Design of a Mobile Language Learning App for Students with ADHD Using Augmented Reality

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***Abstract*—Attention Deficit Hyperactivity Disorder, ADHD for short, impedes submission to traditional teaching as it affects cognitive abilities such as executive function skills, memorization, and focus. In this case, how will kids with ADHD learn languages? This paper provides a solution by presenting the capabilities of a mobile language learning tool called AugmentedFocus, which is designed to support children with ADHD through the use of augmented reality. This association has allowed personalized instruction, accompanied by noticeable augmented reality elements so that learners, teachers, and administrators are able to use their mobile phones to comprehend instructional materials. The objective is to evaluate the application's design, architecture, prototype, some testing results, and adjustments made during its implementation, while discussing other features within the context. More significantly, we aim to demonstrate how the mobile application can enhance engagement and retention in language learning among kids with ADHD. Attention Deficit Hyperactivity Disorder obstructs dependency on traditional measures of teaching since it relates to cognitive skills like executory function skills, memory, and focus. In this case, how will kids with ADHD learn languages? This paper addresses the issue by demonstrating the effectiveness of a mobile language learning app, AugmentedFocus that is specifically created for ADHD kids and shows a Technology in education.**

***Keywords*—ADHD; augmented reality; language learning; technology in education; mobile application; design; prototype**

I. Introduction

ADHD is a neurodevelopmental condition that significantly impairs children's ability to concentrate, focus, and retain information thereby posing great challenges within an educational environment [1]. Traditional methods of learning may not be appropriate for an individual with ADHD because of attention and memory problems entailed by such a disorder. Emerging technologies in education, like AR, may introduce new ways to support these students by engaging them in more interesting and interactive learning experiences [2].

Augmented reality is a technology that has appeared in recent years and is being widely used in different areas. In this case, we are looking to adapt this technology to the learning of children with ADHD because they have great difficulty concentrating and this tool allows them to learn in an entertaining and effective way [3]. Because of this we decided to create a mobile application using augmented reality focusing in ADHD students.

The primary goal of this app is to improve attention retention and reduce impulsivity through interactive and engaging educational content [3]. Using a smartphone, students can access a variety of AR-enhanced lessons. Teachers and administrators also benefit from functionalities that simplify content management and tracking student progress.

Although it was not easy to use augmented reality tools due to our inexperience, this was not a reason not to continue with the research and we continued forward until we achieved the objective.

II. Literature Review

Technological progress in the educational sector has brought forth more ways to better learning, especially for people with cognitive challenges. A new method is by using augmented reality, which places digital elements into the real world so that an interesting mixed environment is created; this has been proven by some studies to help keep students' attention, which is very important to people with ADHD [4, 5].

Previous studies have pointed out AR use in creating relatively immersive learning experiences that foster cognitive engagement, especially through immediate feedback [6]. The use of AR in education has been applied to various fields, from science to language learning [7]. Specifically, however, its use as a methodology for teaching language to students with ADHD has not received much attention. This involves an improvement over the existing work by applying AR where it might best benefit such learners, meeting their individual cognitive design requirements.

Research in study [29] was conducted where an interactive laboratory with augmented reality was successfully implemented for engineering, arts and social sciences, and science students. It facilitates practical learning in various disciplines. Within a period of two years and six months, it attracted 7952 student visits and was used in 24 subjects. Despite the obstacles that appeared (lack of augmented reality content and insufficient technical support), the research demonstrated the great interest that students had in the laboratory, where 71.5% were from engineering [29]. Unfortunately, the laboratory was stopped due to the appearance of the COVID-19 pandemic.

III. Methodology

The approach taken in the development of AugmentedFocus was user-centered and iterative, ensuring that the needs of students with ADHD were addressed at every phase. The methodologies followed were Scrum for software development, Flutter for the mobile app design, and ARCore for integrating any augmented reality functionalities [8] [9].

A. Scrum Method

Scrum is an agile methodology framework primarily focused on software development, although it is being attempted to be used in different areas. The objective of this methodology is to facilitate collaboration within a development team and to deliver products constantly, i.e. in an iterative manner. The main agile principles used by Scrum are adaptability, collaboration and continuous delivery [20]. Fig. 1 shows the order of the tasks developed in the Scrum process.

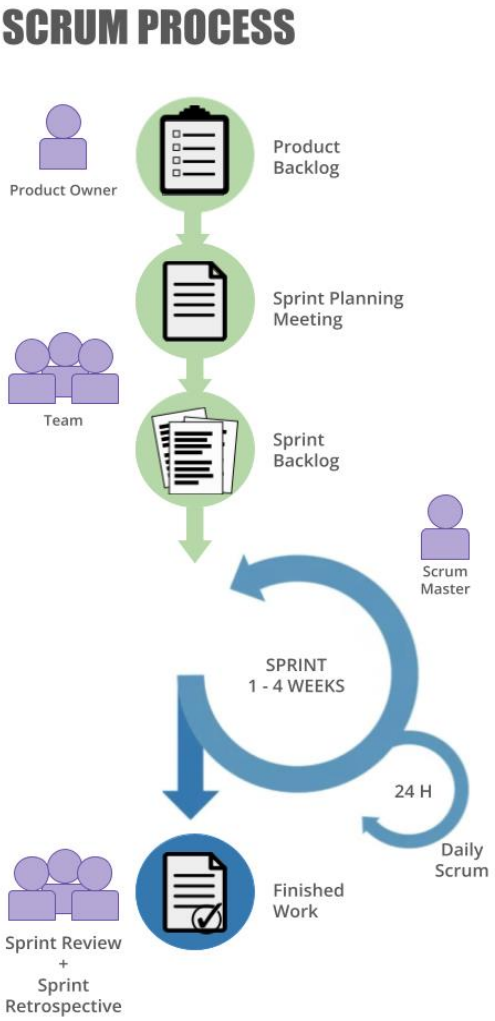

Fig. 1. Scrum process.

The Scrum methodology is composed of four essential components.

1) Small, multidisciplinary teams: Small, multidisciplinary teams that self-organize for the development of each phase and work together to achieve a common goal.

2) Roles

a) Scrum master: The person in charge of supporting the Scrum process, helps solve problems and ensures that the Scrum process is followed.

b) Product owner: This is the representative of the product's stakeholders, helping the team to set the objective to be achieved and prioritize what should be developed.

c) Development team: They are responsible for developing the product and delivering it.

3) Artifacts

a) Product backlog: This is the planned and prioritized list of requirements and tasks to be developed by the Development Team during the development of the product.

b) Sprint backlog: It is the set of tasks chosen for development within a Sprint.

4) Events

a) Sprint: This is the fixed development period in which the chosen set of requirements is implemented.

b) Daily scrum: Short, daily meeting held by the development team to check progress.

c) Sprint planning: Meeting for planning a Sprint.

d) Sprint review: Review meeting of the work accomplished throughout a Sprint.

e) Sprint retrospective: Reflection by the Development Team on a Sprint to find points for improvement.

B. System Design

The AugmentedFocus architecture was designed to support high levels of engagement, ease of use, and scalability. The mobile app was built using Flutter, a robust framework that enables cross-platform compatibility, ensuring that the app can be deployed on both iOS and Android devices [10]. This framework also enables rapid prototyping and testing, which was essential in the iterative design process [11].

Data management and security were priorities from the early stages of development, selecting Firebase as the primary database to store user information, lesson content, and AR assets. Firebase offers cloud-based scalability and strong integration with mobile platforms, making it a suitable choice for this project [12].

The backend API was implemented using Django, a Python framework known for its security and ease-of-use features [13]. Django provided the tools needed to build a secure and responsive application programming interface (API) that connected the mobile frontend to the database and notification system. The API handles user authentication, lesson retrieval, AR asset management, and notifications, which are critical features to ensure a smooth user experience.

C. Augmented Reality Integration

The core functionality of AugmentedFocus lies in its AR-enhanced lessons. We used the ARCore SDK to create immersive and interactive learning environments that integrate 3D objects and animations into language lessons [14]. ARCore was selected due to its compatibility with most smartphones and its ability to render high-quality 3D models in real-time, which is essential for creating engaging content for students with ADHD [15].

AR lessons are designed to incorporate language learning into interactive tasks, such as assembling virtual puzzles, interacting with 3D objects, and completing language-based challenges in a simulated environment. This gamification of learning has been shown to increase motivation and engagement

among students with ADHD, who often struggle to concentrate in traditional learning environments [16].

D. Testing and Evaluation

To ensure that the system met the needs of its users, several rounds of usability testing were conducted with students, teachers, and administrators. Participants were asked to complete specific tasks within the app, such as logging in, accessing lessons, and interacting with AR content. Their feedback was collected and analyzed to identify any usability issues or technical problems that required adjustments [17].

A mixed-methods approach was used to evaluate the application. Quantitative data was collected through system logs and performance metrics, while qualitative feedback was obtained through surveys and interviews with participants. This comprehensive approach allowed us to understand both the technical performance of the system and the user experience aspects [18].

E. Design tools

1) Figma: The use of Figma was essential for the design of the application since this allowed the different prototypes and mock ups to be made in addition to allowing collaborative work with the Development Team because it is a cloud-based technology where several people can edit in real time.

2) Vertabelo: This tool allowed us to create the application's database diagram thanks to the fact that it manages a structure of tables, indexes and relationships between them. This tool was very useful since it is based on cloud technology, which allows the Development Team to work collaboratively.

F. Development tools

1) Flutter: Flutter is an open source development framework created by Google. Firstly, it is well known for its high cross-platform compatibility when developing mobile applications and its simplicity when developing thanks to the Dart language. Secondly, it is a very good work tool because it offers the Hot reload functionalities that allow you to see the changes instantly without restarting the application and Widgets that are reusable components to build the application [10].

2) Dart: It is an open source programming language aimed at developing frontend applications, especially web and mobile. This programming language goes hand in hand with Flutter and is what makes it well known in the creation of multiplatform applications. What stands out most about Dart is the simple syntax it uses because it is very similar to Java, JavaScript and C++, flexible compilation, object-oriented, support for asynchronous functions, automatic memory management and great multiplatform support. Given all of the above, this is why Dart and Flutter are a great match in the frontend development of applications.

3) MySQL: It's relational database manager developed by Oracle. We chose because of his ease of organizing, managing and storing data for application testing.

4) Android studio: An integrated development environment (IDE) for developing Android applications, created by Google. This IDE allows development in languages such as Java, Kotlin, and C++.

5) Firebase: It is a platform based on cloud technology which offers various services such as real-time database, firestore, authentication, storage, hosting, messaging, analytics, crashlytics, predictions and other functionalities based on cloud databases. Firebase was mainly used to host our real-time database and to store and synchronize application data [12].

6) Django: It is a high-level framework that uses the Python programming language, which is characterized by its high development speed, but it does not leave security aside and helps developers avoid common errors in data security. It is also very efficient with both scalability and versatility, allowing developers to adapt their application to the needs of users. Django was chosen due to its ease and speed of development, as well as the great compatibility it has with applications that are related to augmented reality [13].

7) AR Core: It is the SDK developed by Google that focuses on offering a tool to create new interactive and immersive experiences on Android, iOS, Unity and the web. Using interactive objects in the virtual world where it includes motion tracking, depth understanding, environmental understanding, presenters and light estimation. The main use of this tool in the application is to provide augmented reality functionality to generate interactive classes for students with ADHD and thus capture and maintain the attention of students [14].

IV. Development of the Methodology

The Rational Unified Process (RUP) methodology was adopted to guide the development of AugmentedFocus. RUP is a software development process that divides the project lifecycle into four distinct phases: initiation, elaboration, construction, and transition. This methodology was chosen because it offers a structured approach to software development, which is crucial for managing complex projects such as AugmentedFocus [19].

A. Initiation Phase

During the initiation phase, the main focus was on understanding the application requirements, including the specific requirements of students with ADHD. Through collaboration with educators and specialists, key functionalities that AugmentedFocus should include were identified: AR-enhanced lessons, user-friendly navigation, and robust security for student data [20].

Stakeholder meetings were held to align project goals, feasibility, and timelines. An early prototype of the app was also developed to provide a proof of concept for the AR features and mobile interface.

The application requirements were identified through meetings and a prioritized list of applications was created Table I.

These are the functionalities to be developed identified thanks to the meetings with the Product Owner. These user stories also have their own task to be make for every developer during a sprint.

TABLE I. PRODUCT BACKLOG

Code	Title	Value (1/2/3/5/8)
US001	Complete a learning activity with augmented reality	8
US002	Access progress statistics	2
US003	Access additional educational content	5
US004	Record activity progress	1
US005	Set up custom activities with augmented reality	5
US006	Download augmented reality content for offline use	2
US007	Check achievements and progress in activities	2
US008	Log in to the app	1
US009	Interact with objects in augmented reality vocabulary	8
US010	Do vocabulary exercises with augmented reality	5
US011	Explore virtual reality with augmented reality	3
US012	User data security	1
US013	Application accessibility	1

B. Elaboration Phase

This phase includes the system architecture and design. Use cases were defined and a detailed system design was created that described how the various components of the application would interact with each other. The first functional prototype of the application was also developed in this phase, focusing on key features such as user authentication, lesson retrieval, and AR integration [21].

We started with first versions of Fig. 2 logic and Fig. 3 physical diagrams for the app before doing the C4 model diagrams with more specific information.

C. Construction Phase

This phase it's totally focused in the entire application, it was developed in Flutter, we used it to build the front-end of the mobile app, ensuring cross-platform functionality [23]. In parallel, the backend API was built using Django, while Firebase managed data storage and real-time communication between the server and mobile devices [24].

The version control used was github and everything about the application (backend, frontend) is in the repository. We used android studio during the whole development process and using the virtual simulator of android studio to test the application.

D. Transition Phase

This phase focus on deploying the application and ensuring its stability in real-world environments. It includes extensive testing to ensure that the application worked well on different devices and operating systems. In addition, final usability testing was conducted to validate that the user interface was intuitive and accessible for students with ADHD [25].

E. Development

The following images present the system architecture at different levels of the C4 diagram:

The system has three users:

1) *Students with ADHD*
2) *Teachers*
3) *Administrator*

Where these interact with the AugmentedFocus application which is composed of Mobile Application Frontend and Mobile Application Backend, it contains sign-in, security, authenticator controller, AR module, AR controller, lesson controller and notifications functionalities all connected to the database hosted in Firebase, in addition to an external notification system. After that we designed our C4 model diagrams. Firstly Fig. 4 context diagram secondly Fig. 5 container diagram and finally, Fig. 6 component diagram.

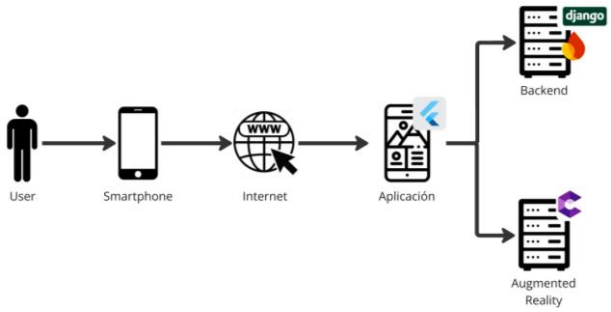

Fig. 2. Logic diagram of AugmentedFocus.

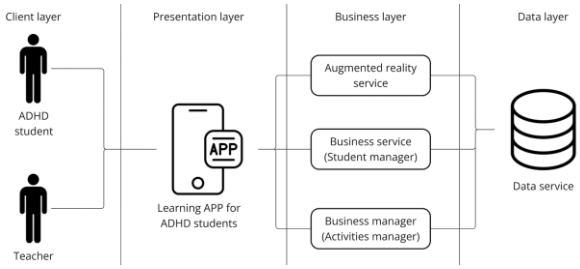

Fig. 3. Physical diagram of AugmentedFocus.

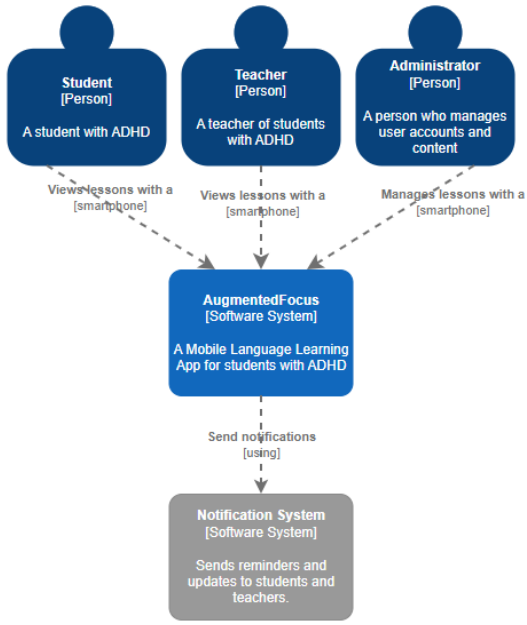

Fig. 4. Context diagram of the AugmentedFocus system.

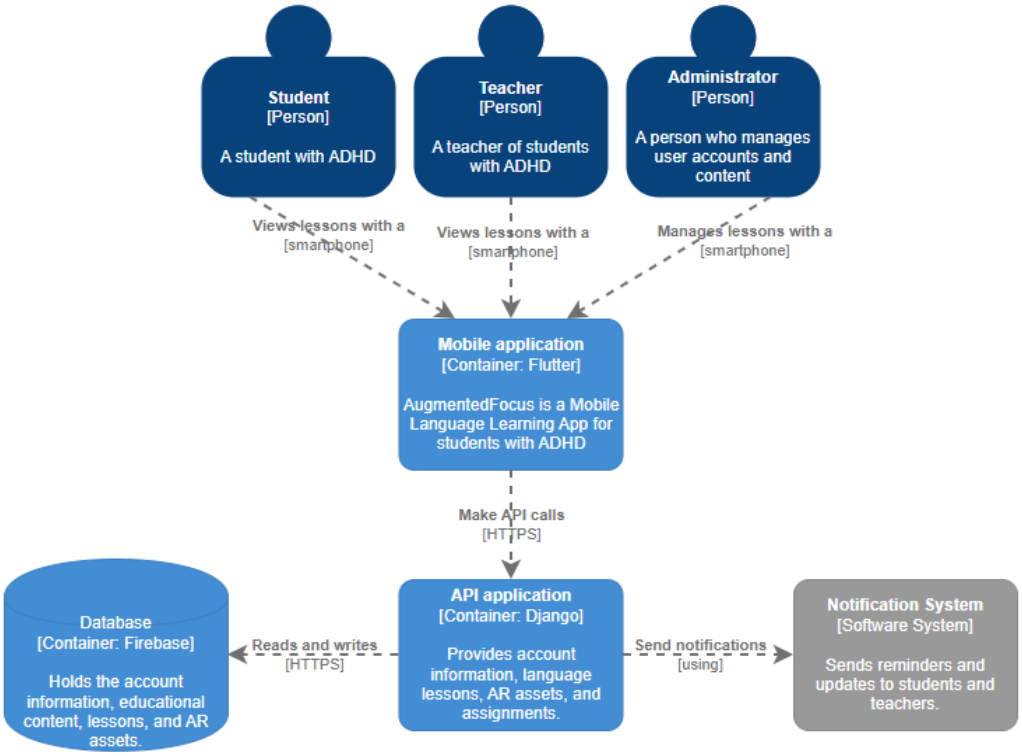

Fig. 5. Container diagram, showing how different systems interact with each other.

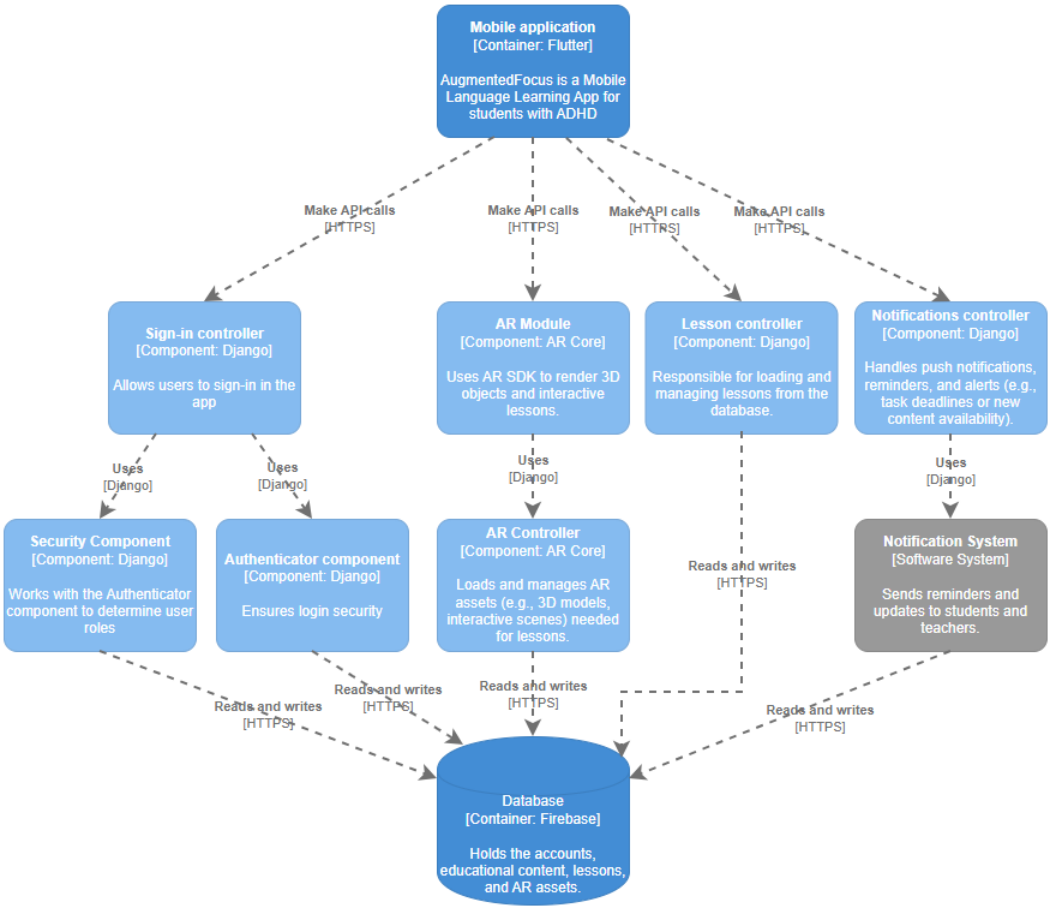

Fig. 6. Component diagram detailing the interactions between the different modules of the system.

After design of the C4 diagrams we decided to start with the mobile application prototypes, since it's an application for kids and teachers we needed to focus on something simple but at the same time useful for our users. Prototypes were designed for the application design which are: Fig. 7 - Welcome Prototype, Fig. 8 - Sign in and Register, Fig. 9 - Upcoming events and Course list, Fig. 10 - Course unit list and Course topic list, Fig. 11 - Grades and Profile, Fig. 12 - Activity and Activity description and Fig. 13. An example of an augmented reality activity. We choose a warm colors and an interface based on a kind of virtual classroom for students because we needed the structure that can be organized due to the activities and different courses that may exist in the school or institute.

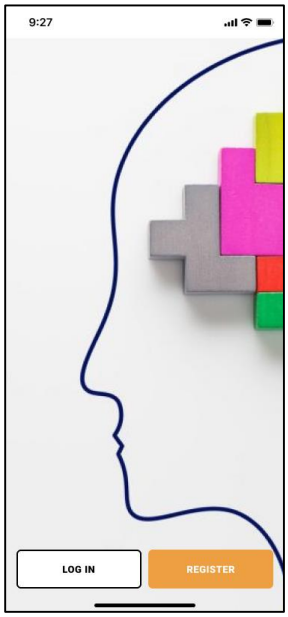

Fig. 7. Welcome prototype.

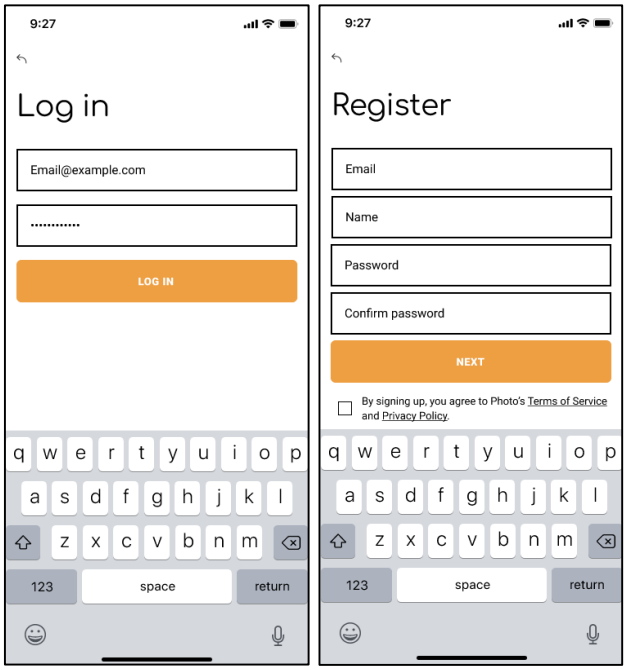

Fig. 8. Sign in and register prototype.

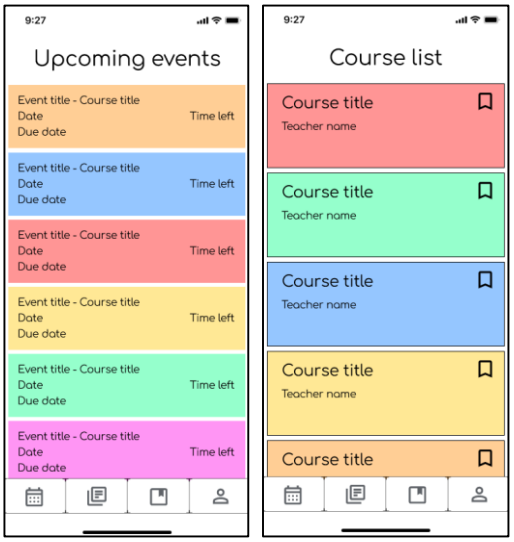

Fig. 9. Prototype upcoming events and course list.

Fig. 10. Prototype of course unit list and course topic list.

Fig. 11. Prototype of grades and profile.

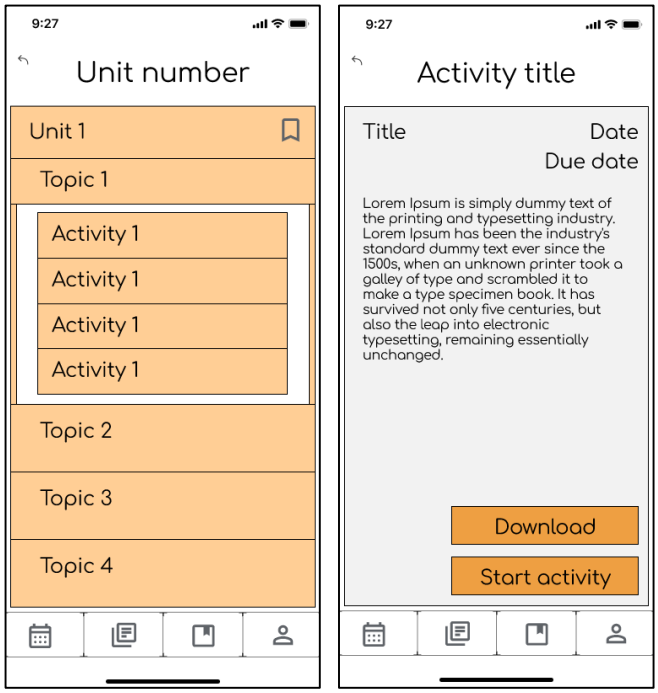

Fig. 12. Prototype of activity and activity description.

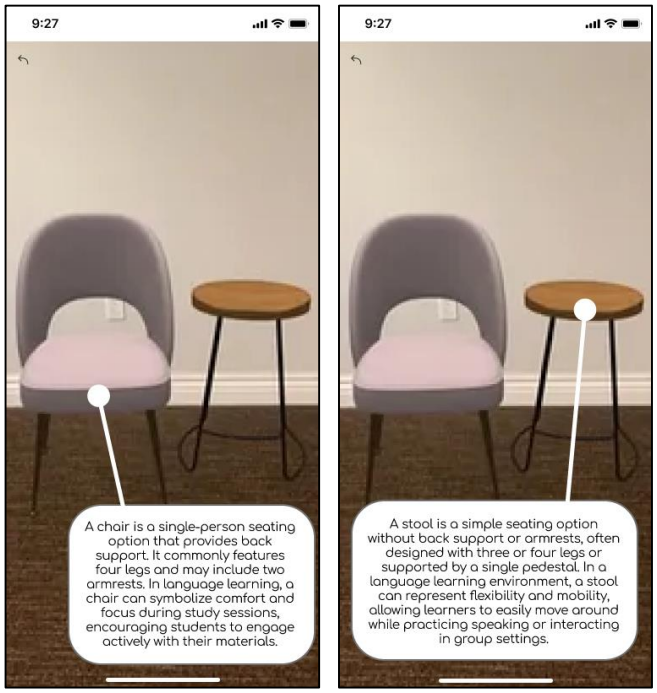

Fig. 13. Prototype of example of augmented reality activity.

V. Application Features

The application offers three very important functionalities to help children with ADHD learn language, including augmented reality activities, a student grade manager, and an augmented reality activity manager.

A. Activities with Augmented Reality

This feature is the main and most important of the application, which gives students the possibility of carrying out language learning activities with augmented reality. This involves interactively combining language classes with 3D models to capture the attention of students with ADHD, which allows capturing and maintaining the attention of these students.

B. Student Manager

Once all students have their account, teachers will be able to monitor information, grades and progress to check their performance within the course and in the same way check whether students are adequately acquiring the knowledge from the classes.

C. Activity Manager with Augmented Reality

The platform provides a manager for augmented reality activities that allows you to enable or disable the different augmented reality activities. This functionality is only enabled for the application administrator.

VI. Results

The tests of usability were done getting a completely well-done performance, the AugmentedFocus app over ten weeks of development. Key performance indicators are lessons activities, lesson completion rates, and feedback on the usability made by the development team. The results were good showing a nice performance and content compared to traditional learning methods. Since we are in the development phase our results are the design and development of the application, which is ready to be tested with real students with ADHD.

VII. Discussion

The results of this study, however, conform to previous studies noting the advantages of augmented reality for students, particular those who are slow learners or have attention problems [26] [27]. The attention deficit that these students may at times present, as a characteristic feature of an educational environment, was mitigated by AR-designed lessons which are interactive and more engaging for students with ADHD [22], [28]. It was evident that this method not only improved students' concentration but also contributed to create a lively and interesting atmosphere which is important in enhancing learning in such age groups. The AR lessons were able to provide experiences that integrate both active visualization and interaction thus making the acquisition of knowledge and skills much easier.

VIII. Conclusion

As AugmentedFocus proves, there can be useful applications of augmented reality in helping students learn with Attention Deficit Hyperactivity Disorder (ADHD), especially in foreign language learning. In the case of this particular app, interactive lessons which also include some gamification elements were included which lead to children having improved focus in their tasks as well as less impulsiveness which is often characteristic of this demographic and is a major obstacle to learning. In this light, the above results indicate that the adoption of new technologies such AR for example, can help change the concept

of how the teachers teach learners with lower cognitive abilities in an even better manner and that is a universal fit approach.

IX. Future Work

Future development of AugmentedFocus will focus on expanding the app to cover a broader range of subjects beyond language learning, such as math, science, and social studies. The approach will broaden the platform's utility, allowing more students to benefit from its interactive features. Additionally, we were thinking about adding adaptive learning algorithms to further personalize lessons based on each student's individual progress and behavior. By tailoring content to users' specific needs, it is hoped to improve learning effectiveness and foster greater motivation. The long-term impact of AugmentedFocus on students' academic performance and emotional well-being will also be evaluated, with the goal of creating a comprehensive educational tool that responds to the unique demands of those with ADHD.

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