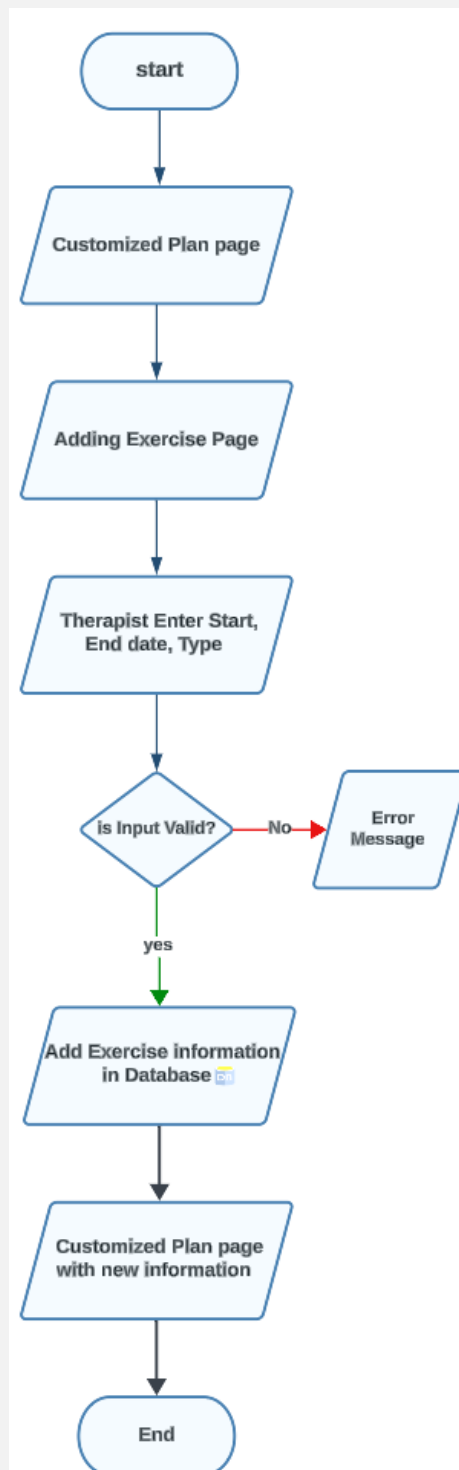


Figure 17 (personalized exercise(user story:20) flowchart)

- Preforming VR Exercise

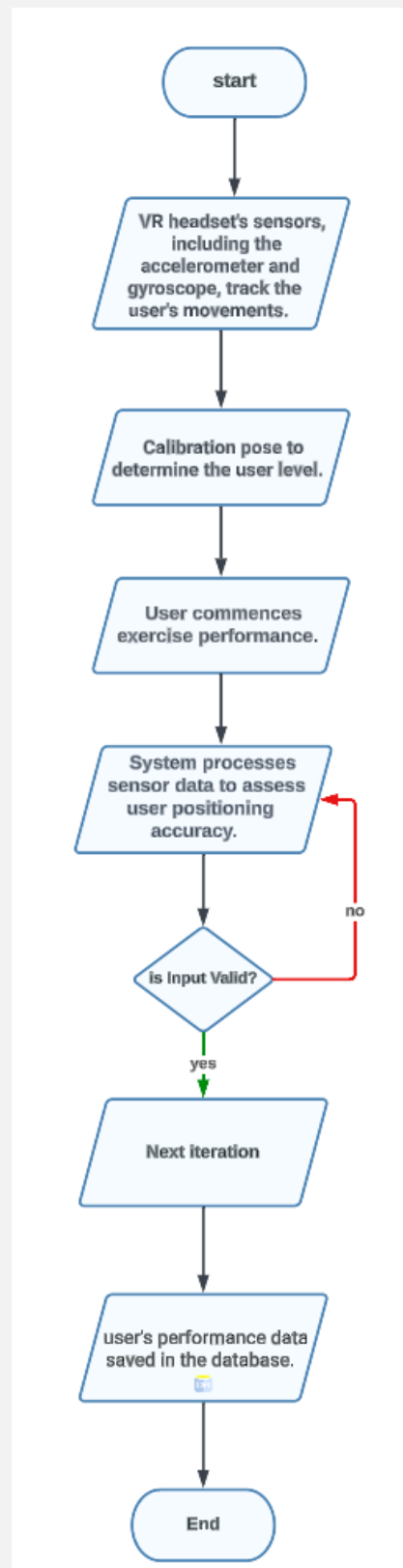


Figure 18(Preforming VR Exercise (user story:25) flowchart)

- **Therapist View Patient Progress**

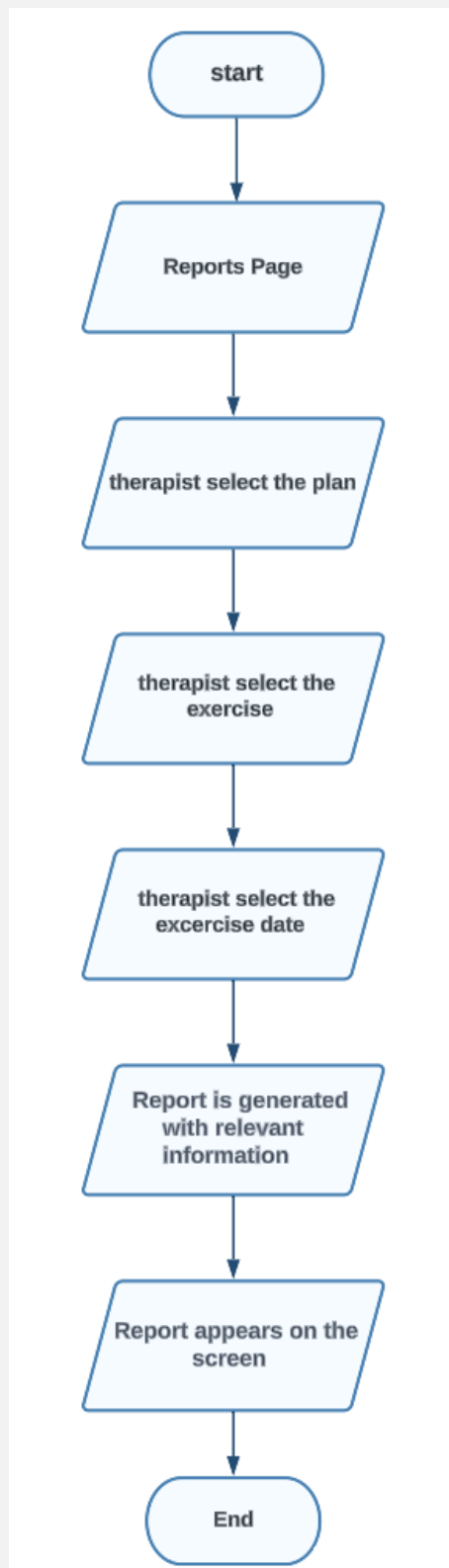


Figure 19(Therapist View Patient Progress (user story:27) flowchart)

4.4 Data Design

4.4.1 Data Models

Since we're using a NoSQL Database, specifically Firebase, we will describe our current database's structure through an Entity-Relationship (ER) diagram and the framework of a non-relational data model.

ER diagram:

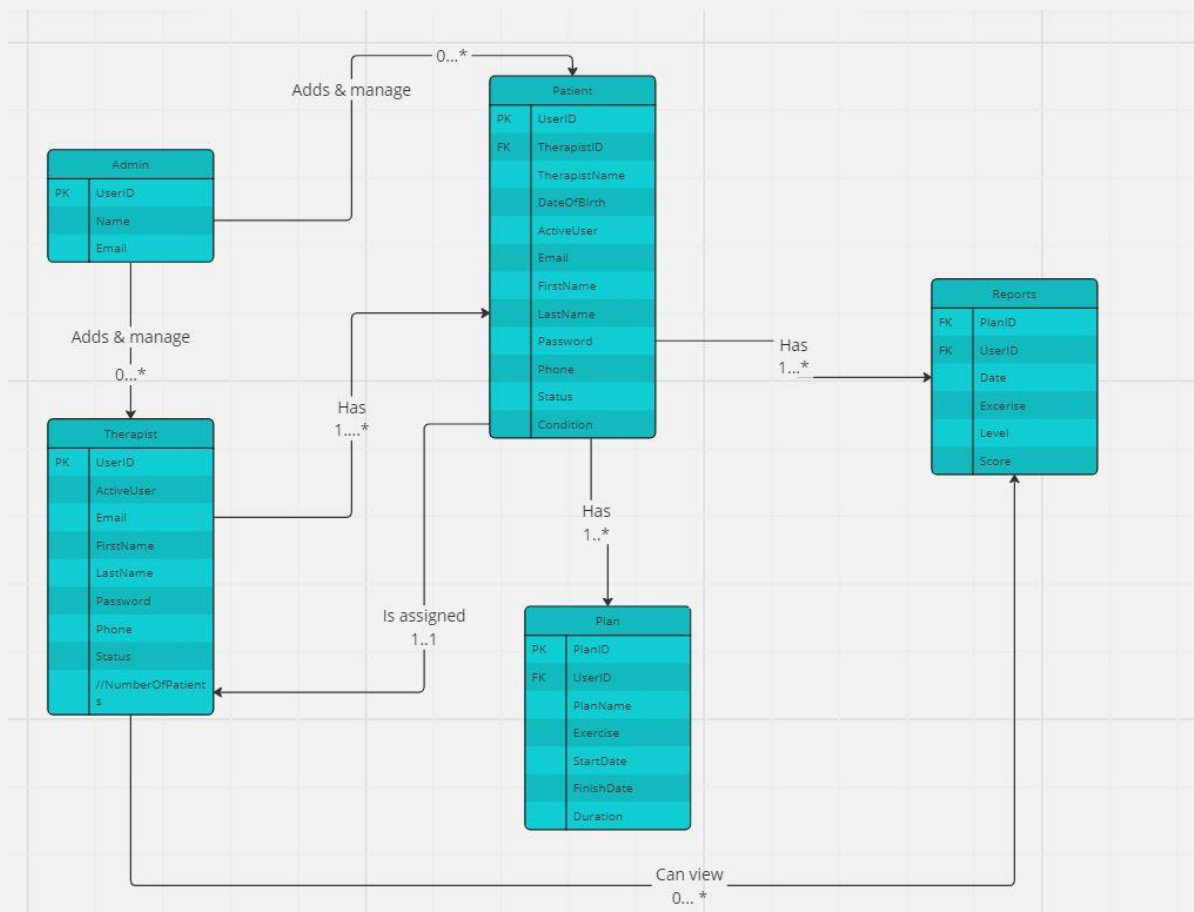


Figure 20 (ER diagram)

Non-relational data model:

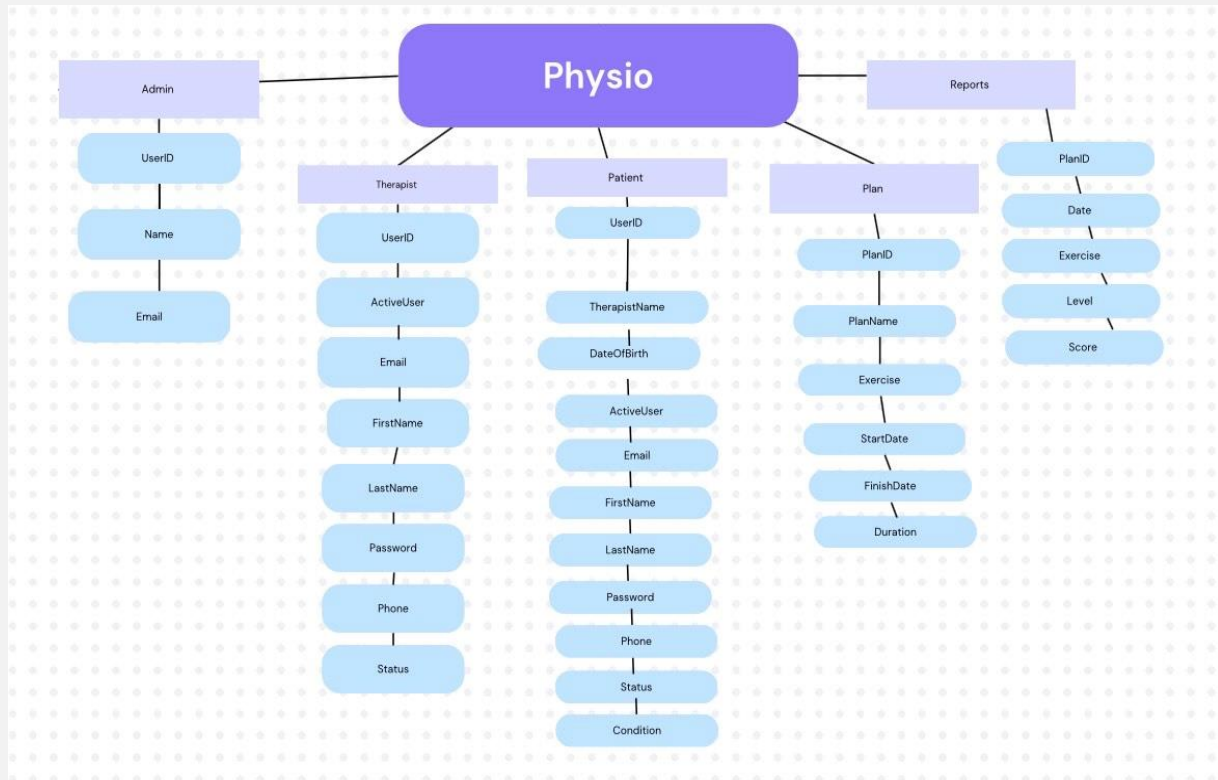


Figure 21 (non-relational data model)

4.4.2 Data Collection and Preparation

Physio didn't require any external data sources during our releases, our general physical therapy knowledge was gathered from discussions and help with our domain expert Dr. Noura AL Najim. We needed to create a database for the user information, which the admin will be gathering manually, as well as a database for the patient plan, which includes the exercises the patient will have to do which therapist will provide for each patient manually, as well as a database for the user's reports, which includes the patient's scores and progress. The databases were made with the following attributes in Table 4.4.2 (A), Table 4.4.2 (B), and Table 4.4.2 (C).

TABLE 4.4.2(A): Attributes for user dataset

Attribute Name	Characteristics	Data type	Possible Values
User_ID	The number of the user's ID	String	Randomly generated ID
User Type	Type of user	String	Admin - Therapist - Patient
First Name	User's first name	String	Doesn't accept integers
Last Name	User's last name	String	Doesn't accept integers
Email	Users email address	String	Should include @
Additional therapist and patient attributes			
Phone	Users phone number	String	10 digits starting with 05
Date of birth	Users date of birth	Date	Doesn't accept future dates
ActiveUser	User account has been activated and password has been sent to user	Boolean	True-false
Additional patient attributes			
Therapist Name	Patient's current assigned therapist	String	Available therapists
Therapist ID	Assigned Therapist's ID	String	Filled by system automatically

Condition	Patient's current physical therapy disorder	String	Thoracic outlet syndrome/ Cervical disc bulge/ Frozen shoulder/ Tennis elbow/ Golfer's elbow/ Carpel tunnel/ Shoulder impingement syndrome/ Shoulder recurrent dislocation
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TABLE 4.4.2(B): Attributes for Plan dataset

Attribute Name	Characteristics	Data type	Possible Values
PlanID	ID of the patient's plan.	String	Randomly generated ID
PlanName	Name of the patient's plan.	String	Accepts characters and integers
User_ID	ID of the user assigned to a plan.	String	Available users
Exercise	Name of exercise in plan assigned to user.	String	Shoulder front raise level 1/ Shoulder front raise level 2 / Shoulder side raise level 1 / Shoulder side raise level 2 / External shoulder rotation level 1 / External shoulder rotation level 2
Start Date	Exercise assigned begging date.	Date	Doesn't accept past date

Finished Date	Exercise assigned end date.	Date	Doesn't accept past date
Duration	Duration in days an exercise has been assigned to a user.	Integer	Filled by system automatically

TABLE 4.4.2(C): Attributes for Reports dataset

Attribute Name	Characteristics	Data type	Possible Values
User_ID	ID of the patient assigned to exercise.	String	Available users
Exercise	Name of exercise in plan assigned to patient.	String	Shoulder front raise level 1 / Shoulder front raise level 2 / Shoulder side raise level 1 / Shoulder side raise level 2 / External shoulder rotation level 1 / External shoulder rotation level 2
Level	Level of exercise assigned to patient	Integer	Accepts integers only
Date	Exercise assigned date.	Date	Filled by system automatically
Score	Score patient achieved after finishing exercise	Integer	Filled by system automatically

4.5 Interface Design

The Physio mobile application is built following these 5 guidelines [25], as they significantly contribute to designing a user-friendly application and enhancing its usability.

Consistency: An effective interface design must be consistent. Physio keeps visual elements, layout, and interaction patterns consistent so users can easily navigate the program. By maintaining consistency, the interface becomes professional and comfortable.

Internal locus of control: Physio gives users control over the system, as it prioritizes user control. For example, if a user accidentally clicks the delete button, the application prompts them to confirm the action, ensuring they want to proceed. Encouraging continued application use makes users less worried about making irreversible mistakes.

Error handling: Physio provides simple, constructive, and specific instructions to assist users. For instance, if a therapist enters a start date before the end date during the creation of an exercise, the text field is highlighted in red, accompanied by a clear message indicating that the start date cannot be earlier than the end date.

Simple action reversal: Physio embraces the concept of easy action reversal, allowing users to undo their steps. By allowing users to fix mistakes, this approach reduces anxiety and encourages the exploration of unfamiliar options. For instance, if an admin mistakenly enters incorrect patient/therapist information, they can easily edit and update the details to rectify errors.

Providing feedback: Physio ensures that users receive immediate feedback, providing reassurance that their actions are registered and the system is functioning correctly. Visual feedback is employed to indicate the successful completion of activities or to highlight errors that require correction. Whether adding or updating information, the application displays messages to communicate the completion of a process or to notify the user of any encountered errors.

By incorporating these guidelines, the Physio mobile application aims to deliver an optimal user experience, fostering user satisfaction and engagement.

4.5.1 Site map

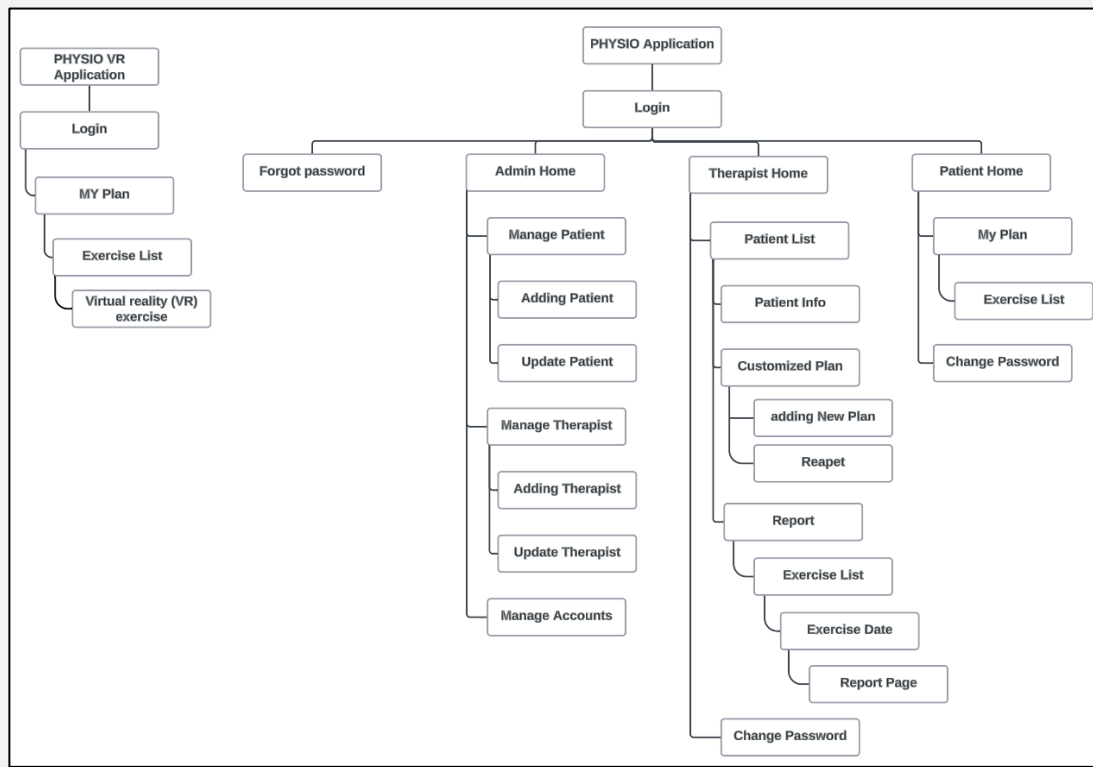


Figure 22(Physio Site map)

4.5.3 Interface wireframes

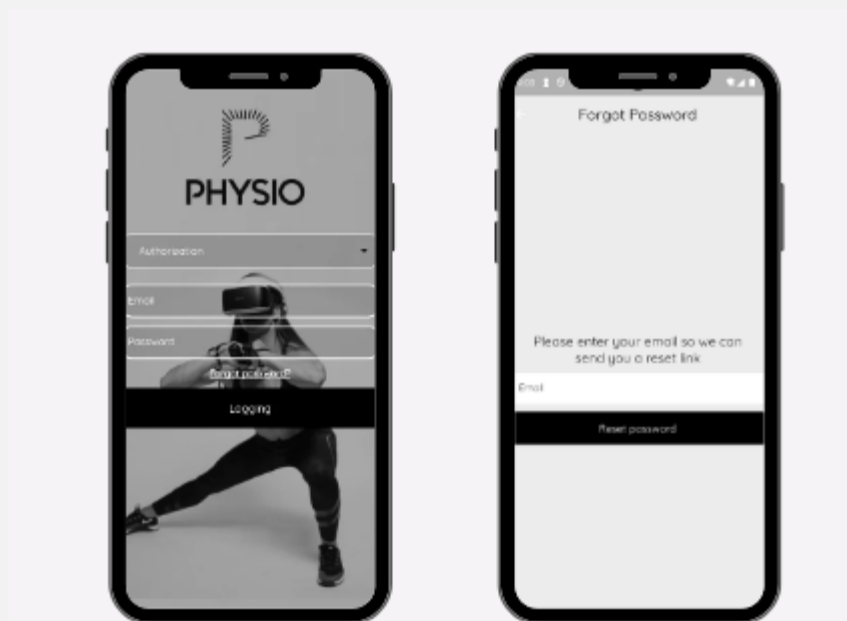


Figure 23 (log in wireframe)

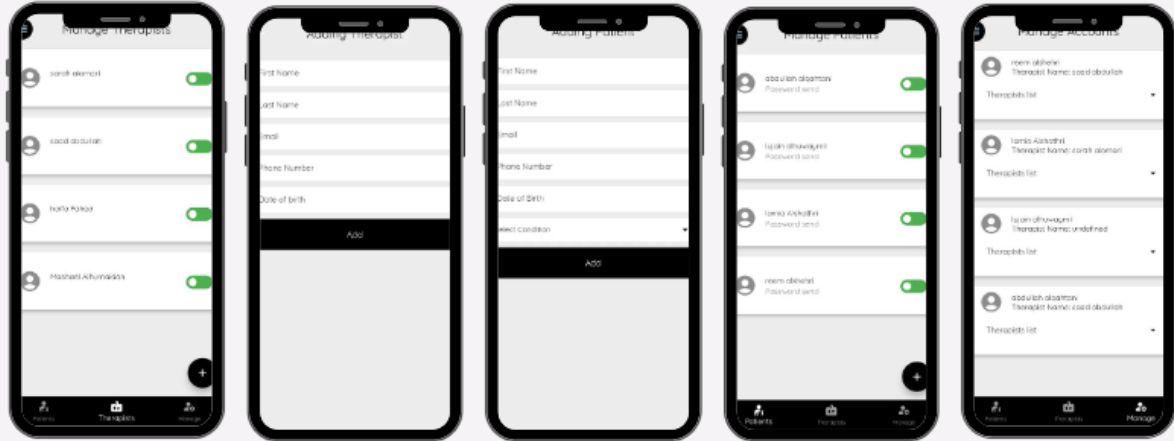


Figure 24(Admin wireframe)

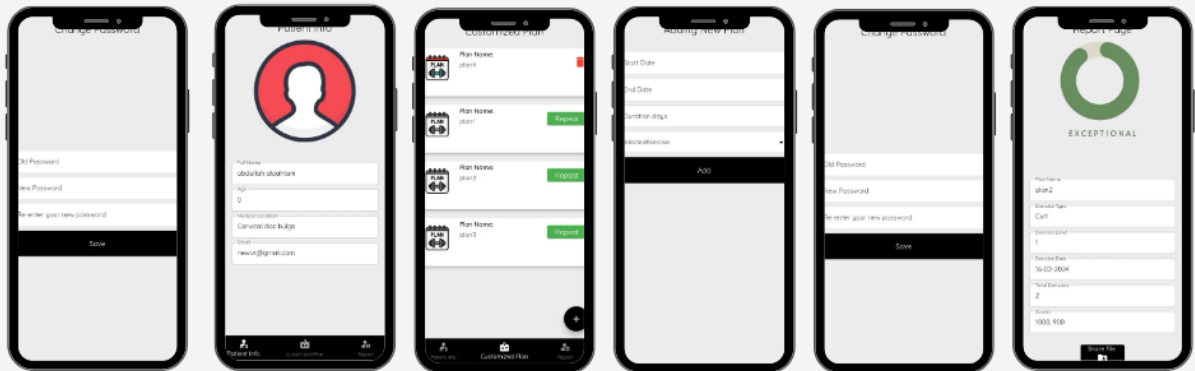


Figure 25(Therapist wireframe)

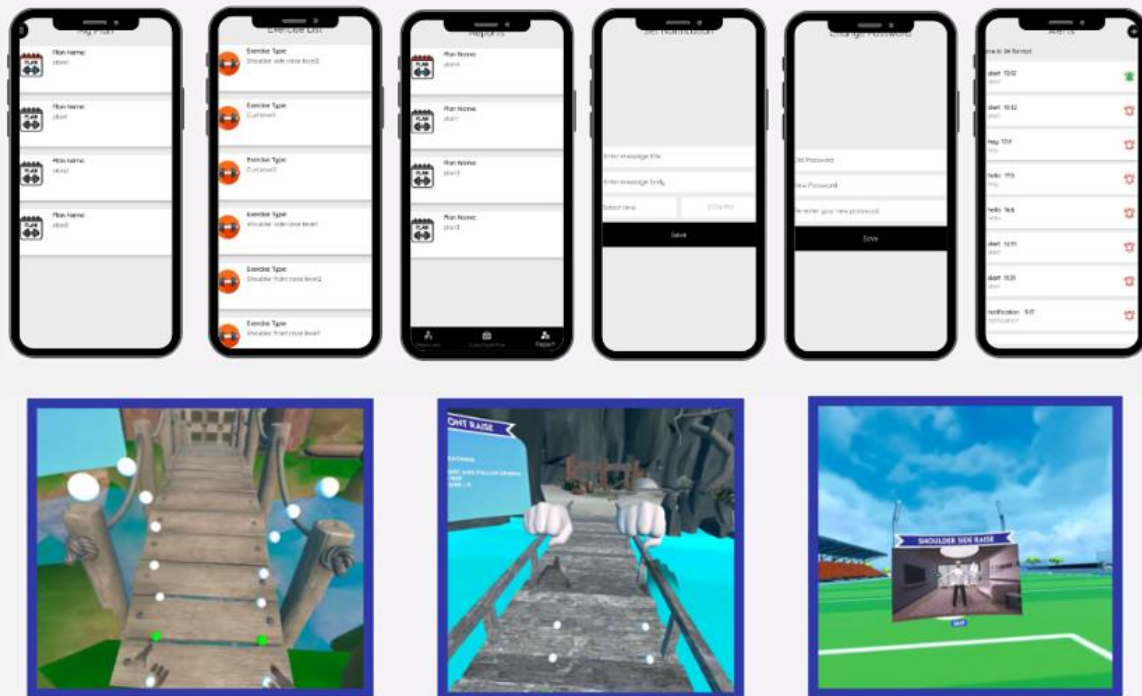


Figure 26 (patient wireframe)

4.6 System implementation

4.6.1 Connecting to Firebase

In this section, we will discuss how Physio connects to Firebase. First, we downloaded Android studio and added Flutter and Dart as plugins.

1-Go to Firebase website and create an account and invite all the team members so they can all have access

2- Navigate to firebase console and click on “Add project”

3- Name the project “Physio” and then click on Create project

4- Select the “Android” platform

5- Type the package name of the application

6- Click on “register app” and follow the setup instructions to download the configuration files

7- Open the flutter project and add the Firebase SDK dependencies to your pubspec.yaml file
firebase_core: ^2.17.0

firebase_auth: ^4.10.1

8- in the terminal, run “flutter pub get” to install all dependencies.

9- import the related packages to your code “import 'package:firebase_core/firebase_core.dart';”

10- initialize Firebase in your application in the main page or the main function as shown in the figure below.

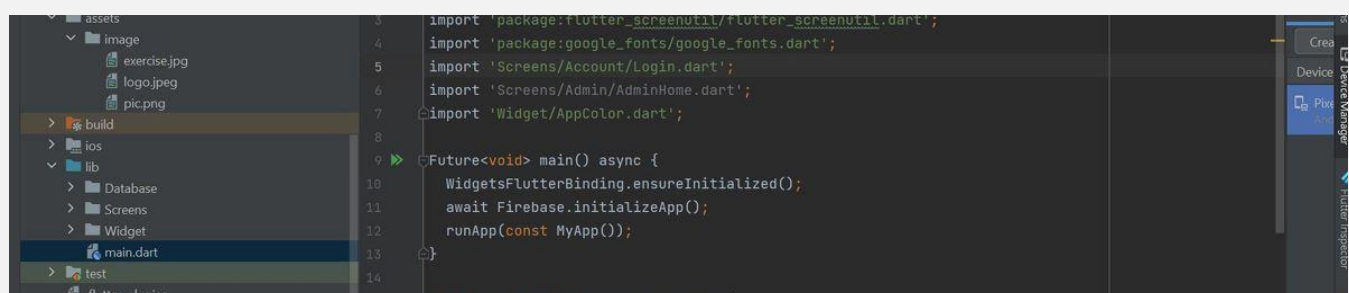


Figure 27 (Connecting to firebase)

11- Run the application

4.6.2 API Integration and related systems

1-Firebase Setup: First, we set up Firebase for our Unity project by creating a Firebase project in the Firebase Console as explained previously. Then, we configured project settings and integrated Firebase SDKs into our Unity project.

2- API Key and Authentication: After setting up Firebase, we got an API key from the Firebase Console to authenticate our Unity project with Firebase services. Depending on what Firebase services we used, we set up additional authentication like OAuth providers or anonymous authentication.

3-Firebase SDK Integration: We brought Firebase SDKs into our Unity project by either importing them through the Unity Package Manager or downloading SDK files from the Firebase website.

4-Accessing Firebase Services: Once Firebase SDKs were integrated, we accessed Firebase services within our Unity scripts using Firebase APIs. For example, to work with the Realtime Database, we used the `FirebaseDatabase.DefaultInstance` object for reading or writing data.

5. Sending Requests to Firebase API: We interacted with Firebase services from our Unity project using appropriate Firebase SDK methods to send requests to the Firebase API. For example, to read data from the Realtime Database, we used methods like `GetValueAsync` or `SetValueAsync`. For example, when a user completes an exercise session in the VR component, the application sends data to Firebase to track the user's progress and performance.

6. Handling Responses: After sending a request, we handled responses asynchronously in our Unity scripts. We attached event listeners to manage data retrieval or error events since we are working with the Realtime Database. When a user completes an exercise session in the VR, the application receives the score data from Firebase. This score is then processed and displayed in the VR for the patient to view, providing real-time feedback. Simultaneously, the application updates the therapist's interface with the same score data, allowing them to track the patient's progress and performance over time.

7- Error Handling and Debugging: We made sure to implement strong error handling in our Unity scripts to deal with situations where requests to the Firebase API failed or encountered

errors. We used Unity's debugging tools and Firebase SDK logging to troubleshoot and debug issues effectively.

8- Testing and Deployment: We thoroughly tested our Unity project to ensure smooth interaction with the Firebase API and VR components. Once testing was complete, we deployed our Unity project, allowing it to connect to the Firebase API in a live environment.

4.6.3 Challenges

In this section, we will discuss the challenging parts of our code that require extensive research of various references for implementation. Initially, our system allowed the deletion of the therapist and patients entirely from both the application and the database. However, we decided to change the function to deactivating instead of deleting entirely. This change was made upon reconsideration, as we recognized the potential need for historical medical data of patients and information about therapists in the future if they needed to use the app again. So instead of deleting them entirely, we can deactivate their accounts and reactivate it again.

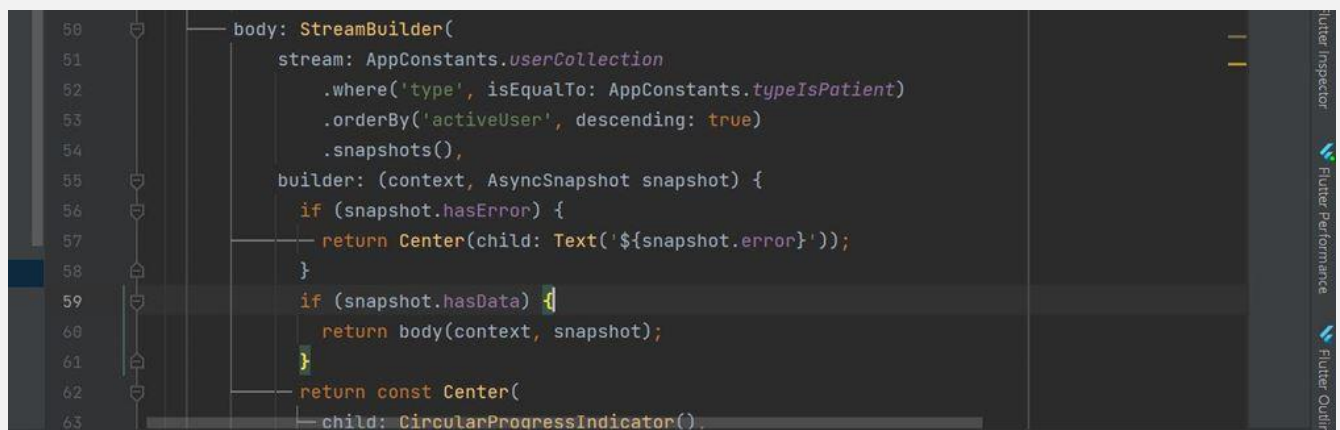


Figure 28 (Connecting to firebase)

As shown in the figure above, we encountered some challenges to make the function work as intended. At the beginning, the users were still entirely deleted from the database even though they still appear in the list. We tried many approaches to code it until it worked correctly. After that, we faced another problem, we wanted the deactivated users to still be visible in the list but with a gray color and a gray flicked button. This process involved retrieving data from the database as we have a Boolean flag that indicates the user's status. Then it should take the retrieved data and order it in a descending order so that the deactivated users can appear in a

different color below the active users. The retrieving process wasn't handled correctly so the deactivated users still appeared with a green flicked button. Despite searching through multiple references, a comprehensive solution to the problem proved elusive. To address this, we combined techniques we had learned with the suggested solutions we found online until we achieved the intended outcome.

Moreover, a significant challenge in our project was ensuring that the application catered to the needs of end-users who may be injured, elderly, or in need of therapy. This required thoughtful consideration of user interface elements, such as font size, color contrast, and navigational simplicity, to ensure accessibility and ease of use for individuals with varying physical abilities.

Another challenge we encountered was seamlessly integrating the database to ensure that data was consistently saved in the correct format. This involved meticulous planning of database schema, validation mechanisms, and error handling procedures to maintain data integrity and reliability across different user interactions.

Link to GitHub: <https://github.com/physioProject/2023-GP1-18.git>

The background features several abstract geometric shapes. In the top left is a light teal circle. In the top right are three overlapping rounded shapes in dark blue and light teal. In the bottom left are three overlapping rounded shapes in dark blue, medium teal, and light teal. In the bottom right is a small dark blue circle.

CHAPTER 5:

SYSTEM evaluation

5 System Evaluation

This section will cover user acceptance testing, a stage of software development when the program is evaluated by its target user base in real-world settings.

5.1 Experimental Results

Experiment 1: VR Exercise Game Performance

TABLE 5.2(A): Experiment 1

Experiment No	Responsiveness (1-10)	Loading time (seconds)	User Satisfaction
1	9	3	9
2	8	4	8
3	9	2	10

In this experiment, the performance of the VR Exercise Game in Physio 5.2(A) it was evaluated based on responsiveness, loading time, and user satisfaction. Participants were asked to rate the app's responsiveness on a scale of 1 to 10, with higher scores indicating better performance. The loading time of the app was also measured in seconds. The results showed that the VR Exercise Game was highly responsive, with quick loading times, leading to high user satisfaction.

Experiment 2: Accuracy VR Exercise Game evaluation

TABLE 5.2(B): Experiment 2

Experiment No	Exercise Tracking Accuracy (%)	Reputation Accuracy Count
1	98%	97%
2	99%	98%
3	97%	99%

In this experiment, the accuracy of the VR Exercise Game in Physio 5.2(B) in tracking exercises and counting repetitions was evaluated. Participants performed a set of exercises while the app tracked their movements and counted repetitions. The accuracy of exercise tracking and repetition count was measured as a percentage. The results indicated high accuracy levels in both exercise tracking and repetition counting, with an average accuracy of 98%.

Overall, the experimental results demonstrate that the VR Exercise Game 5.2 in Physio performs well in terms of responsiveness, loading time, exercise tracking accuracy, and repetition count accuracy. The app provides a seamless user experience, accurately tracks exercises, and ensures reliable performance, leading to high user satisfaction and better outcomes in physical therapy.

5.2 User Acceptance Testing

The last phase of the software testing process and lifecycle is called User Acceptance Testing (UAT), often referred to as End User Testing. The purpose of UAT is to give the end user the ability to verify and review the requirements and determine whether the application satisfies them and may be authorized.

We formed a testing team of twenty end users (patients, therapists, and admins) for our UAT. They varied in age between the 12 and 55 years old, had medium/high level technical skills, and had medium/high level in English.

We tested the physio application with all types of users separately to get an evaluation of the app's functionality, usability, and overall user experience. Then tested physio's VR game with the patients specifically to get a better understanding of the core functionalities, user interface (UI), user experience (UX), performance, and compatibility of our game.

In order to ensure that we get feedback from physio users, we additionally conducted a questionnaire. The questionnaire asks a variety of questions about the application as a way to get feedback from users on the user interface, interaction, usability, and system as a whole.

5.2.1 Demographics of Participants

The test involved 60 participants, including 20 patients, 20 therapists, and 20 administrators, who were asked to evaluate the application. Following the testing, participants were given a questionnaire consisting of 10 questions, which assessed the ease of use and smoothness of the application. Table 7.1.1 presents the demographic information of the users who took part in the application testing.

TABLE 5.2.1(A): Demographics of patient participants

Variable	Value	N=20	Percentage
Age	12-19	0	0%
	20-55	18	90%
	56 and above	2	10%
Gender	Female	13	65%
	Male	7	35%
Level of English language	Beginner	0	0%
	Intermediate	6	30%
	Advanced	14	70%
Level of Technology skills	Beginner	0	0
	Intermediate	6	30%
	Advanced	14	70%

TABLE 5.2.1(B): Demographics of therapist participants

Variable	Value	N=20	Percentage
Age	12-19	0	0%
	20-55	18	90%
	56 and above	2	10%
Gender	Female	11	55%
	Male	9	45%
Level of English language	Beginner	0	0%

Level of Technology skills	Intermediate	3	15%
	Advanced	17	85%
	Beginner	0	0
	Intermediate	3	15%
	Advanced	17	85%

TABLE 5.2.1(C): Demographics of admin participants

Variable	Value	N=20	Percentage
Age	12-19	0	0%
	20-55	19	95%
	56 and above	1	5%
Gender	Femal	4	20%
	Male	16	80%
Level of English language	Beginner	0	0%
	Intermediate	5	25%
	Advanced	15	75%
Level of Technology skills	Beginner	0	0
	Intermediate	5	25%
	Advanced	15	75%

5.2.2 Questionnaire/Interview Results

Following the test, we administered an electronic questionnaire via Google Forms comprising 10 questions to collect user feedback on the system. On average, it took approximately 4 minutes for all users to complete the questionnaire.

Table 5.2.2 provides a visual representation of the distributed results, while **Appendix C** offers a more detailed overview of the questionnaire results.

TABLE 5.2.2 (A): System testing questionnaire for patients.

Question Number	Question	Response
1	Is the application's design and color scheme visually appealing and comfortable for the eyes?	100% Yes 0% No
2	Do the icons used in the application appear clear and facilitate ease of use?	100% Yes 0% Undecided 0% No
3	Was the navigation through the application seamless?	100% Yes 0% No
4	Did you encounter any technical issues or bugs while using the application?	0% Yes 100% No
5	All the functions in this app worked as expected?	100% Yes 0% No
6	Were the confirmation prompts helpful in guiding your actions?	100% Yes 0% No

7	Did you have to learn many things before you could start using the application effectively?	0% Yes 20% Somewhat 80% No
8	How likely are you to continue using the app in the future?	95% Likely 5% Undecided 0% Unlikely
9	Has the notification proven effective in serving as a reminder for your exercises?	100% Yes 0% No
10	Did you enjoy engaging in exercise using virtual reality (VR)?	100% Yes 0% No

TABLE 5.2.2(B): System testing questionnaire for therapist.

Question Number	Question	Response
1	Is the application's design and color scheme visually appealing and comfortable for the eyes?	100% Yes 0% No
2	Do the icons used in the application appear clear and facilitate ease of use?	100% Yes 0% Undecided 0% No
3	Was the navigation through the application seamless?	100% Yes 0% No

4	Did you encounter any technical issues or bugs while using the application?	0% Yes 100% No
5	All the functions in this app worked as expected?	100% Yes 0% No
6	Were the confirmation prompts helpful in guiding your actions?	100% Yes 0% No
7	Did you have to learn many things before you could start using the application effectively?	5% Yes 10% Somewhat 85% No
8	How likely are you to continue using the app in the future?	95% Likely 5% Undecided 0% Unlikely
9	Was the exercise report detailing the patient's performance found to be beneficial?	100% Yes 0% No
10	Was it effortless to assign exercise plans to the patients?	100% Yes 0% No

TABLE 5.2.2 (C): System testing questionnaire for admin.

Question Number	Question	Response
1	Is the application's design and color scheme visually appealing and comfortable for the eyes?	100% Yes 0% No
2	Do the icons used in the application appear clear and facilitate ease of use?	100% Yes 0% Undecided 0% No
3	Was the navigation through the application seamless?	100% Yes 0% No
4	Did you encounter any technical issues or bugs while using the application?	0% Yes 100% No
5	All the functions in this app worked as expected?	100% Yes 0% No
6	Were the confirmation prompts helpful in guiding your actions?	100% Yes 0% No
7	Did you have to learn many things before you could start using the application effectively?	0% Yes 5% Somewhat 95% No

8	How likely are you to continue using the app in the future?	100% Likely 0% Undecided 0% Unlikely
9	Was the aim of the application clear?	100% Yes 0% No
10	Would you recommend the application to other users?	100% Yes 0% No

Results for patients:

- The application's design and color scheme were visually appealing and comfortable for the eyes, according to all respondents.
- All respondents found the icons used in the application to be clear and facilitate ease of use.
- All respondents reported that the navigation through the application was seamless.
- None of the respondents encountered any technical issues or bugs while using the application.
- All functions in the app worked as expected, according to all respondents.
- All respondents found the confirmation prompts helpful in guiding their actions.
- None of the respondents felt the need to learn many things before effectively using the application. A small percentage (20%) had some level of uncertainty, while the majority (80%) had no such requirement.
- Most respondents (95%) expressed a likelihood of continuing to use the app in the future, while a smaller percentage (5%) remained undecided.

- All respondents found the notification was effective in serving as a reminder for the exercises.
- All respondents enjoyed engaging in exercise using virtual reality (VR)

Results for therapists:

- The application's design and color scheme received positive feedback from all therapists, being visually appealing and comfortable for the eyes.
- All the therapists found the icons used in the application to be clear and user-friendly.
- Therapists reported a seamless navigation experience throughout the application, without encountering any issues.
- No technical issues or bugs were reported by the therapists while using the application.
- All functions within the app worked as intended, according to the therapists.
- The confirmation prompts were found to be helpful in guiding the therapists' actions.
- Some therapists felt the need to learn certain aspects before effectively using the application, while others did not require extensive learning.
- The majority of therapists expressed a likelihood of continuing to use the app in the future, while a smaller portion remained undecided.
- The exercise report detailing the patient's performance was regarded as beneficial by all therapists.
- Every therapist found it easy to assign exercise plans to the patients.

Results for admin:

- The admins appreciated the visually appealing design and eye-friendly color scheme of the application.
- All admins agreed that the icons employed in the application were easily understandable and contributed to a user-friendly experience.
- The admins reported smooth and effortless navigation throughout the application.
- None of the admins encountered any technical glitches or bugs while using the application.
- All the functions within the app performed flawlessly, meeting the admins' expectations.
- The admins found the confirmation prompts to be helpful in guiding their actions effectively.
- Admins did not face any significant learning curve to proficiently use the application.
- All the admins expressed a strong inclination to continue using the app in the future.
- All admins thought the aim of the application is clear.
- All the admins will recommend the application to others.

Lastly, this questionnaire enables us to gain a comprehensive understanding of the diverse opinions shared by users. This valuable insight helps us implement the most suitable application that fulfills their needs. Furthermore, the application successfully meets its requirements and offers user-friendly features, enhancing their overall experience.

5.3 Quality Attributes (NFR testing)

TABLE 5.3: Quality Attributes (NFR testing).

User Story	Quality Attribute	Measure	Results
As a user, I want to learn how to use the main functionalities of	Learnability: How fast is it for users to understand	The user should be able to learn how to	We tested on 60 users we measured the Usability by how many completed the main tasks. We

the system within 10 minutes, so that it is easy for me to navigate and understand the therapy exercises.	the main actions once they see the interface?	operate major system functionalities within 10 minutes.	<p>tested 3 main features: adding a new patient, creating a therapy plan, and viewing patient plan.</p> <p>20 out of 20 admins complete adding a new patient successfully. $20/20=1$</p> <p>18 out of 20 therapists complete creating a therapy plan successfully. $218/20=0.9$</p> <p>20 out of 20 patients complete the viewing plan successfully $20/20=1$</p>
As a user, I want the application to respond quickly within 5 seconds to my interactions, so that I can have seamless and immersive experience.	<p>Performance:</p> <p>How quickly and predictably does the system respond to user input or other events?</p>	The application's response time should range between 1 to 5 seconds.	For each user we measure the performance of the system using a timer tool. From the result, we found that the maximum response time of each task was 5 sec, and the minimum was 500 milliseconds.
As a user, I want the application to be available 24 hours a day, so that I don't get discouraged during my treatment process.	<p>Availability:</p> <p>Is it available when and where I need to use it?</p>	The application should be available for users 98% of the time.	<ul style="list-style-type: none"> Our application depends on Firebase which is available 99.95% of the time , Which lead us to the fact that the availability of the application is going to be $> 98\%$.
As a user, I want my account to be secured, so that my data can be protected from unauthorized access.	<p>Security:</p> <p>Is it secure from unauthorized access?</p>	The application should not allow any successful logins by unauthorized users.	We tried 20 tries for unauthorized access login. The system did not allow any unauthorized access

5.4 Discussion

This section aims to discuss the results of user feedback and the questionnaire, highlighting how the application will improve based on the gathered insights. According to users, the application effectively solves the problem of being able to perform physical therapy sessions without regular clinic visits. User feedback suggests that "the interface of the application is clear and consistent.

During testing, administrators provided valuable feedback, stating that "it's better to keep the patients that are inactive rather than just removing them from the patients list." We carefully considered this feedback and implemented it into our application.

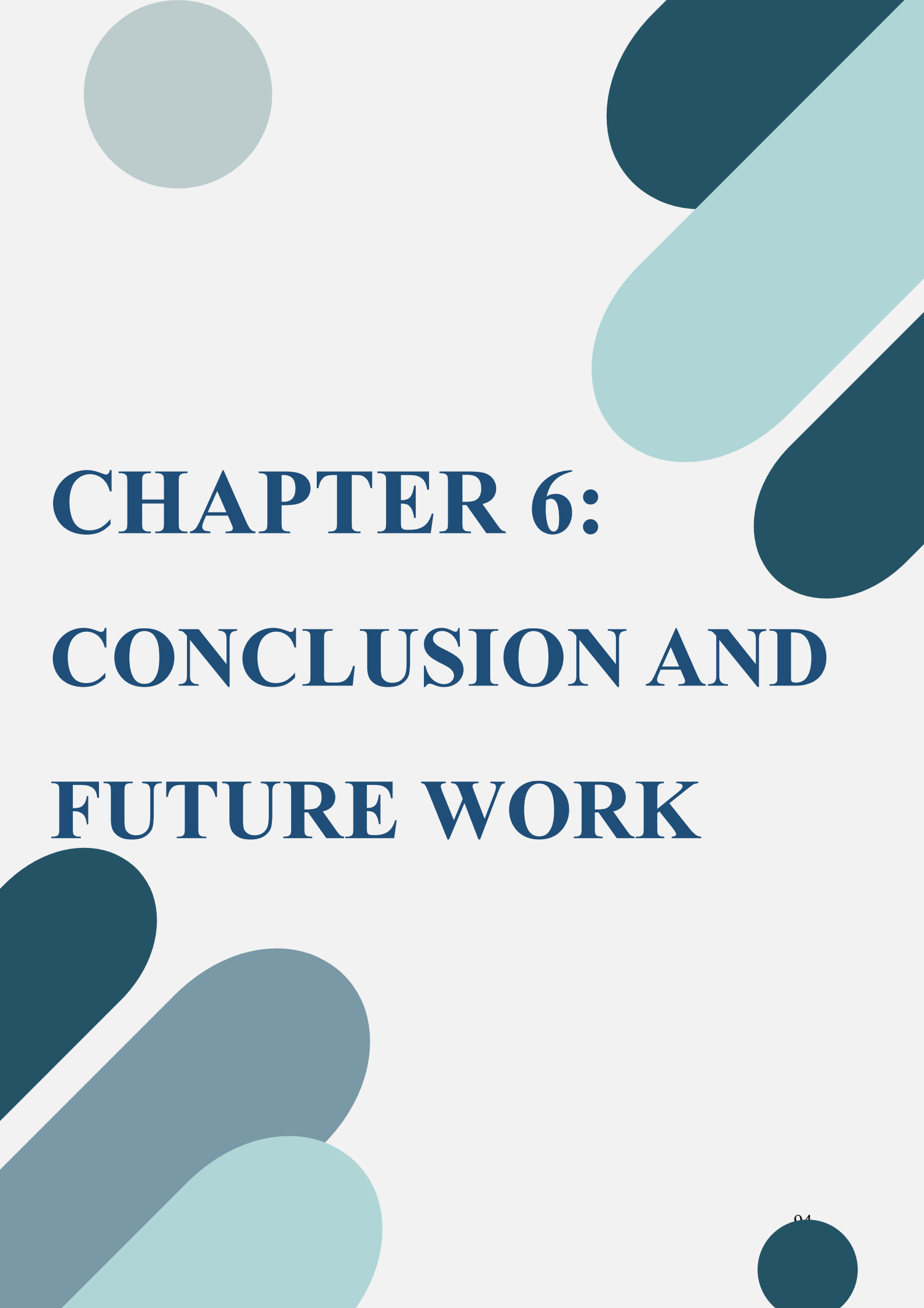
Additionally, a therapist suggested that "when adding exercises to a patient, only the exercises that have not reached their end date should be displayed in the patient's plan." We took this comment into consideration and added this functionality to our application.

Lastly, a patient expressed their liking for the interface colors, stating "I really like the interface colors, it looks good and clear. It's not essential, but I wouldn't mind if you added different colors." We appreciate this recommendation and will work on incorporating more color options in future releases.

For our non-functional requirements we measured Learnability, Performance, Availability, and Security. For the learnability we tested on the 60 patients by how many could complete the task we give them on 3 main features, each feature for a specific type of user. On the admin task of adding a patient all of them passed successfully, On the therapist task of creating a user plan 18 out of 20 passed successfully, and on the patient task all of them passed successfully. For the Performance the application's response time ranged between 1 to 5 seconds. We measure the time of the performance for each user. The result was very successful, we found that the range time of each task was between 500 milliseconds and 5 seconds. Then we have Availability which means that the application should be available for users 98% of the time. Since it depends on firebase database. We found out the result was successful. Lastly for security, we talk about the user's information to be secure, not allowing any unauthorized access to it. All the user's information is kept protected within the application and database.



Overall, the evaluation of the application was positive, with users expressing satisfaction with its functionality and purpose. The feedback and suggestions from users have played a crucial role in shaping the application's improvements, ensuring a better user experience, and addressing specific needs identified during testing.



CHAPTER 6: CONCLUSION AND FUTURE WORK

6 Conclusions and Future Work

In conclusion, recognizing the challenges many patients face in scheduling an appointment and finding nearby physical therapy centers due to the need for regular visits to the center and as the demand for physical therapy sessions continues to rise, our commitment to developing a physical therapy application integrating VR stands poised to address this growing challenge. In Physio project, we aim to make the rehabilitation journey accessible and memorable for every patient. Our project adheres to the agile methodology which gave us a lot of flexibility. Also, it allowed us to organize our requirements into sprints. During our project, we had five sprints, each one of them took 3-4 weeks, and every sprint involved 4 phases: planning, execution, review and retrospective. The weekly meetings with our Scrum Master and seminars that were conducted by the GP committee provided valuable insights and guided us in the right direction for developing our project. Moreover, we had daily meetings between the team members to track the progress and ensure how things are going for everyone so we can provide support for each other for any challenges faced during the project's development. Throughout this document, we introduced our project, outlined the main problem and solution, provided insights into our background, conducted a detailed analysis of our competitors, delved into our system description and design, and presented outcomes of our testing process. Drawing from the positive feedback received from our testers, we're delighted that they not only liked it but also found the Physio application to be clear and user-friendly. We're pleased that everything worked as intended with the current version of Physio.

. • Global and local impact

Physio will continue to improve access to physical therapy sessions globally. Moreover, Physio holds the potential to stimulate investors interest in innovations, fostering an appetite for investments within the local economy.

• Problems and challenges encountered during the software development

At the project's outset, we grappled with unfamiliarity surrounding the Flutter framework, the Dart programming language, and the process of setting up a Firebase database. Moreover, we encountered runtime errors for which solutions weren't readily available online. Time constraints added pressure, given our involvement in other projects, exams, and assignments. Once we started implementing VR, we faced a new set of challenges. Firstly, integrating VR

components into our existing software required us to learn new technologies and understand how VR development differs from traditional app development including learning new concepts like 3D modelling and user interaction in virtual environments. However, as we progressed through the project, we improved our time management skills and acquired the ability to troubleshoot errors not commonly addressed on the internet. And now we are equipped with a solid understanding of Dart and Flutter's framework.

- Limitations of the system

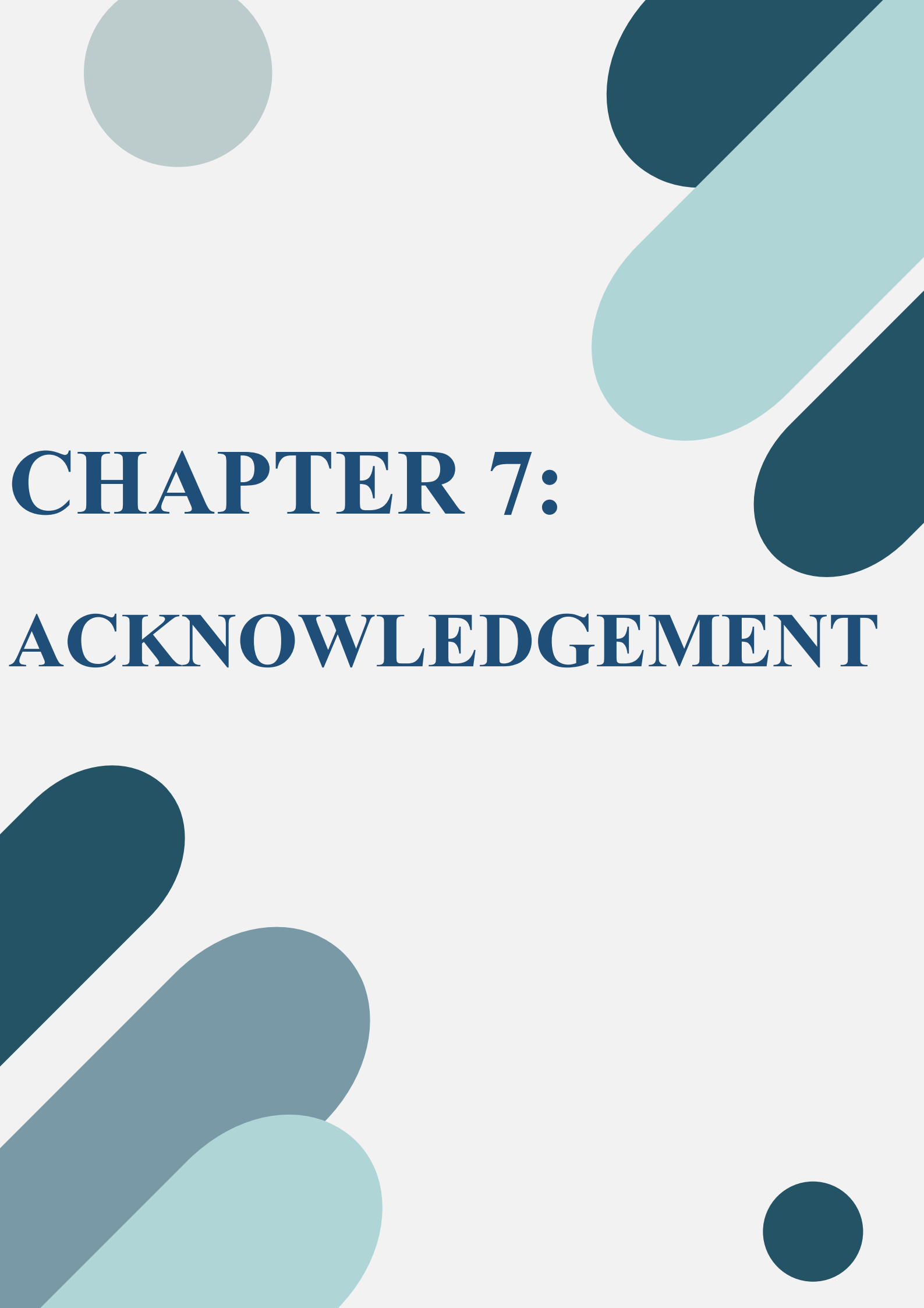
The application supports Android devices only and it's in one language only (English). Furthermore, the app will not allow patients to rate their therapists nor their customized plans which would help to improve the patient experience environment.

- The main contribution of the project

Physio seeks to revolutionize physical therapy by integrating VR to simulate real-life scenarios. Furthermore, Physio aims to make the rehabilitation journey more engaging, enjoyable, personalized, accessible, easy and cost-effective.

- Future work

In the future, we may consider expanding the app to include compatibility with IOS and the incorporation of an Arabic version. Additionally, we are exploring the potential integration of a live chat feature between therapists and patients.

The background features several abstract geometric shapes. In the top left, there is a light teal circle. In the top right, there are overlapping shapes in dark blue and light teal, including a large light teal shape and a dark blue shape. In the bottom left, there are overlapping shapes in dark blue, medium teal, and light teal. In the bottom right, there is a small dark blue circle.

CHAPTER 7:

ACKNOWLEDGEMENT

7 Acknowledgements

We would like to express my sincere gratitude to Dr. Sahar Bayoumi, our supervisor, for her invaluable guidance, support, and expertise throughout the development of our application physio. Dr. Bayoumi's extensive knowledge and insights have been instrumental in shaping our vision and ensuring the quality and effectiveness of our solution. Her dedication and commitment to our project have been truly inspiring.

We also want to express our heartfelt appreciation to Dr. Nora AlNajim and the Healthy Clinic physical therapy team. Their expertise and collaboration have been essential in understanding the needs of patients and therapists, as well as in designing a comprehensive and tailored treatment approach within our application. Their feedback, guidance, and contributions have played a vital role in refining our solution and ensuring its relevance and effectiveness in real-world clinical settings. Furthermore,

We would like to acknowledge the support and collaboration received from the College of Computer and Information Sciences at King Saud University, particularly the Information Technology department, their commitment to fostering innovation has been instrumental in facilitating the development and implementation of our specialized physiotherapy application. We are grateful for their partnership and the opportunities they have provided us.

We consider ourselves truly fortunate to have had the guidance and support of such esteemed professionals throughout our journey. Their contributions have been invaluable, and without their encouragement, we would not have been able to accomplish this project successfully.

The background features several abstract geometric shapes. In the top left, there is a light teal circle. In the top right, there are overlapping shapes in dark blue and light teal, including a large light teal shape and a dark blue shape. In the bottom left, there are overlapping shapes in dark blue, medium teal, and light teal. In the bottom right, there is a small dark blue circle.

CHAPTER 8:

REFERENCES

8 References

- [1] "Need for Physical Therapists Expected to Keep Increasing | UMass Lowell." Accessed September 9, 2023. <https://www.uml.edu/news/news-articles/2016/herald-pt.aspx>.
- [2] "KSA Physiotherapy Market, 2016." *Glasgow Research & Consulting* (blog), July 27, 2019. <https://www.glasgowinsights.com/blog/ksa-physiotherapy-market-2016/>.
- [3] "Physiopedia - Universal Access to Rehabilitation Knowledge." Accessed September 9, 2023. <https://www.physio-pedia.com/home/>
- [4] "Why Pain in the Neck and Shoulders Radiates down the Arm." Accessed September 9, 2023. <https://www.spinalbackrack.com/why-pain-in-the-neck-and-shoulders-radiates-down-the-arm/>
- [5] "People Using VR Continuous One Line Drawing of Virtual Reality 3380389 Vector Art at Vecteezy." Accessed September 9, 2023. <https://www.vecteezy.com/vector-art/3380389-people-using-vr-continuous-one-line-drawing-of-virtual-reality>.
- [6] "What is Agile? | Agile 101 | Agile Alliance." [Online]. Available: <https://www.agilealliance.org/agile101/>. [Accessed: May 7, 2024].
- [7] "Physical Therapy. In Encyclopaedia Britannica". Accessed September 24, 2023. <https://www.britannica.com/science/physical-therapy>
- [8] "What Is Virtual Reality?" Accessed September 25, 2023. <https://www.techtarget.com/whatis/definition/virtual-reality>.
- [9] "Virtual Reality Meets Creative Arts Therapy - VA News." Accessed September 9, 2023. <https://news.va.gov/107572/virtual-reality-meets-creative-arts-therapy/>.
- [10] "Understanding Sensors: Magnetometers, Accelerometers and Gyroscopes." *Virtual Reality Society* (blog), May 5, 2017. <https://www.vrs.org.uk/virtual-reality-gear/motion-tracking/sensors.html>.
- [11] "Schematic Illustration of the Imitative Virtual Reality Pipeline Used... | Download Scientific Diagram." Accessed September 9, 2023. https://www.researchgate.net/figure/Schematic-illustration-of-the-Imitative-Virtual-Reality-Pipeline-used-in-this-experiment_fig2_328497657

- [12] "The Evaluation of the Scoring Systems: The Fixed Effects Model under Known Variances." *Accreditation and Quality Assurance : Journal for Quality, Comparability and Reliability in Chemical Measurement* 21, no. 4 (2016): 10.1007/s00769-016-1215-y. <https://doi.org/10.1007/s00769-016-1215-y>.
- [13] "Scoring Systems in the Critically Ill: Uses, Cautions, and Future Directions." *BJA Education* "Scoring Systems in the Critically Ill: Uses, Cautions, and Future Directions." *BJA Education* 19, no. 7 (July 2019): 212–18. <https://doi.org/10.1016/j.bjae.2019.03.002>.
- [14] App Store. "PhysiApp," September 22, 2023. <https://apps.apple.com/sa/app/physiapp/id1047722007>.
- [15] App Store. "Luna Physical Therapy," August 23, 2023. <https://apps.apple.com/sa/app/luna-physical-therapy/id1434554640>.
- [16] "KinesteX - AI Fitness & Physio on the App Store." Accessed September 24, 2023. <https://apps.apple.com/sa/app/kinestex-ai-fitness-physio/id1619135943>.
- [17] "5 Best Physical Therapy Apps That Empower Patients." Accessed September 11, 2023. <https://www.exer.ai/posts/best-physical-therapy-apps>.
- [18] "Pappas Physical Therapy NOW on the App Store." Accessed September 11, 2023. <https://apps.apple.com/in/app/pappas-physical-therapy-now/id1476337712>.
- [19] "What is a Product Owner: Key Roles and Responsibilities Explained [2023 Edition]." [Online]. Available: <https://www.simplilearn.com/what-is-a-product-owner-article>. Accessed: May 8, 2024.
- [20] "Introduction to the Scrum Events." [Online]. Available: <https://www.scrum.org/resources/introduction-scrum-events>. Accessed: May 8, 2024.
- [21] "An Overview of the Scrum Framework." [Online]. Available: <https://resources.scrumalliance.org/Article/overview-scrum-framework>. Accessed: May 8, 2024.
- [22] "What is Jira? | Definition and Overview." [Online]. Available: <https://www.productplan.com/glossary/jira/>. [Accessed: May 8, 2024].
- [23] "What Is GitHub? (And What Is It Used For?)." [Online]. Available: <https://blog.hubspot.com/website/what-is-github-used-for>. [Accessed: May 8, 2024].

- [24] “Layered Architecture. What Is Layered Architecture and When to Use It?” {ddimitrov.dev}, November 22, 2020. <https://ddimitrov.dev/2020/11/22/layered-architecture-what-is-layered-architecture-and-when-to-use-it/>.
- [25] “User Interface Design Guidelines: 10 Rules of Thumb.” Interaction Design Foundation, 1 year ago. Available: <https://www.interaction-design.org/literature/article/user-interface-design-guidelines-10-rules-of-thumb>. [Accessed: November 28, 2023].
- [26] Rubin, K. S. (2017). *Essential Scrum: A practical guide to the most popular agile process*. Upper Saddle River, NJ: Addison-Wesley.

The background features several abstract geometric shapes in two shades of blue: a light teal and a dark navy blue. In the top left, there is a light teal circle. In the top right, there are overlapping shapes, including a dark navy blue semi-circle and a light teal elongated shape. In the bottom left, there are more overlapping shapes, including a dark navy blue semi-circle and a light teal elongated shape. In the bottom right, there is a small dark navy blue circle.

CHAPTER 9:

APPENDIX

9 Appendix

An appendix is included at the end of the report. Appendices include the material needed for the report, but which is unnecessary to include in the text itself. The appendices must be referred to in the text and they must have all the necessary information needed for interpretation. Appendices are situated at the end of the report and numbered consecutively. The written form for reference to appendices within the text is: Appendix A, Appendix B, etc. In the References it is: APPENDIX A: Title, APPENDIX B: Title, etc.

a. Appendix A: interviews for requirement elicitation

- Interviews with the therapist:

Interview Outline		
Interviewee: Dr. Noura AlNajim	Interviewer: Rand Almeghamis	
Location: Healthy Clinics	Appointment date: 14/9/2023	
	Start Time: 3:00 pm	End Time: 3:16 pm
Objectives: Collecting the requirement elicitations	Reminders: Dr. Norah is a physiotherapist who works at Healthy Clinics with 2 years of experience	
Agenda:		
Introduction	1 minute	
Background about the application	2 minutes	
Overview of the interview	1 minute	
Permission to record	1 minute	
Asking the questions	10minutes	
Closing	1 minutes	
General Observation: None		

Unresolved Issues /Topics Not Covered: None	
Questions:	Notes:
Question 1: What are your initial thoughts about incorporating virtual reality technology into physiotherapy sessions?	Answer: I think it's a positive step, especially for patients who are unable to visit the clinic. For example, people who live far away or individuals with disabilities who find it hard to get in and out of the car, among many other reasons.
	Observations: None
Question 2: How important is it for you to have the ability to customize exercise plans and treatment protocols within the application? Can you provide specific examples of customization options that would be beneficial to you?	Answer: Of course it's important, treatment usually follows a protocol for certain cases, such as post-surgeries and total elbow replacements. They may have the same treatment plan and repetitive exercises; however, the exercises might vary depending on their strength, as noted in their initial assessment. Therefore, I suggest incorporating different levels of strength exercises to accommodate individual needs.
	Observations: None
Question 3: How important is it for you to have access to analytics or insights derived from the collected exercise data? What types of analytics or reporting capabilities would be most valuable to you as a therapist?	Answer: It's very important to approach and proceed with the treatment considering that no two patients will progress in the same way. Therefore, it's very important to track the outcomes and measurements of the patients after every session. As for the second question, I would say that range of motion is a good measurement to use.
	Observations: None
Question 4: Do you believe that the integration of the application and virtual reality system can impact the efficiency of your therapy sessions in terms of time management and patient throughput? If so, how?	Answer: Honestly, patient throughput depends on whether the patient performs the exercises or not. However, in terms of time, the patient will definitely save a lot of time by not having to drive to the clinic. Additionally, they can perform the exercises at their own suitable time.
	Observations: None
Question 5: As a therapist, how do you anticipate the application and virtual reality system will contribute to long-term patient engagement and adherence to their prescribed treatment plans?	Answer: Definitely, I believe it will contribute to long-term patient engagement since the exercises as form of a game will be more fun to them to and everyone love to play some games.

	Observations: None
Question 6: As a physiotherapist, what additional features or functionalities would you like to see in the application to further enhance patient care and treatment outcomes?	Answer: Yes, outcome measures would be a valuable addition as they allow us to track the patient's performance over time.
	Observations: None

Interview Outline		
Interviewee: Dr. Saleh Alshalhoub	Interviewer: May Alnajim	
Location: Healthy Clinics	Appointment date: 14/9/2023	
	Start Time: 3:30 pm	End Time: 3:47 pm
Objectives: Collecting the requirement elicitations	Reminders: Dr. Saleh is a physiotherapist who works at Healthy Clinics with 4 years of experience	
Agenda: Introduction Background about the application Overview of the interview Permission to record Asking the questions Closing	 1 minute 2 minutes 1 minute 1 minute 11 minutes 1 minutes	
General Observation: None		

Unresolved Issues /Topics Not Covered: None	
Questions:	Notes:
Question 1: What are your initial thoughts about incorporating virtual reality technology into physiotherapy sessions?	Answer: It's an amazing idea! It will save a lot of time and effort, benefiting patients in many ways. They won't have to physically come to the clinic and that leads to avoiding traffic and other inconveniences.
	Observations: None

<p>Question 2: How important is it for you to have the ability to customize exercise plans and treatment protocols within the application? Can you provide specific examples of customization options that would be beneficial to you?</p>	<p>Answer: It's very important since patients have different cases and diagnoses. For example, two patients may have the same diagnosis, but the specific muscle we need to target for each patient may differ, which is determined during the initial assessment. Therefore, monthly follow-ups are important. Based on these follow-ups, I can make changes to the exercise plans.</p> <p>Observations: None</p>
<p>Question 3: How important is it for you to have access to analytics or insights derived from the collected exercise data? What types of analytics or reporting capabilities would be most valuable to you as a therapist?</p>	<p>Answer: It's essential, and I believe measuring the range of motion would be a good indicator of how the patient is progressing. If you can incorporate how to obtain this measurement, it would be great.</p> <p>Observations: None</p>
<p>Question 4: Do you believe that the integration of the application and virtual reality system can impact the efficiency of your therapy sessions in terms of time management and patient throughput? If so, how?</p>	<p>Answer: Yes, I think it will be more enjoyable for the patient to have a goal to achieve or a game to beat. It will add a sense of challenge for the patient to complete all their exercises.</p> <p>Observations: None</p>
<p>Question 5: As a therapist, how do you anticipate the application and virtual reality system will contribute to long-term patient engagement and adherence to their prescribed treatment plans?</p>	<p>Answer: Yes, as I mentioned in the previous question, it will make the patient more excited to complete all of their exercises. Additionally, the patient may even forget that they are doing actual exercises since it's presented in the form of a game.</p> <p>Observations: None</p>
<p>Question 6: As a physiotherapist, what additional features or functionalities would you like to see in the application to further enhance patient care and treatment outcomes?</p>	<p>Answer: I would recommend adding a notification reminder for their sessions.</p> <p>Observations: None</p>

Interview Outline		
<p>Interviewee: Dr. Sarah Almehatrash</p>	<p>Interviewer: Rand Almeghamis</p>	
<p>Location: Healthy Clinics</p>	<p>Appointment date: 14/9/2023</p>	
	<p>Start Time: 3:55 pm</p>	<p>End Time: 4:09 pm</p>
<p>Objectives: Collecting the requirement elicitation</p>	<p>Reminders: Dr. Sarah is a physiotherapist who works at Healthy Clinics with 1 year of experience</p>	
<p>Agenda:</p>		

Introduction	1 minute
Background about the application	2 minutes
Overview of the interview	1 minute
Permission to record	1 minute
Asking the questions	8minutes
Closing	1 minutes
General Observation: None	

Unresolved Issues /Topics Not Covered: None	
Questions:	Notes:
Question 1: What are your initial thoughts about incorporating virtual reality technology into physiotherapy sessions?	Answer: It's a great idea because it helps us as therapists with the patients' appointments. Sometimes, patients don't have to come for every appointment, especially for repetitive exercises.
	Observations: None
Question 2: How important is it for you to have the ability to customize exercise plans and treatment protocols within the application? Can you provide specific examples of customization options that would be beneficial to you?	Answer: It's very important because each patient has a different condition, even if they have the same diagnosis. Their body's response to treatment can vary, and one patient may be able to do certain exercises while another may not. That's why a customized plan of exercises is important.
	Observations: None
Question 3: How important is it for you to have access to analytics or insights derived from the collected exercise data? What types of analytics or reporting capabilities would be most valuable to you as a therapist?	Answer: It's very important because we assess the patient's improvement after each session. Their progress serves as an indicator of whether I am doing well or need to make changes. Using a pain scale would be a good measurement for me.
	Observations: None

<p>Question 4: Do you believe that the integration of the application and virtual reality system can impact the efficiency of your therapy sessions in terms of time management and patient throughput? If so, how?</p>	<p>Answer: Absolutely, but first, it's very important to meet the patient for their first session to assess their condition and demonstrate how to perform the exercises correctly. Once they understand the exercises, they can perform them at home, saving them time from coming to the clinic. This approach ensures that the sessions are effective.</p> <p>Observations: None</p>
<p>Question 5: As a therapist, how do you anticipate the application and virtual reality system will contribute to long-term patient engagement and adherence to their prescribed treatment plans?</p>	<p>Answer: Yes, I believe so. By turning the exercises into a game, it will make the patient look forward to doing them exercises instead of feeling lazy or unmotivated.</p> <p>Observations: None</p>
<p>Question 6: As a physiotherapist, what additional features or functionalities would you like to see in the application to further enhance patient care and treatment outcomes?</p>	<p>Answer: Yes, if I can specify the repetition number for each exercise, it will be very helpful. This way, patients will know exactly how many times they need to repeat each exercise.</p> <p>Observations: None</p>

- Interviews with the patients:

Interview Outline		
Interviewee: Lubna Alshabanat	Interviewer: Rand Almeghamis	
Location: Healthy Clinics	Appointment date: 13/9/2023	
	Start Time: 1:00 pm	End Time: 1:14 pm
Objectives: Collecting the requirement elicitations	Reminders: Lubna is 21 years old female Urban Planning student who suffers from Tennis elbow.	
Agenda: Introduction Background about the application Overview of the interview Permission to record Asking the questions Closing	 1 minute 2 minutes 1 minute 1 minute 8 minutes 1 minutes	
General Observation: None		

Unresolved Issues /Topics Not Covered: None	
Questions:	Notes:
Question 1: How comfortable are you with using technology, such as smartphones or tablets, for healthcare purposes?	Answer: I am quite comfortable using technology, such as smartphones or tablets, for healthcare purposes. I am familiar with using these devices and feel confident in using healthcare-related applications.
	Observations: None
Question 2: What are your expectations and goals in using the physiotherapy application? What specific outcomes or improvements are you hoping to achieve?	Answer: My expectations and goals in using the physiotherapy application are to relieve my upper body pain, improve my mobility and strength, and enhance my overall well-being. I hope to achieve specific outcomes such as reduced pain, increased range of motion, improved posture, and enhanced functional abilities in my daily activities.
	Observations: None
Question 3: How important is it for you to have personalized exercise plans tailored to your specific condition within the application?	Answer: Having personalized exercise plans is extremely important to me. I believe that targeted exercises designed for my unique needs will optimize the effectiveness of my therapy and ensure that I am addressing the root causes of my upper body pain.
	Observations: None
Question 4: How interested are you in the concept of gamified exercises within the physiotherapy application? Do you believe it would enhance your motivation and engagement during your therapy sessions?	Answer: I am highly interested in the concept of gamified exercises within physiotherapy applications. I believe that gamification can significantly enhance my motivation and engagement during therapy sessions. By introducing elements of fun and competition, it can make the exercises more enjoyable and encourage me to stay consistent with my treatment.
	Observations: None
Question 5: What types of progress tracking or feedback mechanisms would be most valuable to you within the application? For example, visual progress charts, exercise completion badges, or personalized recommendations.	Answer: I think visual progress charts would be valuable for me to see how I am improving over time.
	Observations: None

Question 6: Are there any specific features or functionalities you would like to see in the application that would make it easier for you to understand and perform the prescribed exercises correctly?	Answer: I would suggest adding visual demonstrations or videos, would greatly assist me in understanding and performing the prescribed exercises
	Observations: None

Interview Outline		
Interviewee: Ghala Altraif	Interviewer: May Alnajim	
Location: Healthy Clinics	Appointment date: 13/9/2023	
	Start Time: 1:30 pm	End Time: 1:45 pm
Objectives: Collecting the requirement elicitations	Reminders: Ghala is 26 years old female employee who works in a company that suffers from Frozen shoulder.	
Agenda:		
Introduction	1 minute	
Background about the application	2 minutes	
Overview of the interview	1 minute	
Permission to record	1 minute	
Asking the questions	9 minutes	
Closing	1 minutes	
General Observation: None		

Unresolved Issues /Topics Not Covered: None	
Questions:	Notes:
Question 1: How comfortable are you with using technology, such as smartphones or tablets, for healthcare purposes?	Answer: When it comes to using technology for healthcare purposes, I would say I'm neither extremely comfortable nor uncomfortable. I have some experience using smartphones and tablets, but I may need a bit of guidance when it comes to healthcare applications. I'm open to exploring and learning how to use them effectively if it can assist me with my pain.
	Observations: None

<p>Question 2: What are your expectations and goals in using the physiotherapy application? What specific outcomes or improvements are you hoping to achieve?</p>	<p>Answer: My main expectation in using the physiotherapy application is to get some relief from my upper body pain. If I can experience a reduction in pain levels and improve my ability to move and perform daily activities, I would consider it a successful outcome. My goal is to regain functionality and improve my overall quality of life.</p> <p>Observations: None</p>
<p>Question 3: How important is it for you to have personalized exercise plans tailored to your specific condition within the application?</p>	<p>Answer: It's essential to me, I believe that individualized treatment is the key to addressing my upper body pain effectively. Having exercises that cater to my unique needs and limitations will ensure that I'm getting the right treatment and not worsen any existing issues.</p> <p>Observations: None</p>
<p>Question 4: How interested are you in the concept of gamified exercises within the physiotherapy application? Do you believe it would enhance your motivation and engagement during your therapy sessions?</p>	<p>Answer: The concept of gamified exercises within the physiotherapy application sounds interesting, but I'm not sure how much it would enhance my motivation and engagement. I'm more focused on finding relief from my pain rather than seeking entertainment during therapy sessions. However, if gamification can make the exercises more enjoyable and help me stay consistent with my treatment, then I'm open to giving it a try.</p> <p>Observations: None</p>
<p>Question 5: What types of progress tracking or feedback mechanisms would be most valuable to you within the application? For example, visual progress charts, exercise completion badges, or personalized recommendations.</p>	<p>Answer: In terms of progress tracking and feedback mechanisms, I would prefer simple and straightforward methods. Visual progress charts might be helpful, as long as they are easy to understand and provide a clear overview of my improvement. I just want to see tangible progress and know that I'm moving in the right direction.</p> <p>Observations: None</p>
<p>Question 6: Are there any specific features or functionalities you would like to see in the application that would make it easier for you to understand and perform the prescribed exercises correctly?</p>	<p>Answer: It would be great to have notifications that remind me of my therapy sessions</p> <p>Observations: None</p>

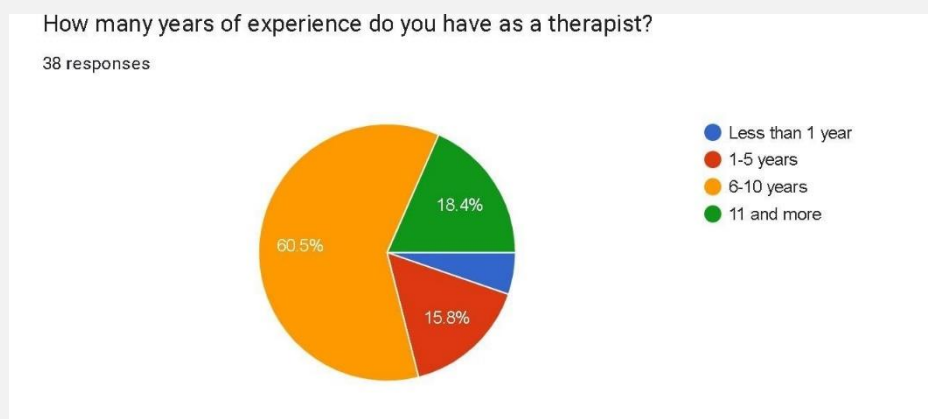
Interview Outline		
Interviewee: Abdullah Alhussain	Interviewer: Rand Almeghamis	
Location: Healthy Clinics	Appointment date: 13/9/2023	
	Start Time: 2:00 pm	End Time: 2:14 pm
Objectives: Collecting the requirement elicitations	Reminders: Abdullah is a 40-year-old father of two children, and he suffers from Post elbow fracture.	
Agenda:		
Introduction	1 minute	
Background about the application	2 minutes	
Overview of the interview	1 minute	
Permission to record	1 minute	
Asking the questions	8 minutes	
Closing	1 minutes	
General Observation: None		

Unresolved Issues /Topics Not Covered:	
None	
Questions:	Notes:
Question 1: How comfortable are you with using technology, such as smartphones or tablets, for healthcare purposes?	Answer: I would say I'm okay with using smartphones and other forms of technology, but I have never tried a healthcare App before.
	Observations: None
Question 2: What are your expectations and goals in using the physiotherapy application? What specific outcomes or improvements are you hoping to achieve?	Answer: My main aim is pain relief. Sometimes, I can't sleep at night because of the pain. And being able to move freely would be nice as well.
	Observations: None
Question 3: How important is it for you to have personalized exercise plans tailored to your specific condition within the application?	Answer: I don't actually know how important it is to have personalized plans and how they can be helpful, but if my doctor says so, then I think it's important.
	Observations: None

Question 4: How interested are you in the concept of gamified exercises within the physiotherapy application? Do you believe it would enhance your motivation and engagement during your therapy sessions?	Answer: I'm so interested, because I like to play a lot of games, I think it will motivate me to do the exercises since there is a fun way of doing them.
	Observations: None
Question 5: What types of progress tracking or feedback mechanisms would be most valuable to you within the application? For example, visual progress charts, exercise completion badges, or personalized recommendations.	Answer: I actually don't have anything in mind, as long as there is something that shows me my progress, I will be okay with it.
	Observations: None
Question 6: Are there any specific features or functionalities you would like to see in the application that would make it easier for you to understand and perform the prescribed exercises correctly?	Answer: I think having a video the demonstrate how the exercises are done would be good guidance, and it will assure me that I'm doing the exercise correctly.
	Observations: None

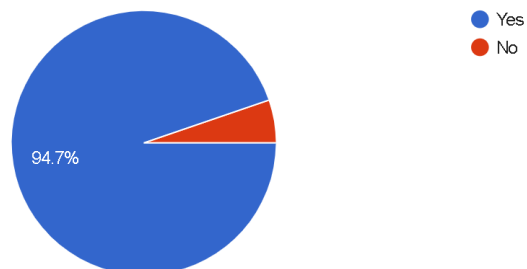
Appendix B: Questionnaires for requirements elicitation.

- Therapists' questionnaire:



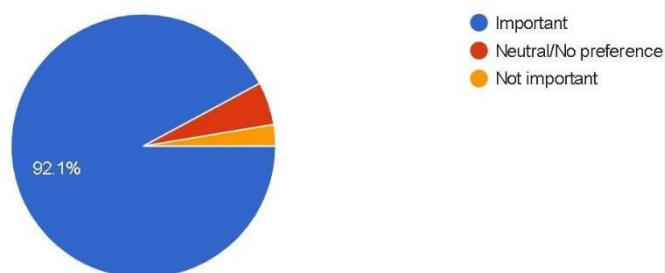
As a therapist, do you believe incorporating a game-like format into exercises could make therapy sessions more engaging for your patients?

38 responses



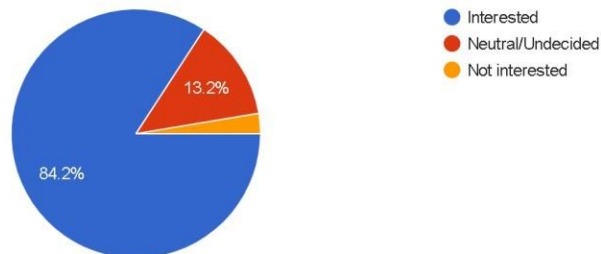
How important is it for you to have access to patient progress data and analytics?

38 responses



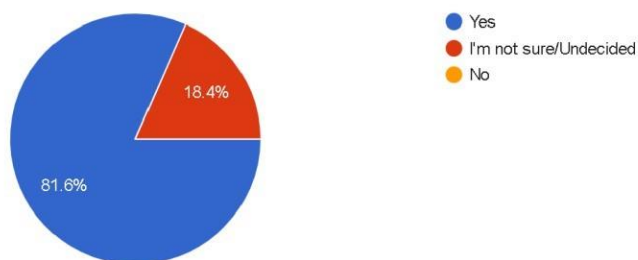
How interested are you in incorporating Virtual Reality (VR) therapy into your practice?

38 responses



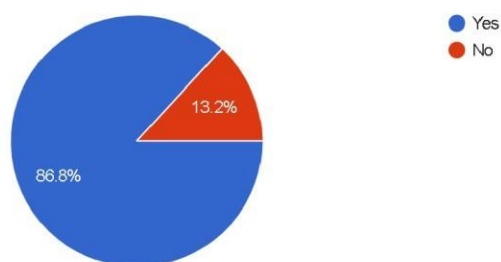
Do you believe Virtual Reality (VR) therapy can enhance patient engagement and treatment outcomes compared to traditional therapy approaches?

38 responses



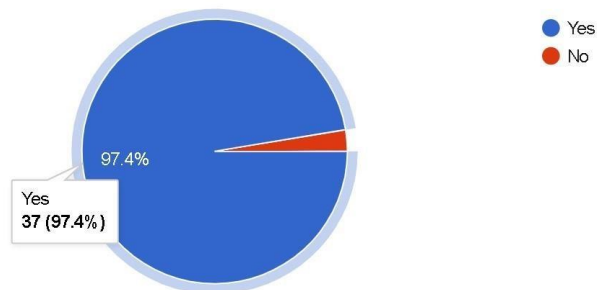
Do you believe that incorporating this app into your workflow would enhance your ability to manage a larger number of patients efficiently?

38 responses



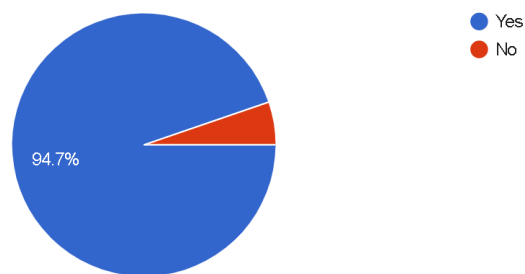
Do you believe that having the ability to customize each patient's exercise plan within the physiotherapy application would be helpful?

38 responses



In your experience, do you believe the physiotherapy app would assist patients in overcoming challenges related to attending every therapy session?

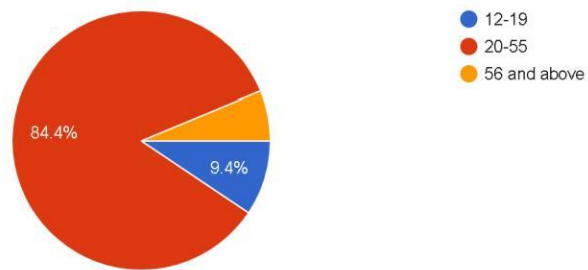
38 responses



- Patient questionnaire:**

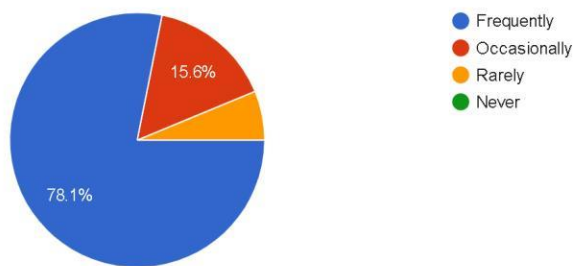
what is you age range ?

32 responses



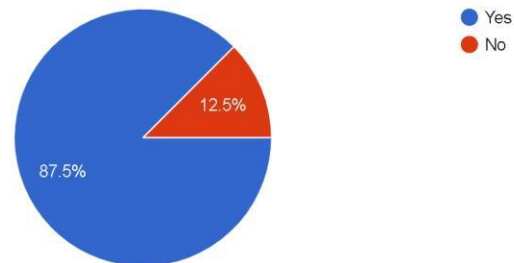
How frequently do you use smartphones or tablets in your daily life?

32 responses



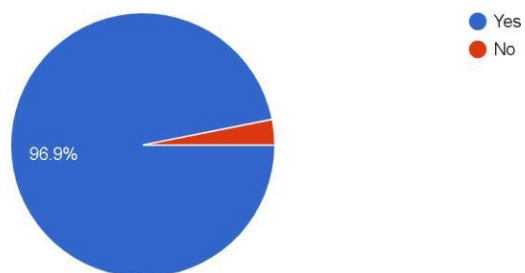
Are you open to using technology, such as smartphones or tablets, for healthcare-related purposes?

32 responses



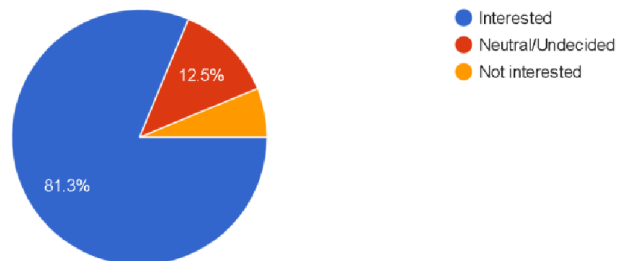
is it challenging for you to visit the clinic daily for your therapy sessions?

32 responses



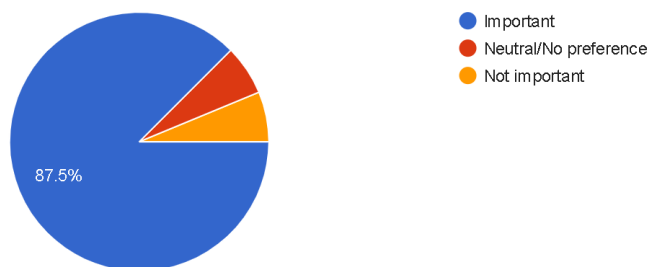
How interested would you be in participating in therapy exercises that are presented in the form of interactive games?

32 responses



How important is it for you to have a personalized therapy plan tailored to your specific needs and goals?

32 responses

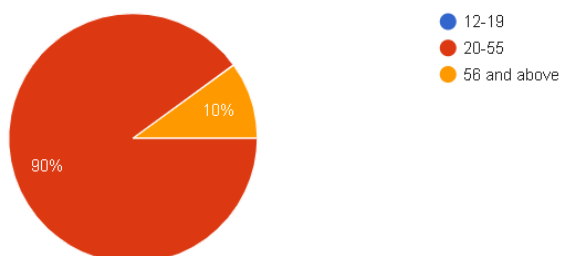


b. Appendix C: Questionnaires for testing.

• For patients:

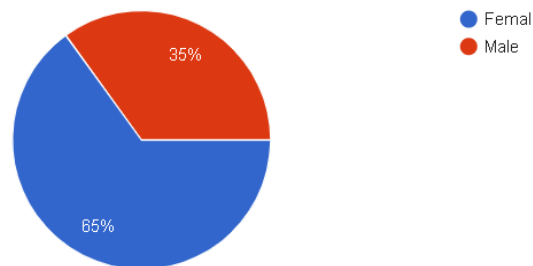
what is you age range ?

20 responses



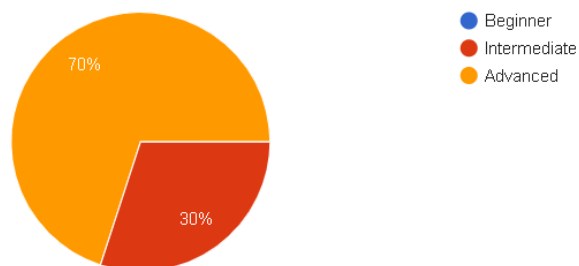
what is your gender

20 responses



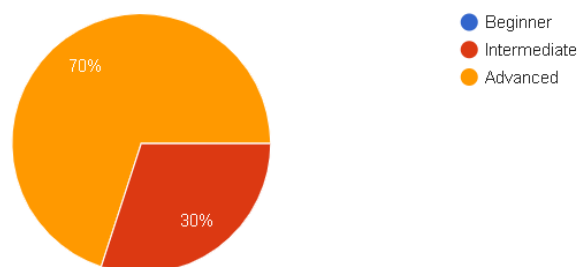
Which of the following best describes your level of proficiency in the English language?

20 responses



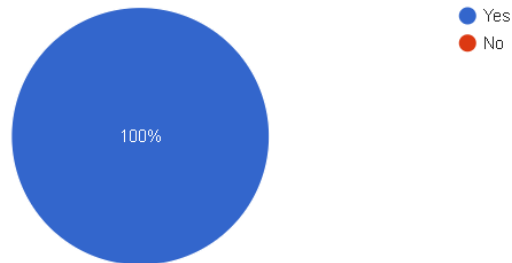
What is your level of proficiency in technology skills?

20 responses



Is the application's design and color scheme visually appealing and comfortable for the eyes?

20 responses



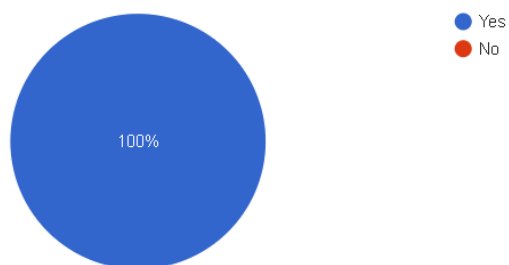
Do the icons used in the application appear clear and facilitate ease of use?

20 responses



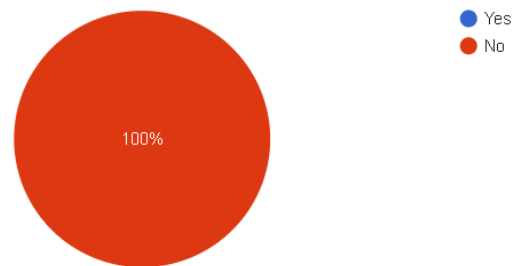
Was the navigation through the application seamless?

20 responses



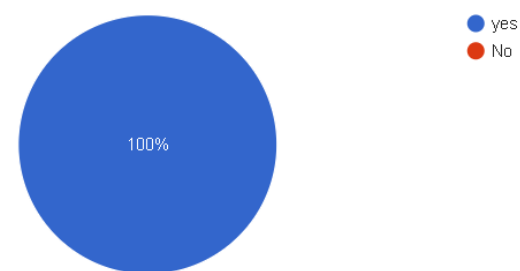
Did you encounter any technical issues or bugs while using the application?

20 responses



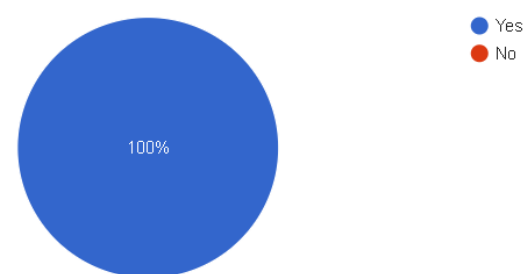
All the functions in this app worked as expected?

20 responses



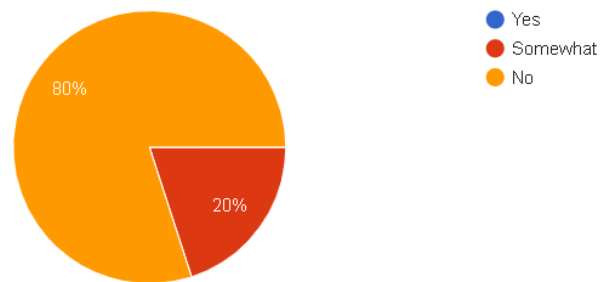
Were the confirmation prompts helpful in guiding your actions?

20 responses



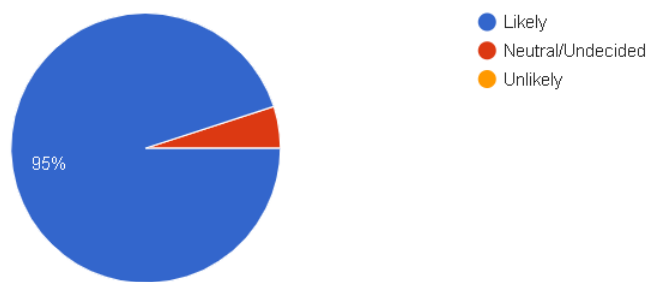
Did you have to learn many things before you could start using the application effectively?

20 responses



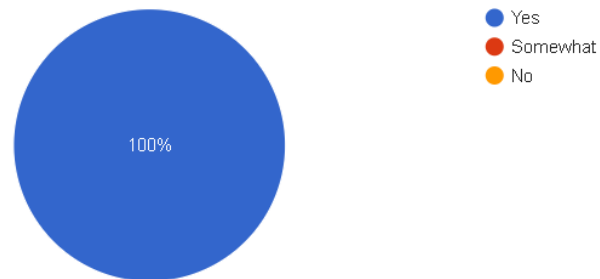
How likely are you to continue using the app in the future?

20 responses



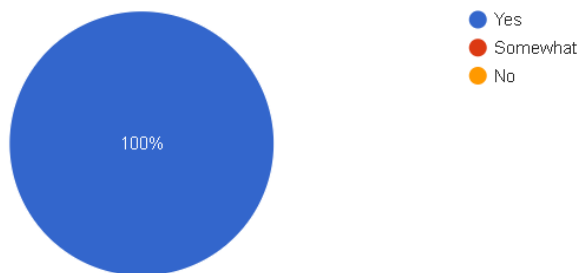
Has the notification proven effective in serving as a reminder for your exercises?

20 responses



Did you enjoy engaging in exercise using virtual reality (VR)?

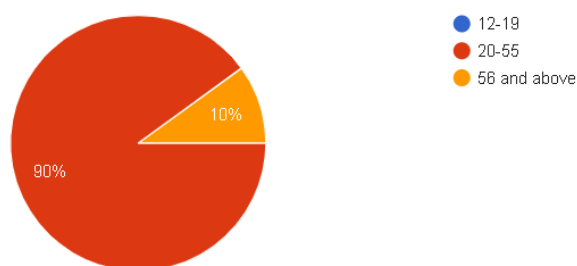
20 responses



- **For the therapist:**

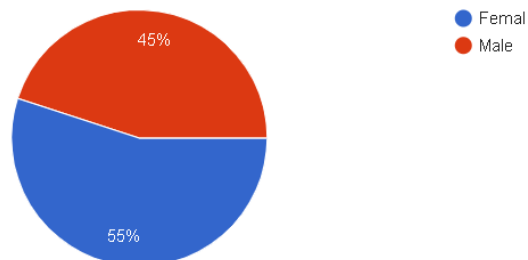
what is you age range ?

20 responses



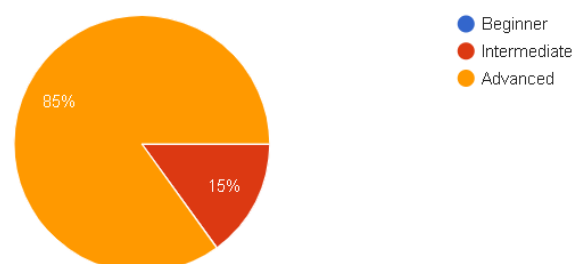
what is your gender

20 responses



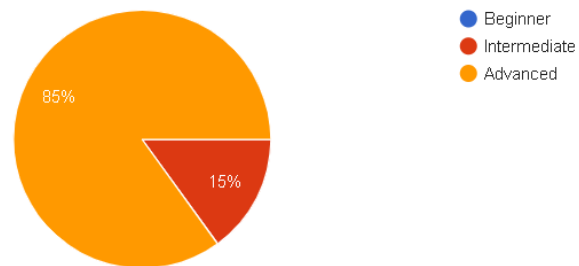
Which of the following best describes your level of proficiency in the English language?

20 responses



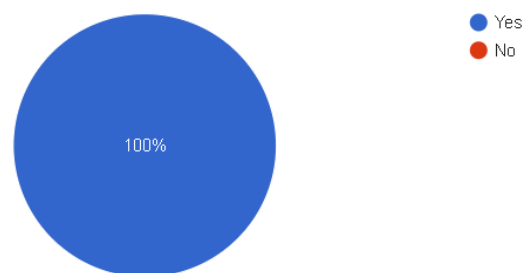
What is your level of proficiency in technology skills?

20 responses



Is the application's design and color scheme visually appealing and comfortable for the eyes?

20 responses



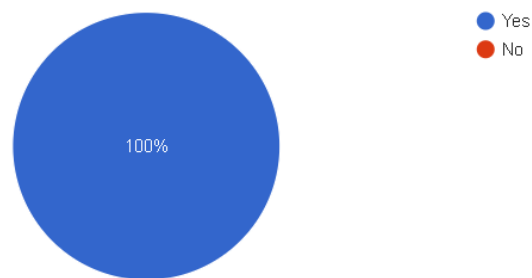
Do the icons used in the application appear clear and facilitate ease of use?

20 responses



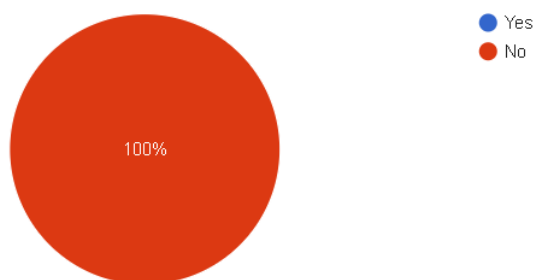
Was the navigation through the application seamless?

20 responses



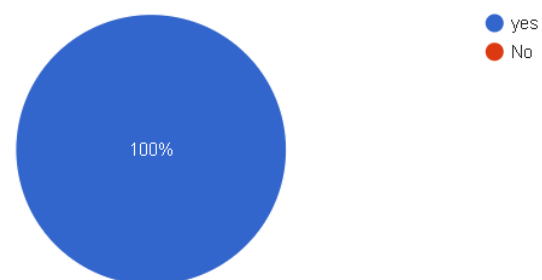
Did you encounter any technical issues or bugs while using the application?

20 responses



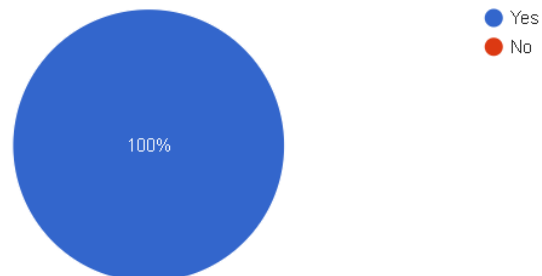
All the functions in this app worked as expected?

20 responses



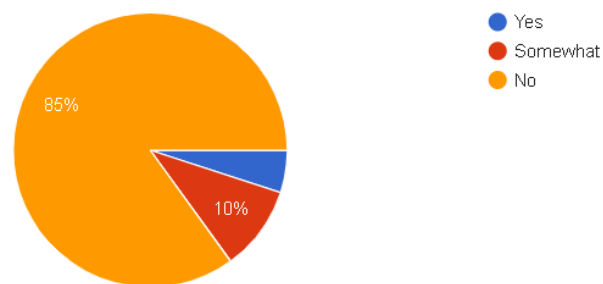
Were the confirmation prompts helpful in guiding your actions?

20 responses



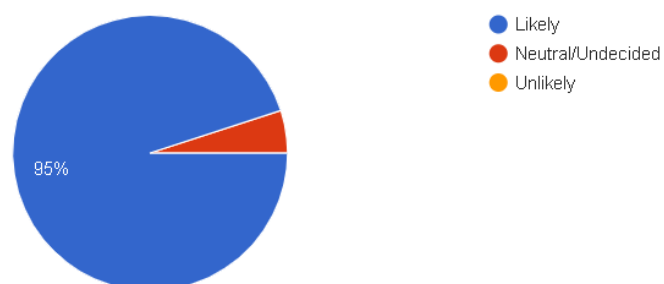
Did you have to learn many things before you could start using the application effectively?

20 responses



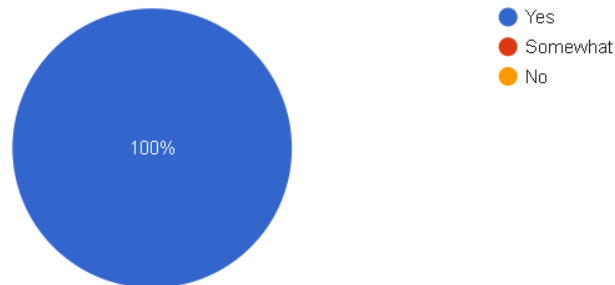
How likely are you to continue using the app in the future?

20 responses



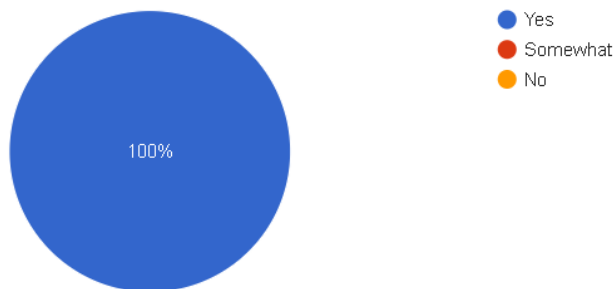
Was the exercise report detailing the patient's performance found to be beneficial?

19 responses



Was it effortless to assign exercise plans to the patients?

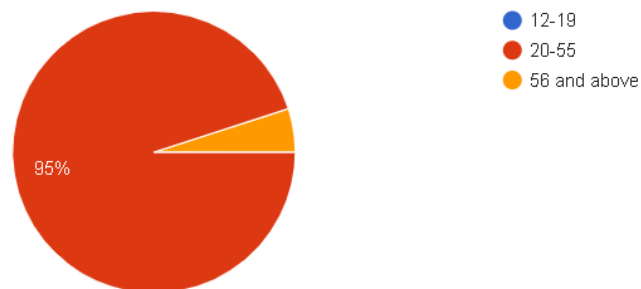
20 responses



- **For the admin**

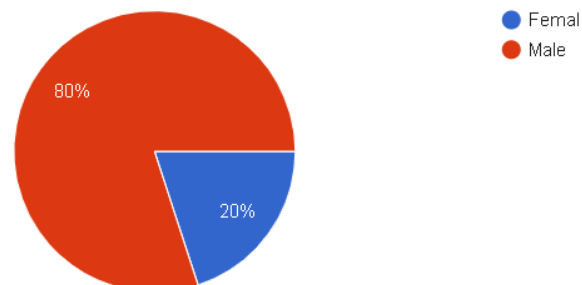
what is you age range ?

20 responses



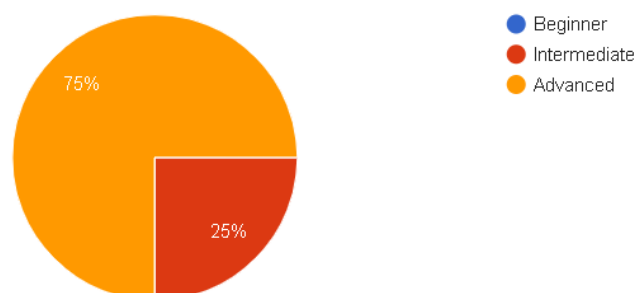
what is your gender

20 responses



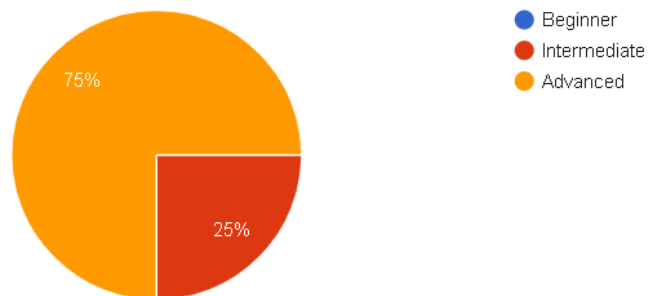
Which of the following best describes your level of proficiency in the English language?

20 responses



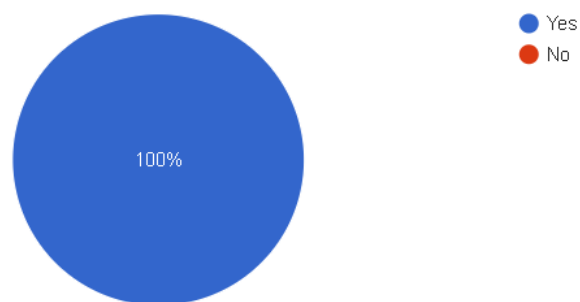
What is your level of proficiency in technology skills?

20 responses



Is the application's design and color scheme visually appealing and comfortable for the eyes?

20 responses



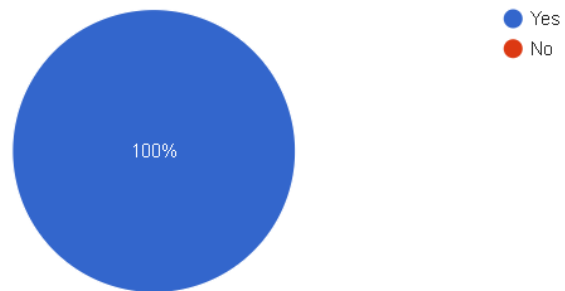
Do the icons used in the application appear clear and facilitate ease of use?

20 responses



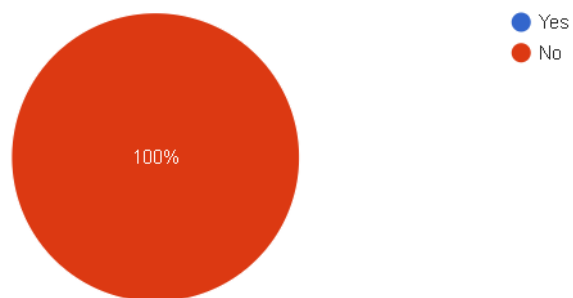
Was the navigation through the application seamless?

20 responses



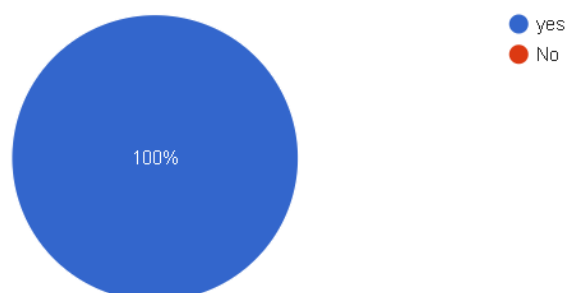
Did you encounter any technical issues or bugs while using the application?

20 responses



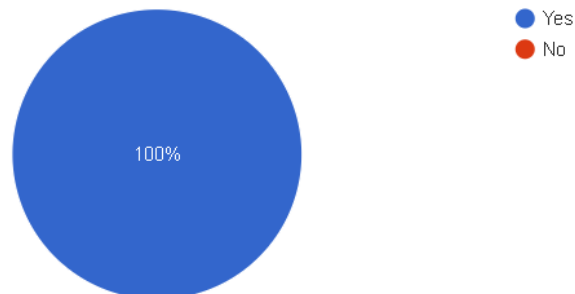
All the functions in this app worked as expected?

20 responses



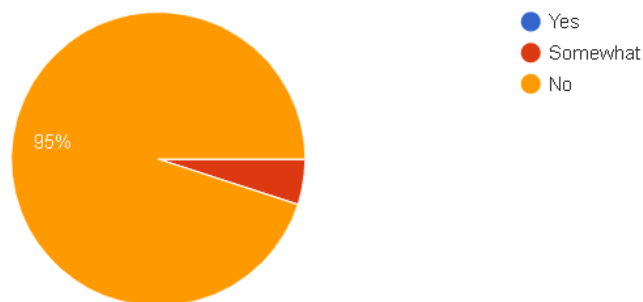
Were the confirmation prompts helpful in guiding your actions?

20 responses



Did you have to learn many things before you could start using the application effectively?

20 responses



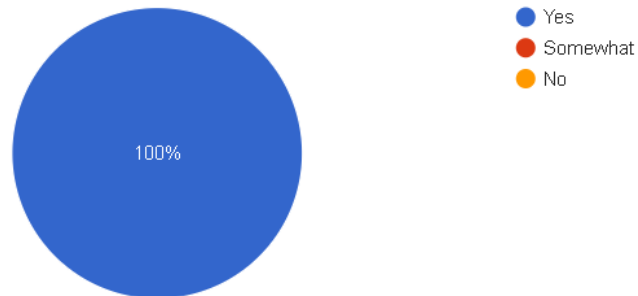
How likely are you to continue using the app in the future?

20 responses



Was the aim of the application clear?

20 responses



Would you recommend the application to other users?

20 responses

