

AR Communication Software for Children with Autism

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Abstract—Children that have autism spectrum disorder (ASD) often face various challenges in verbal communication, which makes it difficult for them to express their emotions and needs. This project explores the development of a software solution for an Augmented Reality (AR) platform that supports communication and self-expression for children with autism. The system aims to create an interactive and customizable environment in which the caregiver of the child can freely modify the content to tailor it to the unique needs of the child. The development follows an iterative prototyping approach to refine the application through feedback from professionals and users. This report details the rationale, objectives, and the development approach of the project.

Keywords— *Autism Spectrum Disorder, Augmented Reality, Assistive Technology, Communication, Human-Computer Interaction, Prototyping, ASD, AR.*

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects the communication, social interaction, and behaviors [1] of adults and children. Many children with ASD struggle with conventional communication methods, which makes it difficult for them to express their needs and emotions effectively. Although various assistive technologies exist, they often lack flexibility, fail to sustain engagement, or are not tailored to the unique needs of autistic children. Augmented Reality (AR) presents a promising advancement in assistive communication tools, offering a more interactive and adaptable solution.

This project focuses on developing a software-based communication solution tailored for an AR system. Our goal is to provide an engaging, interactive, customizable software that can be tailored to the individual needs of the child. The use of AR allows for digital overlays in the user's physical environment, which in turn offers a multi-sensory experience that can promote understanding and interaction. By emphasizing visual support, contextual clues, and interactive elements, the system aims to supplement or enhance the communication pathways that children with ASD find most accessible.

II. PROBLEM STATEMENT

Children who face communication challenges – such as those on the autism spectrum – often encounter impairments in social interactions, and communication [2]. Which can hinder their participation in social and educational contexts. Existing tools are often limited in customization and sometimes fail to sustain user engagement due to lack of interactivity. This gap underscores the need for a more responsive and immersive communication tool.

An augmented reality-based software offers a promising solution by introducing dynamic visuals and auditory stimuli that enhance communication without overwhelming the user. The ability to adapt to individual preferences while encouraging interaction in a real-world context makes AR an ideal medium for this application. A flexible, user-friendly system tailored to individual learning profiles has the potential to improve expressive capabilities and social confidence.

III. PROJECT OBJECTIVES

For this project, our current objectives are:

- Develop a functional AR communication software.
- Allow for caregiver-driven customization of content and interface settings.
- Allow for emotion recognition.
- Design the user interface with accessibility and engagement as top priorities.
- Gather user feedback during development to ensure the system evolves to meet real-world needs.

IV. PROJECT METHODOLOGY

Our project adopts a waterfall model with prototyping. This approach offers us a structured development process with built-in opportunities for iterative testing and refinement. Key stages include:

- **Requirement Gathering:** Consultation with specialists, therapists, end-users, to come up with a list of necessary requirements.
- **System Design:** Development of wireframes, and program design.
- **Prototype Creation:** Building early versions of the software for internal evaluation.
- **Evaluation:** User testing sessions with educators and therapy professionals.
- **Implementation:** Iterative enhancements leading to a stable, deployable prototype.

V. STRUCTURE DIAGRAM

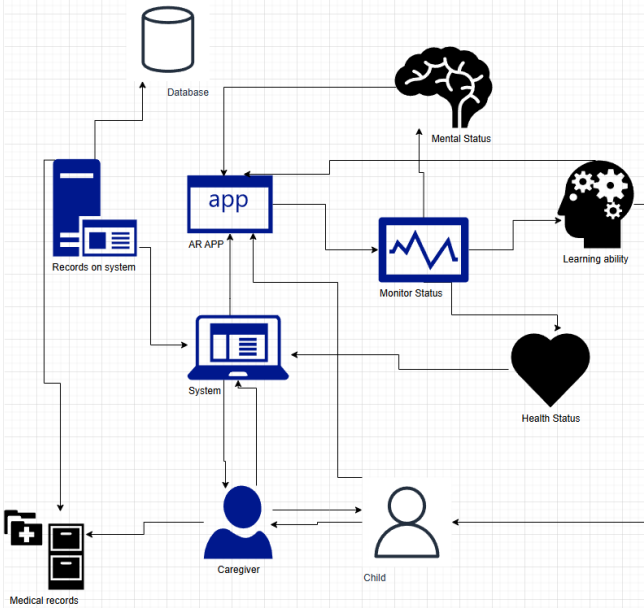


Figure 1: Structure Diagram of Our Project.

When designing our project, our vision is for pediatricians and healthcare professionals to systematically analyze and study the communication patterns and behavior in children with autism. The structure of this project uses an application as a tool for better understanding and appropriate communication. Certified medical practitioners utilize the application to track developmental progress across cognitive, emotional, and educational domains. The child using the app through the Augmented Reality (AR) headset will be able to immerse himself/herself in activities to help them understand and communicate in an efficient way. Every piece of information will be stored in the system with a database which only medical professionals will have access to.

VI. SYSTEM DESIGN

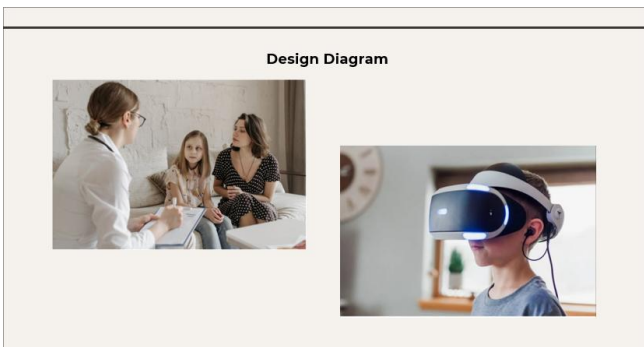


Figure 2: Design Diagram of Our Project.

The project employs a streamlined, user-centric design to ensure accessibility for its intended users (families and clinicians). We have the family visit their licensed medical doctor to have an evaluation of how the child interacts or communicates with other people. Following this evaluation, the next step is to gradually introduce the child to AR so that they can get accustomed to the platform. During this time, the

doctor will be connected to a computer using the app to compile the data for analysis.

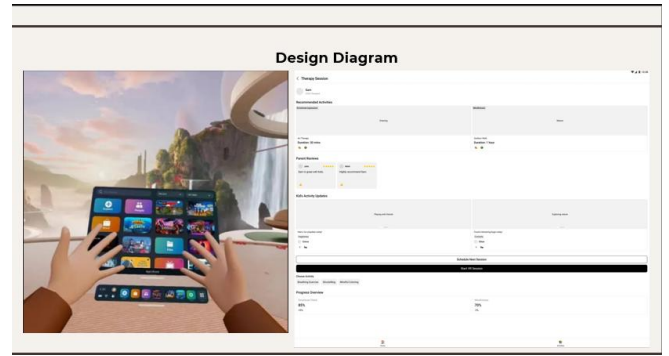


Figure 3: Wire Frames of Our Project.

The Augmented Reality headset incorporates a customizable menu of gamified activities, allowing the child to select various therapeutic modules aligned with their preferences. Each of the activities is designed to automatically transmit performance metrics (e.g., completion rates, response patterns) to the healthcare professionals' portal for behavioral assessment. The application, synchronized across AR hardware and clinical workstations, features role-specific profiles for medical practitioners. These profiles provide a centralized dashboard for progress tracking, adaptive goal setting, and session scheduling, enabling doctors to efficiently manage caseloads across multiple patients.

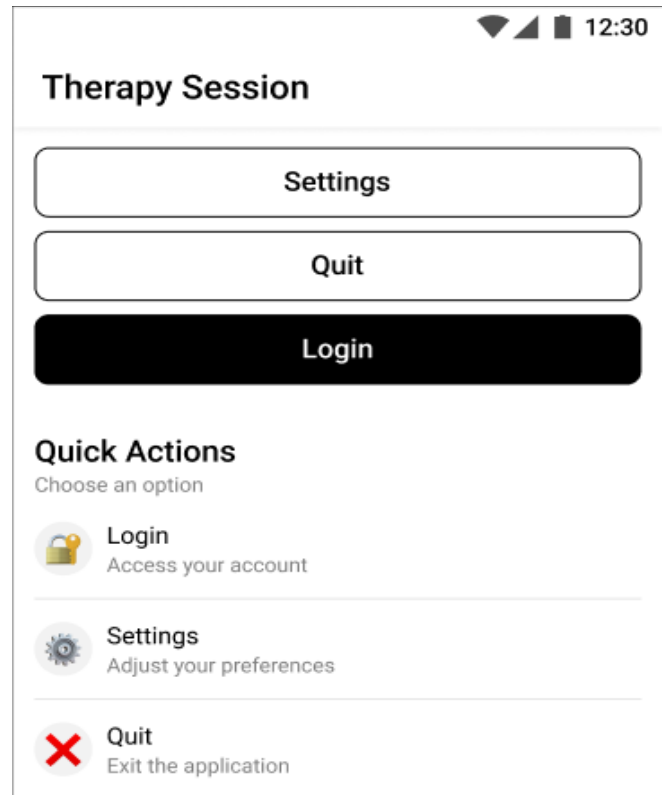


Figure 4: Login Screen for the Therapist.

A visualized concept for the project is to have a log in for the therapist/caregiver. In here, they can modify the activities for each session and have a clear progress of how the child

has been during the session. They can also start sessions with activities if the child has any trouble choosing an activity.

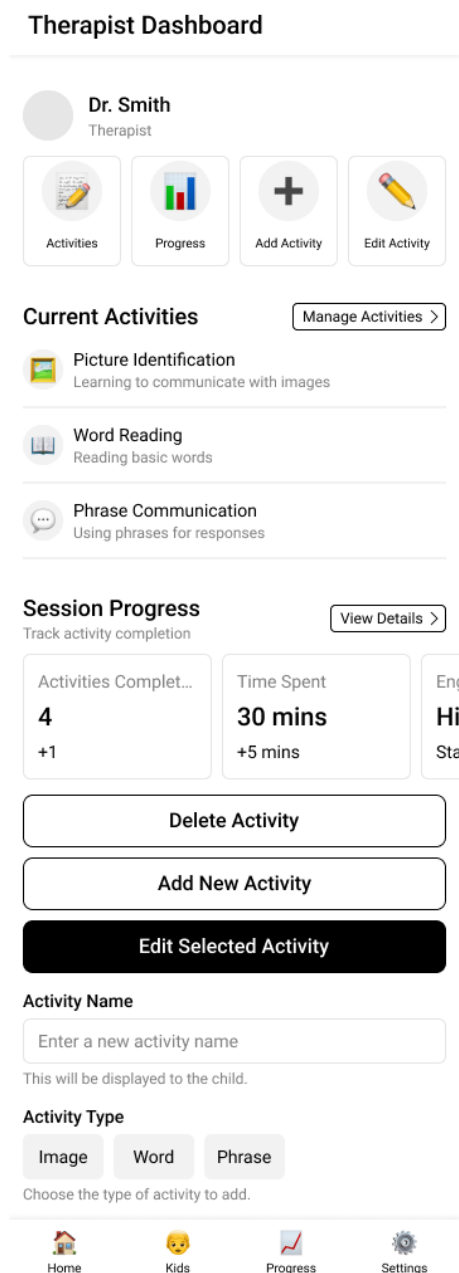


Figure 5: Menu Screen for the Therapist

This menu has access to all the content that can be personalized for the therapist/caregiver will use to have steady progress with the child. In here, we have information such as the doctor's name, the activities that will be implemented during the session and a progress to keep track of any communication that the child has learned.

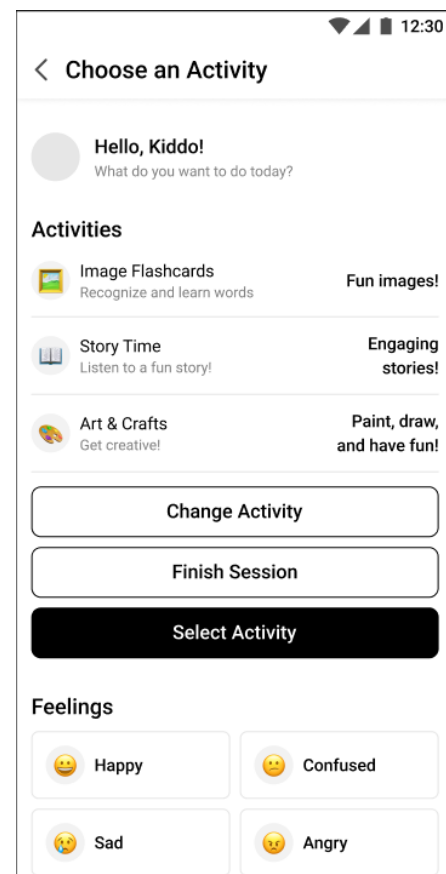


Figure 6: Menu Screen for Children.

This menu has more restrictions since it is for a child and to not overwhelm them with too much information. This simple menu has the child's name, the activity they want to partake in and a feelings option to express how they are currently during the session.

VII. FUNCTIONAL REQUIREMENTS

Our current functional requirements for the project are as follows:

- AR (Augmented Reality) Overlay with Symbols:
 - These visual symbols will help the child who has difficulty trying to communicate.
- User Interface with AR Elements:
 - Since we do not know how the child will react to complete immersion, the layout and interface will be displayed in the real world.
- Customizable Content:
 - Dynamic library of games or activities for the child to participate in and interact with the doctor for better communication.
- Reward System:
 - Implementation of rewards for completing simple exercises.
- Motivational System:
 - Promote the child for good engagement.
- Basic Text-to-Speech System:
 - For better communication skills, we have a text-to-speech system so the child can also learn.
- Progress Tracking System:

- Useful for the licensed professional to maintain a curriculum with the child and keep steady progress.
- Emotion Recognition Assistant:
 - To maintain the safety of the child and have a safe environment and to keep the child at ease.
- Visual Setting Customization:
 - Adjust brightness, sounds and animations to accommodate the child wearing the headset.
- Voice Recognition and Commands:
 - Implement for an interaction through voice commands.
- Multi-language Support:
 - Create new ways of learning using different languages.
- Alert System:
 - Allow professionals to act if the child is under any kind of stress.
- Offline Functionality:
 - To maintain integrity and confidentiality, we will develop some parts with offline capabilities to keep information of patients secure.

VIII. NON-FUNCTIONAL REQUIREMENTS

Our current non-functional requirements for the project are as follows:

- System Usability:
 - Make the system easy for both the medical professional and the child to use.
- Performance:
 - The system should always run smoothly and not cause any disturbance during the therapy session.
- Portability:
 - For cases where the child needs to be attended to in a different setting, have a way to keep data and take it to where the session will occur.
- Scalability:
 - Implement a database for keeping more patients.
- Availability:
 - The system should be ready at any time of the day.
- Security:
 - Access to confidential information should be given to medical professionals and the creators of the system.
- Maintainability:
 - Maintain updates for the software to prevent any intrusions and keep the software running without any problems.

IX. CYCLOMATIC COMPLEXITY

To evaluate the complexity of our system, we conducted a cyclomatic complexity analysis on the main functional modules of the software. Our system diagram includes major modules such as the AR activity interface, text-to-speech communication module, and progress tracking system. After analyzing the complete module structure and their control paths, the total cyclomatic complexity was calculated to be twelve, this indicates a moderate level of complexity. The

result reflects our design intention to maintain simplicity and usability, particularly considering our target users. The cyclomatic complexity evaluation was supported using GitHub Copilot, an AI-based assistant, which helped in structuring the control flow analysis and refining the module logic [18].

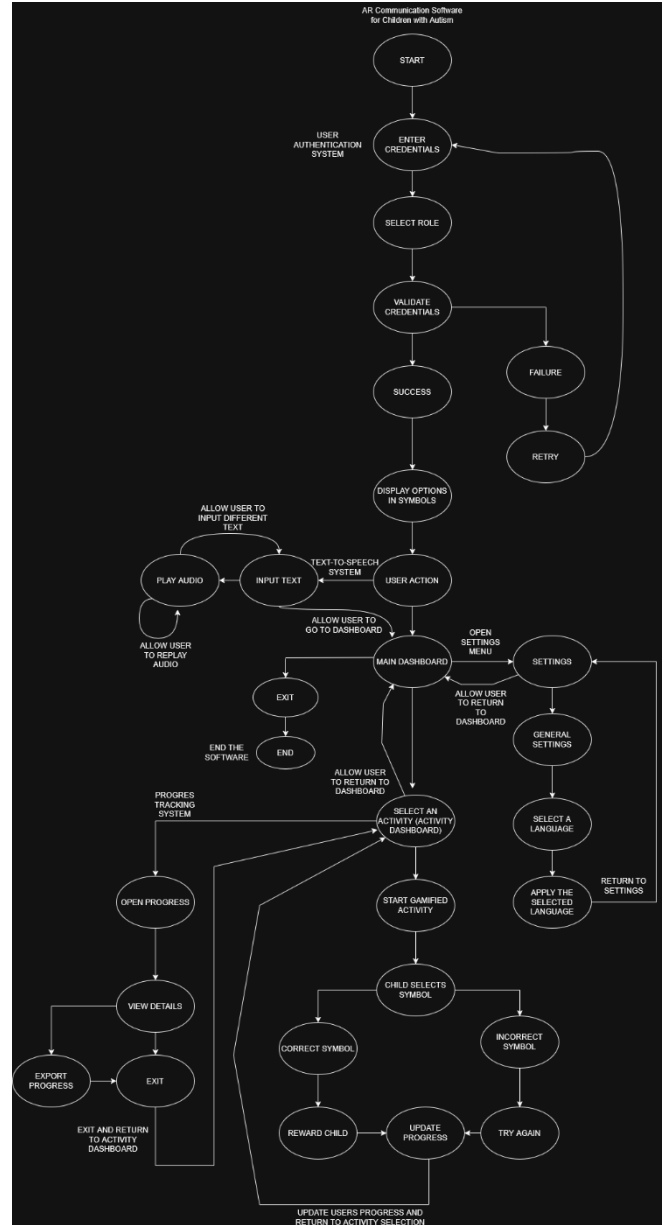


Figure 7: Cyclomatic Complexity Graph.

X. APPLICATION IMPLEMENTATION

This section details the concrete development and implementation progress achieved during the Capstone II phase, focusing on the system architecture, database development, and the completion of the first educational activity.

A. Core Application Infrastructure

The core application, developed in Unity Engine using C#, is a standalone APK application targeting the Meta Quest 3s headset.

- **Account Administration Panels:** Fully functional sign-up and login panels have been developed to manage the creation and administration of user accounts. These panels are the main interaction that the user will be able to do as soon as the application is started.



Figure 4: Authentication Panels.

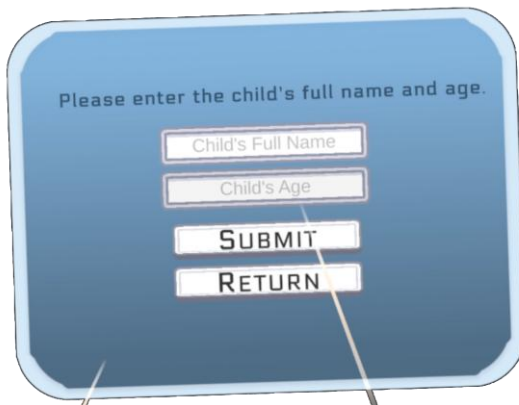


Figure 5: Sign Up Panel.

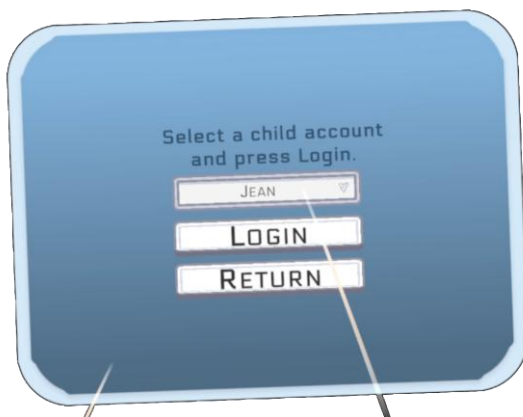


Figure 6: Log-in Panel.

- **Dashboard Development:** The entire main user dashboard is complete, providing centralized navigation to key sections: Activities, My Profile, Export Data, Settings, Help / About, and Logout. Currently, the Activities and Settings submenus are the menus that have been fully developed with their intended purpose implemented. The other selections which lead to the other submenus must be developed. The icons used to facilitate with

navigation were generated with the assistance of Gemini Pro (a generative AI designed by Google) [19].



Figure 7: Main Dashboard of The Application.

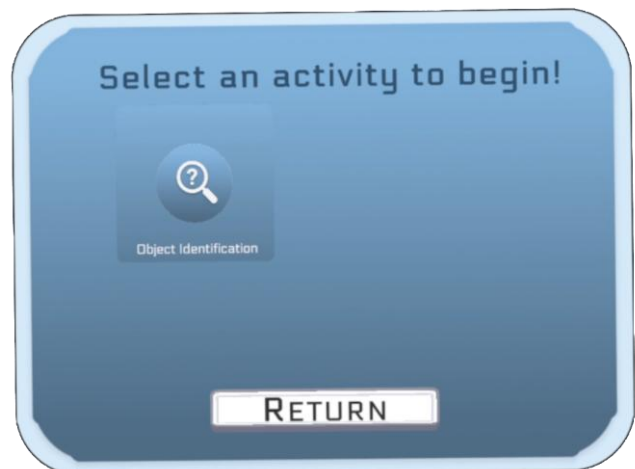


Figure 8: Activities Selection Submenu.



Figure 9: Settings Submenu.

The settings menu will serve as the hub for anything related to the applications settings. Currently we have implemented sound effects when the user selects/clicks on a button, thus we have developed an audio volume setting in which stores the preference based on the account that is logged into the application.

B. Object Identification Activity

We have developed and fully implemented the first activity called “Object Identification”.

- **Purpose:** The purpose of this activity is to aid the child in identifying everyday objects in a safe, controlled AR environment. This activity is meant to expand their vocabulary and object knowledge.
- **Mechanism:** The activity presents two AR-rendered objects (left and right) with a textual prompt on the top of the screen (e.g., “Select the kitchen chair.”), requiring user selection.
- **Data Integration:** This activity is fully integrated with the database, successfully creating and logging accurate entries in the database tables.

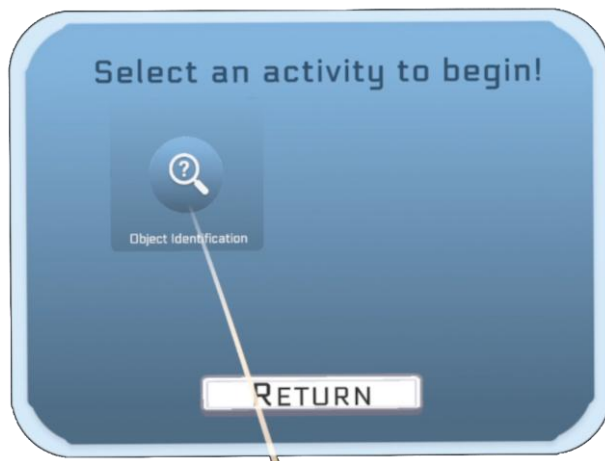


Figure 10: Object Identification Activity Selection.

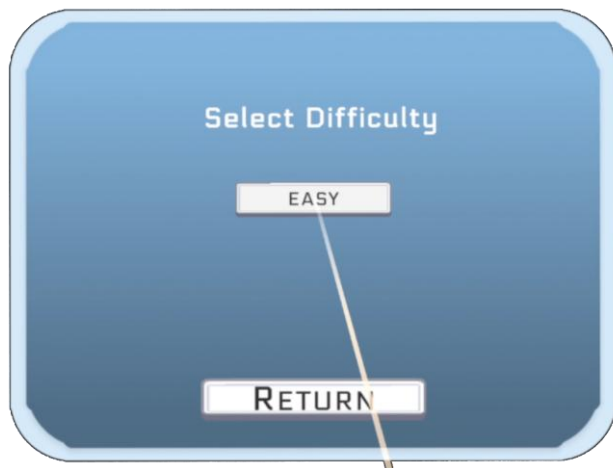


Figure 11: Difficulty Selection for The Activity.

- **Difficulty Selection:** The activity features a difficulty selection screen in which the user will be able to select the activities difficulty. Currently the Object Identification activity features an “Easy” difficulty but there will be more difficulties implemented into the activity.



Figure 12: Start Pop-Up for The Activity.

- **Start Pop-Up:** Once the user selects the difficulty the activity scene will load, and a popup panel will appear prompting the user to get into a safe and open environment before starting the activity. This is because the activity relies on assets that will spawn in the environment, and they will need to be in an open space.

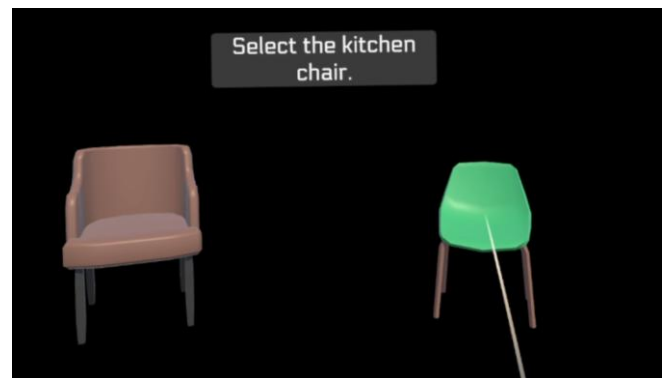


Figure 13: Object Identification Activity in Action.

Once the user selects the “Start” button the activity session will start. They are shown two objects and a text prompt with the task that they must complete (**Note:** the background of the activity is black because this screenshot was taken with the Meta Quest 3s headset connected to the computer and connected to Unity Engine, currently Unity Engine does not support passthrough therefore the background won’t show the real world as AR should and instead shows a black background).

- **Pause Menu:** The activity features a fully functional pause menu that allows the user to either “Continue” the activity or “Exit” the activity. If the user selects the “Exit” button, then they will be taken to the activity selection menu.

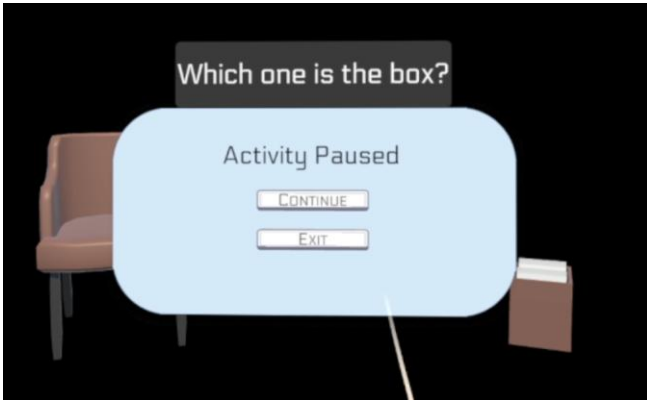


Figure 14: Activity Pause Menu.

- **Activity Completion:** When the activity is successfully completed and all tasks were done. The user is then shown a pop-up panel that tells them that the activity was completed, and it shows them the score that they received.



Figure 15: Activity Completion Pop-up.

C. Database Schema and Logic

The standalone application features a fully localized SQLite database utilizing a Unity Engine plugin called **SQLite4Unity3D**. This plugin allows us to safely implement our database in the application completely localized without the need for the application being connected to the internet. The following tables constitute the current schema:

| Table Name | Function/Data Stored |
|----------------------|---|
| ActivityConfigPreset | Holds difficulty settings and activity parameters to prevent hard-coding difficulty logic in multiple scripts. |
| ActivityResponse | Stores every individual response detail from the activity, including the item presented, the child's selection, and the time taken to answer each item. |
| ActivitySession | Stores high-level session metadata: session start/end time, total duration (in seconds), and the total amount of items presented during that session. |
| ChildAccount | Stores basic child profile information (full name, age). |
| ProgressMilestone | Designed to store achievement data and track milestones achieved by the child for motivational purposes. |

Table 1: Database Tables.

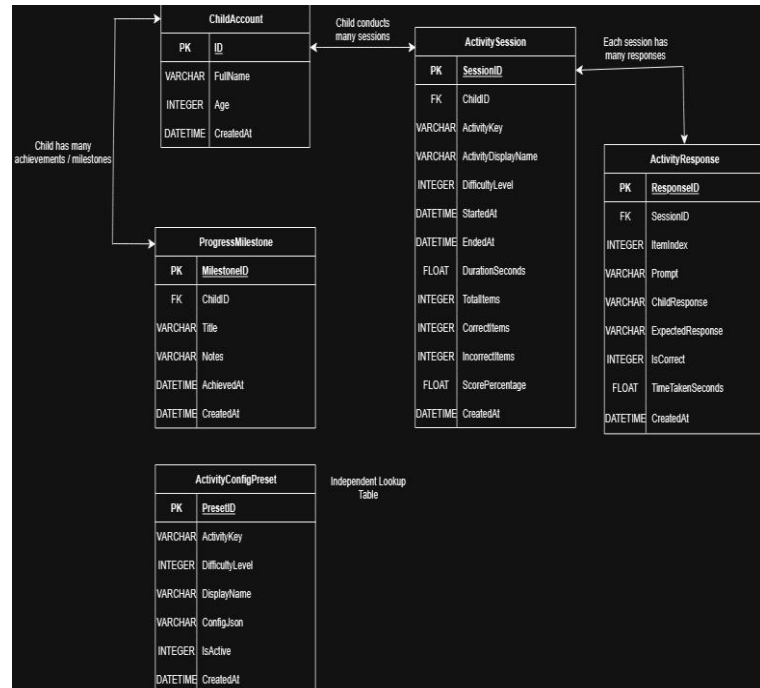


Figure 16: Entity-Relationship Diagram of our Database.

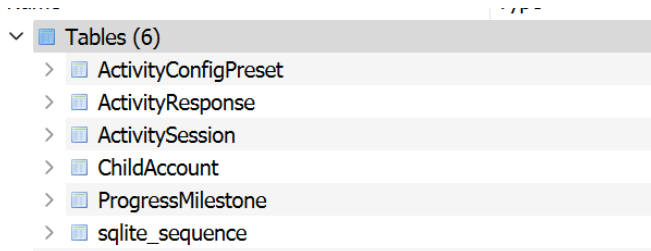


Figure 17: Database Viewed with DB Browser (for SQLite).

Currently the ChildAccount and ActivitySession tables are fully implemented. Our current activity successfully records and inserts all relevant information upon session start, pause, and exit into the ActivitySession table.

XI. FUTURE WORK AND OPTIMIZATION

The remaining efforts will focus on:

- Implementing the other two planned activities for the application.
- Implementing the Medium and Hard difficulty configurations for all activities.
- Conducting aesthetic and performance optimization of the application.
- Implement the logic of the remaining menus and any of the remaining features.
- Develop the Companion Web Application, including secure clinician login, the data import utility, and the data visualization (charts and graphs) components.
- Implement the other database tables into the application.

XII. CONCLUSION

In conclusion, we are making fast and considerable progress in the development of our project. The Capstone II phase has successfully transitioned the project from its theoretical design foundation to a functional prototype. The implementation of secure authentication, the centralized dashboard, and the completion of the Object Identification activity represents an approximate 50% of the overall project completion. With the foundational data integrity established by the fully functional **ActivitySession** table, the project has validated its core technical architecture.

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