Virtual Reality for Early Childhood Education: A Technology-Driven Approach to Learning Arabic Alphabets and Numbers

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***Abstract*—The integration of Virtual Reality (VR) in early childhood education has garnered significant attention for its potential to enhance learning experiences. This study focuses on the development of a VR-based educational application for children aged 3 to 7, designed to improve learning outcomes and increase engagement in learning the Arabic alphabet and numbers. The application was developed using the Waterfall model, which provided a structured approach through the stages of analysis, design, coding, testing, and maintenance. A comprehensive survey was conducted to assess the application's technical performance, design, content, and overall user experience. The results indicate that the application successfully motivates children to learn in an engaging and interactive VR environment. It demonstrated effective functionality on high-performance mobile devices and tablets. However, performance issues were noted on lower-end devices, with slower load times and occasional lag, highlighting the need for device optimization in future versions. Additionally, while the app's VR capabilities were praised, a non-VR version could improve accessibility for children without VR headsets. This study contributes to the development of innovative educational tools that combine immersive technology with early childhood learning. Future iterations will focus on enhancing device compatibility, accessibility, and exploring long-term educational impacts. This research lays the foundation for further advancements in VR applications for educational purposes, particularly for young learners.**

***Keywords*—virtual reality, education, childhood learning, interactive applications, Arabic language**

I. Introduction

The rapid development of technology has brought promising changes across many fields, including education, health, economy, and social behaviors, through various tools that have transformed traditional methods [1, 2]. Among these advancements is Virtual Reality (VR), considered one of the latest innovations that has brought about a qualitative shift in the interaction between humans and machines [3]. VR provides an interactive digital environment that simulates both real and imaginary worlds, which can be interacted with using specialized devices, such as VR glasses, headphones, and motion control tools [4]. VR enables users to engage with these interactive environments by integrating graphics computing, artificial intelligence, and sensors to create an immersive experience that simulates the human senses [5].

Mobile learning, particularly in early education, has become a significant trend, as applications offer attractive, fun, and easily accessible learning environments for children [6]. This approach relies on integrating technology to communicate ideas to children using VR, artificial intelligence, and multimedia tools [7]. These applications provide environments that encourage active participation from children, utilizing senses such as touch and immediate response [8]. Additionally, they rely on the concept of gamification to increase motivation and reduce the boredom often associated with traditional learning methods [9]. This flexibility allows children to learn at their own pace, anytime and anywhere, enhancing the educational process both at home and in school [10].

Education has adopted VR due to the immersive, creative, and interactive opportunities it provides students to experience situations and environments that aren't possible using traditional texts [11]. With VR, common educational barriers ingrained through traditional methodology are minimized. In early childhood education, VR takes educational tools and provides a unique and immersive experience that ignites and engages children using interactive real-world learning experiences, while simultaneously allowing for entertainment [12]. VR promotes interaction and attention by providing a dynamic learning environment that enhances the educational experience while reducing distractions [13]. This immersive environment, resembling a game-like experience, fosters enthusiasm among children, motivating them to participate and continue learning, thus facilitating comprehensive skill development [14].

Early education is important, as it is considered the basis for developing cognitive and linguistic skills [15]. Piaget's theory of cognitive development [16] and Vygotsky's theory of social learning [17] are regarded as the most significant theories concerning cognitive learning; both were fundamental in creating this educational VR application. Piaget supported the idea that early childhood should involve hands-on, active learning experiences, which aligns with the VR design implemented in this study. According to Vygotsky's social learning theory, social interactions play a crucial role in learning. The application fosters learning by allowing children to engage with virtual peers and educational content, stimulating their cognitive and social development. These theories inform the design of the application and emphasize an experiential and collaborative learning experience in VR.

Traditional methods of teaching the alphabet and numbers face challenges in capturing children's attention and motivating them to learn [18]. With technological

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advancements, VR has emerged as a tool that enhances learning by offering direct, sensory-rich experiences [19].

This study focuses on the experience and development of a VR application for children, as well as improving the educational process and enhancing it by simulating the educational process using VR to provide a more interactive three-dimensional environment. This application aims to complement traditional education by offering an engaging, child-friendly alternative. This interactive approach allows children to be exposed to the alphabet and numbers within pretend play to better understand the concepts with sight, sound, and touch association. This research further examines the technical, pedagogical, and some challenges facing the users of this application. In particular, this study describes the development methodology, application design, and outcomes of the first user experience evaluation. Ultimately, this research aims to offer clear insights into the effectiveness of VR as an educational tool in early childhood learning environments.

Based on the theories of cognitive development and language acquisition, this study hypothesizes that the use of VR will significantly enhance early childhood learning of Arabic alphabets and numbers by providing an engaging, interactive environment that promotes active participation and cognitive growth.

Although this application targets early learners, the design and development process follow structured engineering principles, particularly the Waterfall Software Development Life Cycle (SDLC) [20]. By combining immersive VR environments with formal system analysis, architecture design, and usability testing, this study offers a model for applying engineering-based pedagogical methods to early education.

II. Literature Review

Several research articles have investigated the application of VR in early childhood education, and the published literature indicates the high potential for cognitive and social learning through VR. Piaget's cognitive development theory posits that children learn best through active engagement and experiential learning. This aligns with the VR application created for this study to underscore engagement through interaction and task-based activity. In addition, Vygotsky's social learning theory demonstrates the role social interaction can play in learning, which the VR application supports by allowing children to interact with avatars and other interactive elements in a virtual environment**.**

According to Zhang's study [21], the authors summarize the use of VR technologies as an educational and interventional tool for Autism Spectrum Disorder (ASD). Based on prevailing rehabilitation and training theories, VR-based devices offer advantages in improving communication and interaction skills. The researchers reviewed empirical studies on VR applications for ASD and found that incorporating VR into training or treatment programs improves social aspects of functioning for individuals with ASD. Participants reported significant improvements in social functioning, emotion recognition, speech, and language after VR-based intervention. However, limitations include challenges related to the authenticity assumption, safety concerns, and ethical considerations. The research emphasizes that VR applications for communication and social interactions are based on the belief that virtual experiences reflect real-world behaviors. However, the realism of the virtual world can be influenced by factors such as the autonomy allowed in VR, the realism of avatars and scenarios, and how users interact with these systems.

Piaget's theory of cognitive development emphasizes active, hands-on learning. This supports the potential of VR as an interesting way to simulate an active learning environment, where children's active explorations, problem-solving, and discovery solutions [16]. Vygotsky's social learning theory can also be supported by VR's ability to promote social interaction, as VR provides children with opportunities for engaging with peers and avatars in a virtual environment, supporting their developing communication skills [17]. These theories suggest that VR can support both cognitive and social growth in young learners.

Further study [22] on the lasting effects of VR in early childhood education can help build a better understanding of the impacts of extended engagement with immersive, dynamic environments, to examine how this engagement affects social and cognitive development over time. This study could determine if extended exposure to VR influences academic achievement and long-term social behaviors overall.

Although VR has great potential in early childhood education, one of the biggest challenges it faces at the current time is accessibility in those circumstances when resources are limited. Across the globe, there are many areas where schools and educators cannot financially invest in quality VR equipment, including head-mounted displays, controllers, and computers, so that the applications can run effectively. These limitations could serve as barriers to the widespread use of VR in educational settings, particularly for the developing world or countries that are impoverished. One possible solution is that less complicated VR applications are readily available for mobile devices or less-expensive headsets, providing a less expensive form of VR that a wider number of schools and students could access. Similarly, Augmented Reality (AR) applications, which have lower-cost hardware requirements, could provide a similar or related solution in that they could provide an immersive, interactive way for young learners to experience education, while still being affordable.

As Garzón [23] implies, adding more affordable VR / AR options as part of educational contexts may help minimize challenges and concerns. However, it will always need more investment aimed at developing scalable, low-cost technology to offer these immersive learning modalities to underfunded classrooms.

VR has also been widely applied in enhancing cognitive and motor skills in early childhood. Studies like Moro [24] have demonstrated VR's potential in fostering creativity and problem-solving skills in young children by immersing them in interactive, gamified environments where they actively participate in learning through exploration. This approach aligns with research by Li [25], who found that VR helps improve attention span and engagement, particularly in children who may struggle with traditional educational methods. These immersive experiences not only capture children's attention but also facilitate deeper understanding through interactive, hands-on learning in a visually stimulating environment.

In the study of Yılmaz [26], the authors examined children's learning outcomes with an AR animal application concerning summer activities. In addition, a sequential exploratory research design was used to utilize both quantitative and qualitative methods of research. Two teachers and 37 students from the Ministry of National Education's Central District kindergartens in Kilis participated during the 2019–2020 academic year. One of the groups used the AR application while the other did not. The children were tested on animal recognition before and after the intervention. The authors found that animal recognition improved for both groups but that the AR group recognized more animals and were able to identify additional and more complex details, as indicated through their drawings.

Additionally, VR can help develop spatial awareness and analytical skills. Due to the ability of VR applications to create opportunities for children to manipulate, touch, see, and play with virtual objects and environments that provide opportunities for cognitive development with dynamic analytical challenge activities, which otherwise may not be possible with traditional educational resources. VR is an engaging way to develop critical thinking and logical reasoning skills [27].

To evaluate the impact of VR technology in early childhood education, it is important to evaluate the transparency of the data collection and the appropriateness of the assessment tools for collecting the data. The study will collect data with various evaluation measures, including surveys, observations, and teacher and parent feedback, which will include a comprehensive model of the VR application. The assessment tools and measures in this study will go through the validity process according to several stages, including pilot testing and reliability testing, to ensure valid and reliable data.

According to Ismajli's study [28], a descriptive analysis of how knowledge understanding seems to occur as a direct result of interactive strategies, considering the individual capabilities and requirements of each learner. The researchers aimed to describe the extent to which teachers differentiate instruction based on content and learning processes. The study was conducted with 200 students, 30 teachers, and 30 parents from both public and non-governmental schools. Results indicated that the perception of differentiated instruction in primary schools was not at the right level, and the differences between public and non-governmental schools were minimal. The study highlights the importance of collaboration between parents and schools in promoting differentiated instruction.

With the implementation of VR and AR technologies, educators can successfully customize the learning experiences for each child based on their learning style, including visual, auditory, or kinesthetic, thus creating personalized learning pathways for every student. Differentiated instruction is necessary for the different learning needs of children. For instance, VR with content modification can build off a child's learning style, resulting in more personalized learning experiences that strengthen engagement and retention.

This challenge is made even more difficult when using emerging technologies, such as VR and AR, where teachers need to be prepared to use these technologies. As reported by Marougkas [29], the preparedness and willingness of the teachers to utilize new technologies can be very significant to the success of VR or AR analysis undertaken by students in a classroom. Nevertheless, professional development and training teachers to use these tools with fidelity are necessary to optimize the educational value that VR and AR provide.

The studies reviewed show a clear upward trend in how VR and AR can be used for early childhood education. Along with traditional methods, these technologies significantly improve autistic children's social and communication skills. AR technology has proven successful in animal learning, and the exploration of differentiated instruction emphasizes the need to develop instructional strategies that meet students' varying needs. However, despite the successes, these studies also highlight several challenges or barriers that must be overcome before these technologies can be implemented more widely. Both VR and AR have demonstrated their effectiveness in specific educational areas, but more integrated applications are needed to meet a broader range of learning needs. In this study, the research will be expanded upon by creating a VR application designed to teach the alphabet and numbers, contributing to the growing body of knowledge in this area.

III. Research Methodology

This study utilizes the Waterfall model, which is one of the most common Software Development Life Cycle (SDLC) models [30]. The sequential nature of this model is illustrated as the process flows from requirements analysis, design, coding, testing, and maintenance [31, 32]. While the Waterfall model has its benefits, its most significant advantage is its rigid, linear process that helps the project move from one step to the next. For projects where the development process should be as clear and step-by-step as possible, the model is used to recognize design faults at the stage of product development. Additionally, it is applied in projects that require high-quality control, as it has large documentation and planning [33]. The study of Sinha [34] notes that the Waterfall model provides a detailed planning and documentation phase that anticipates problems earlier and provides a framework that better serves educational objectives. These structured phases also help with tracking progress, which is useful when designing content for younger learners who need an orderly, predictable delivery. Each stage is started and finished before progressing to the next stage, so the design stages of this model are sequential rather than overlapping. Using this guided method allows for the creation of educational tools in a systematic way to reduce errors, while also creating an efficient teaching and learning experience. The Waterfall Model follows Linear Sequential Steps, as shown in Fig. 1.

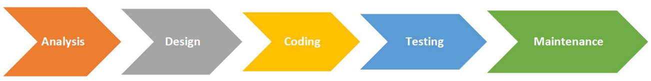

Fig. 1. Sequential phases of the Waterfall SDLC.

In the first stage, two main axes were applied: study and understand the characteristics of the research community to have a clear understanding of real conditions, and review the characteristics of the community, which is a prerequisite for knowing the research sample to be included in the research. These steps are widely viewed as important in setting the limits of the research and ensuring that the study is relevant to the stated goals.

Important aspects were analyzed, like cognitive abilities, span of attention, and technical skill, to ensure that the app was representative of children aged 3–7. This involved surveys and interviews with parents, teachers, and practitioners in early childhood education. These activities are based on Piaget's theory of cognitive development, which demonstrates hands-on learning, and Vygotsky's social development theory that emphasizes social interaction in the learning process during the data collection process.

The cognitive stages of the age group of interest were also carefully reviewed in this study. Understanding how children aged 3–7 develop skills, process information, and socially interact to determine not only how to develop the effectiveness of application design, but also how it could support a child's age-related development in learning.

The deliverables of this stage are a complete and clear set of requirements, promoting the development of an educational tool that meets protocols defined by developmental and educational frameworks.

To determine the sample size, the following formula was applied for a finite population [35]:

$$n' = \frac{n}{1 + \frac{n}{N}}$$

where:

n' = Adjusted sample size for a finite population

n = Initial sample size

N = Total population size

This formula ensures the sample size reflects the sample characteristics of the research community. Within the population characteristics of children aged 3–7, there were considerations in understanding their cognitive, social, and technological capabilities. In addition, the finite population correction was considered to ensure the sample is manageable, and identifies the representativeness while identifying a sample that will reflect accuracy, without knowing the size and characteristics of the targeted community.

Data collected from the questionnaires, surveys, and observations will be presented in visual formats as tables and charts in the results section to facilitate a clear understanding of the findings and their implications.

During the design phase, a survey was created in order to evaluate the feasibility and effectiveness of the VR application. The development of the survey started with defining the purpose of the survey and asking the questions that aligned with the purpose of the study. The questions were specifically written to reflect a clear meaning for the audience of teachers, parents, and children. The questionnaire used an expert review and pilot testing in part to assess its validity to ensure the content was valid. Reliability was established through test-retest and internal consistency. The questionnaire provided a measurement of perceptions of app usability, user engagement, and educational impact with specific attention to support for young learners. The final questionnaire included closed-ended Likert-scale questions.

Continuing in the Design Phase, the focus was on creating detailed architectural designs for the system based on the defined requirements. A database was designed to organize the content of the application. The User Interface (UI) was also developed with the goal of captivating children through 3D designs, bright colors, and gesture controls to ensure that children's attention is captured in an engaging and accessible manner. The UI included a main menu to access the educational activities "The World of Letters" and "The World of Numbers", as well as a 3D garden and interactive audio-visual elements to help attract children's attention.

As research by Zhang [36] indicates, the UI design for educational tools aimed at young children must be visually appealing and easy to navigate. Simplified interactions that avoid cognitive overload can enhance the child's engagement with the learning process. The 3D Max was used, with an A-frame library, and Adobe Photoshop. The application was designed to be interactive by supporting audio interaction and designing gradual educational levels to suit the abilities of all children.

The database was designed to keep track of the child's level and audio data for performance analysis. In summary, this stage includes designing an application that features game engines, interaction techniques, voice recognition, and storage. In addition, a questionnaire was designed at this stage to evaluate the feasibility of the application.

In the Coding phase, the Visual Studio Code program was used, which uses the A-Frame programming language. A system was built to learn the alphabet and numbers using VR and audio, kinetic, and visual techniques. The app uses different ways to teach the children by showing things (visual), using sound (auditory), and letting them move and interact (kinesthetic). This helps children learn in the way that works best for them, which is essential when developing educational applications for children. This approach helps enhance the engagement and retention of young users.

In the Testing phase, the application was tested for target users. The testing process coincides with the development phase to facilitate debugging and reduce wasted time and effort. The basic functions of the application were tested to ensure that all the application functions work as they should, such as sound effects, buttons, and images. Security tests and device compatibility tests were also conducted. User experience testing is crucial for educational software to identify any usability issues that might affect the effectiveness of learning.

After identifying and fixing the discovered bugs, the Maintenance phase is considered the last step of the waterfall phase. It included presenting the maintenance to general users, including the supervisor and the evaluation committee, who will provide a score for evaluating the application. In this phase, the bugs were fixed and addressed. The application was also evaluated to measure its effectiveness for community use, especially for children. The maintenance phase is important for educational software to keep the application updated to the times and continue to serve the user's requirements.

IV. Results

The questionnaire was distributed to 10 experts from Al-Zaytoonah University of Jordan. Additionally, questionnaires were distributed to 80 parents who assisted their children in answering the questions to assess the user interface of the application. These experts were professors from the Department of Arts, the Faculty of Architecture and Design, and the Faculty of Science and Information Technology. The experts were selected to include a mix of opinions related to the educational design, usability, and user interface of the application. The results were evaluated using a Likert scale and categorized the responses as Positive, Neutral, and Negative. A Likert scale is a widely accepted method of evaluation in studies of educational software, allowing researchers to quantify user perspectives and attitudes to measure the degree of satisfaction with specific features of the application [37]. Fig. 2 presents examples of the application interfaces, which include four pages: the start page, the main menu, the Numbers world, and the Alphabets world.

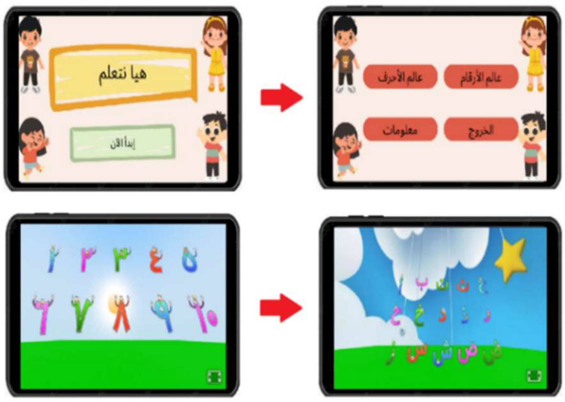

Fig. 2. Sequence of the main screens of the application.

Fig. 3 shows the results of the application evaluation by the faculty of Science and Information Technology professors regarding the application's performance in terms of speed, response, and compatibility. The evaluation provided crucial insights into the technical performance of the application, which are essential for determining its effectiveness in real-world educational settings. In terms of speed, 70% of faculty members gave a positive evaluation, indicating that most experts found the application to work efficiently. However, 30% gave a negative evaluation, which may be attributed to the Internet speed or device performance. This discrepancy highlights that the app's performance is device-dependent.

Performance testing revealed that on high-performance devices like flagship smartphones, the app loaded within 2–3 seconds with no noticeable lag. On mid-range devices, the load time increased to 3–5 seconds, with occasional frame rate drops. On low-end devices, the app had noticeable lag within a 5–7 second load time and occasional freezes, particularly during interactive features like animations and sound synchronization.

As for the response, 80% of respondents rated it positively, showing that the application has a fast and smooth interaction with users. However, 20% gave an unsatisfactory evaluation, which may be due to the delayed response in some types of devices with low efficiency or due to the slowness of some specific features. As noted by Anderson [38], compatibility issues can arise when applications are not optimized for various device configurations. In this case, ensuring that the app works seamlessly across different devices would enhance the user experience. The positive compatibility rate reached 80%, indicating that the majority of the faculty members found that the application met their standards and expectations. Further investigation may be necessary to identify the specific devices causing issues, such as low-end smartphones or older tablet models.

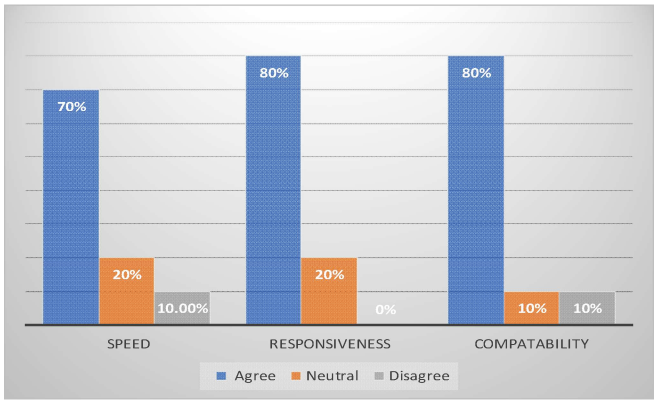

Fig. 3. Respondents' feedback on the application's performance.

Fig. 4 shows the results of the graphic design and multimedia professors' evaluation of the application. The results indicate that 80% of the professors agreed that the visual design of the application is appropriate, with the majority agreeing that the color choices, fonts, text styles, and illustrations are well-suited. The remaining 20% may differ based on personal preferences. As noted by Zhang [39], visual design plays a crucial role in educational software for children, as it must be both engaging and functional to guide the user through the learning process. 70% of the professors agreed on the appropriateness of the user interface, believing the application design is simple, with easy-to-understand buttons and icons, and visual interactions that capture children's attention. Regarding the sounds and visual elements, 70% of the professors found them appropriate, suitable for children, and compatible with most tastes and genders. Furthermore, 80% of professors agreed that the interactive design of the application is appropriate, confirming that the interactive elements suit children's needs very well. Future updates will consider adding more interactive features such as additional sounds, animations, or gamified elements to enhance engagement further.

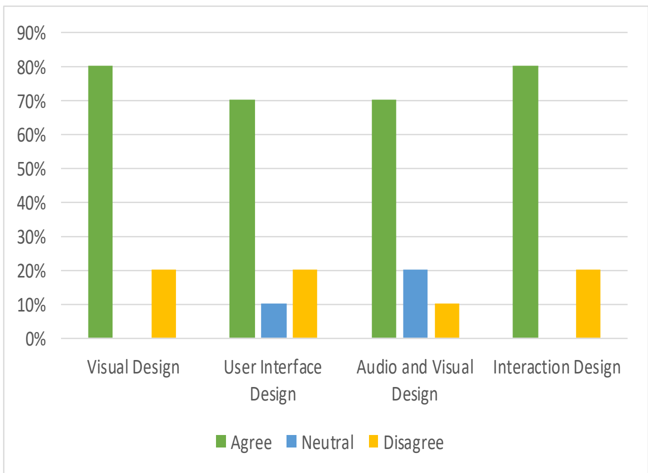

Fig. 4. Respondents' feedback on the application's graphics.

As illustrated in Fig. 5, the results of the app content evaluation showed that the vast majority of teachers, 80%, agreed that the app content is linguistically accurate, and 20%

disagreed with the linguistic accuracy, which indicates some linguistic errors that need some corrections. These errors are not a major problem but will be addressed in future updates. Some linguistic inconsistencies were identified and will be corrected in future iterations, ensuring a higher level of language accuracy for young learners. Language accuracy is crucial in educational software, as poor language use can hinder learning, particularly in applications aimed at young children who are still developing their language skills [40]. Most respondents also agreed that the app provides an appropriate gradation in difficulty levels, indicating that the app is suitable for most levels of children. There is a 30% of respondents who disagreed with the gradation of difficulty, indicating that children may find the app too difficult or too easy. There is also a high percentage of teachers who agree that the app provides an interactive experience, but there is also 20% who disagree with the interactivity, indicating the need to add more interactive elements such as images and interactive sounds. Adding more interactive features could help to increase engagement, as noted by Chang [41]. Although the vast majority still agree that the app is motivating enough, there is a need to increase the motivational elements, as 20% of respondents did not find the app motivating enough. Points or digital rewards can be added to increase the motivation element for children. Some linguistic inconsistencies were identified and will be corrected in future iterations, ensuring a higher level of language accuracy for young learners.

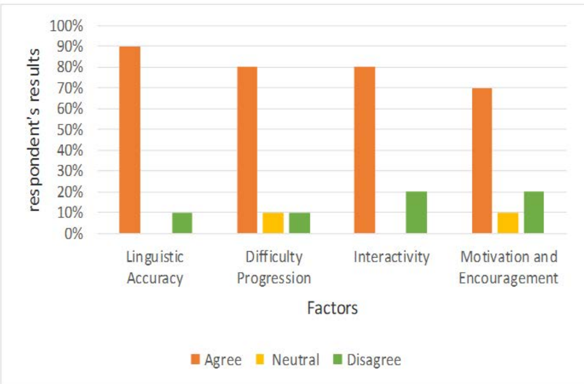

Fig. 5. Respondent's feedback about the Application's content.

Fig. 6 shows the average assessment of the different factors of the application using the Likert scale. The results of the assessment of the VR experience gave a result of 4.5, which reflects high satisfaction with the quality of VR and that the application exploits the capabilities of virtual learning satisfactorily. However, a small percentage showed neutrality, and another small percentage showed dissatisfaction, which can be explained by the lack of familiarity with VR, as it is a new experience for some users. As noted by Marougkas [42], familiarity with VR technology plays a key role in shaping user satisfaction, particularly among those who are new to this immersive medium. The overall satisfaction rating for the application was 4, which indicates a high level of satisfaction with the application, with the possibility of improving some aspects to enhance user satisfaction. Interaction and motivation received a rate of 4.5, which indicates that users find the experience interesting and helps in motivation and continuity of learning. As for educational effectiveness, it received an average of 3.5, which indicates that there is satisfaction but a need for more improvements to enhance the educational content or improve the way it is presented. Educational effectiveness ratings reflect the importance of refining content presentation to ensure that the educational goals are met while keeping the learners engaged. The majority of users 4% found the application easy to use, without distracting children, reducing their concentration, or causing difficulty in understanding the content, indicating that there were no difficulties in navigating between the application interfaces and understanding how to use it. In summary, the results indicate the success of the application in creating an enjoyable and engaging educational experience using VR, reflecting the role of VR in adding an element of fun and interaction to the educational process.

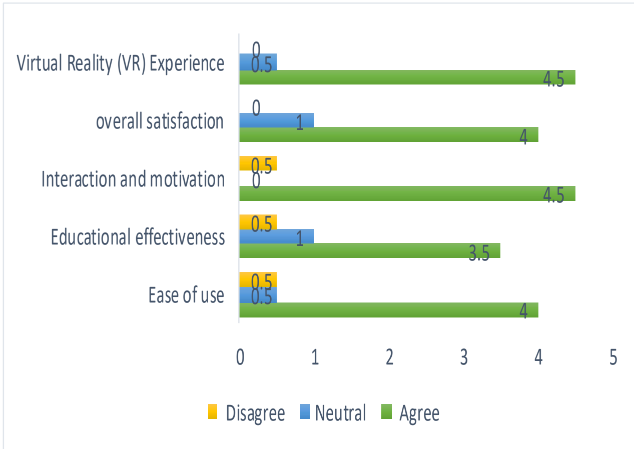

Fig. 6. The results of the parents' evaluation of the application.

V. Discussion

A survey was conducted to evaluate the effectiveness of the application from several aspects: technical performance, design, content, and overall user experience. The primary objective was to assess the application's effectiveness in integrating VR into the educational process for children aged 3 to 7 years. This age group represents a critical period in cognitive and developmental learning, where immersive tools like VR can have the most impact. A questionnaire was given to university professors, experts in evaluating the application's educational design, usability, and interface. These experts, selected from arts, design, and technology departments, provided a comprehensive evaluation of the application from multiple perspectives. It would be beneficial to highlight the testing methods or results more explicitly, especially with the surveys or expert evaluations you conducted. Mentioning the evaluation results in terms of how the app performed for children at different cognitive levels could strengthen the validation of the design choices. For instance, specifying how the app caters to various cognitive abilities within the target age group (3–7 years) would demonstrate that the application is tailored to meet developmental needs, ensuring a more comprehensive educational experience.

The application was developed using the Waterfall model, a structured approach that ensured clear documentation and systematic evaluation at each development stage. This model's rigidity provided an advantage in maintaining quality control and allowed for early identification of design faults.

During development, the use of 3D Max, A-frame, and Adobe Photoshop was used to create realistic, engaging scenes that captured children's attention. These tools facilitated the creation of a highly interactive educational experience that aligned with both Piaget's hands-on learning theory and Vygotsky's social learning theory.

Regarding technical performance, the app was evaluated on its speed, response, and compatibility across various devices. As shown in Fig. 3, 70% of faculty members gave a positive evaluation for speed, but 30% found the app's performance slower on lower-end devices, which aligns with the challenges identified in earlier research on the device-dependency of VR apps. Further performance testing confirmed that high-performance devices had fast load times, while mid-range and low-end devices showed slower performance. In future iterations, optimizations will be made to improve device compatibility, especially in low-resource environments.

Regarding the app's content accuracy, 80% of the teachers found the application's content linguistically accurate, but 20% identified areas for improvement. These inconsistencies will be addressed in future updates to ensure higher language accuracy, crucial for applications targeting young learners still developing language skills.

In terms of long-term impact, future research will involve follow-up evaluations to assess the sustained influence of the VR application on cognitive and social development, a critical component of this study, as VR exposure may have long-term educational effects. This will further contribute to the understanding of how VR can support both cognitive and social growth in children.

Finally, device accessibility remains a significant challenge for implementing VR in early childhood education, particularly in low-income areas where VR equipment may be scarce. Addressing these challenges through partnerships with educational institutions and non-profit organizations could help provide more children with access to the educational benefits of VR technology.

VI. Conclusion

This study explores the development and effectiveness of a VR-based educational application designed for children aged 3 to 7. The findings from the survey show that the application successfully engages children in learning the Arabic alphabet and numbers, enhancing their motivation and participation through interactive and immersive experiences. By incorporating the principles of cognitive development, the app offers a playful and educational environment that supports young learners' engagement and cognitive growth. However, challenges remain, particularly related to device compatibility. Many users reported slower performance on lower-end devices, limiting accessibility. To address this, future iterations of the app should optimize performance for a wider range of devices, including mid-range smartphones and tablets. Additionally, developing a non-VR version of the application could increase its reach, making it more accessible to children who do not have access to VR headsets. The inclusion of more gamified elements and interactive features, such as digital rewards or additional audio-visual components, could further enhance user engagement and motivation. Collaboration with educational institutions, non-profit organizations, and humanitarian groups could also help provide the necessary technology in underfunded educational settings, bridging the gap in access to these educational tools. Looking ahead, further research is needed to assess the long-term impact of VR exposure on children's cognitive and social development. Evaluations conducted over several months could provide valuable insights into the lasting effects of immersive learning. Overall, this application represents a step forward in integrating VR technologies into early childhood education, offering a more engaging and effective learning environment. Future updates could expand the app's features, such as adding more languages or aligning the content with national curricula, to ensure its continued relevance and effectiveness in diverse educational contexts.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Mohammad Al Khaldy conceptualized the study, designed the research framework, and oversaw the development of the VR application. Ameen Shaheen contributed to the methodology, including the software development process, and provided technical expertise throughout the study. Wael Alzyadat assisted with the data analysis, including evaluating the effectiveness of the VR app, and provided insights into the educational aspects of the project. Aysh Alhroob supported the user testing phase, coordinated the survey distribution, and assisted with the analysis of user feedback. All authors contributed to the manuscript writing, review, and approved the final version of the paper.

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