Indonesian Journal of Electrical Engineering and Computer Science
Vol. 37, No. 3, March 2025, pp. 1702~1711
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v37.i3.pp1702-1711

Visual treatment with AR for children with dysphasia

Misael Lazo Amado, Meyluz Monica Paico Campos
Facultad de Ciencias e Ingeniería, Universidad de Ciencias y Humanidades, Lima, Perú

Article Info

Article history:

Received Apr 16, 2024
Revised Sep 19, 2024
Accepted Oct 7, 2024

Keywords:

AR
Dysphasia
Educational application
Learning disabilities
Visual processing

ABSTRACT

The language disorder known as dysphasia significantly affects the ability to communicate effectively, presenting challenges in both comprehension and expression of language. To address this issue, the development of a visual treatment using augmented reality (AR) specifically designed for children with dysphasia has been proposed. The methodology selected for this project is analysis, design, development, implementation, and evaluation (ADDIE), an innovative methodology that encompasses analysis, design, development, implementation and evaluation. This methodology is perfectly adapted to the needs of the project, allowing a systematic and complete approach at all stages of the process of creating the visual treatment. The results obtained show that the visual treatment with AR has been positively evaluated by development experts and dysphasia specialists. Its innovative capacity to assist children with this disorder in health and educational settings is highlighted. This approach provides an effective tool to improve the communication and language development of children affected by dysphasia, offering new opportunities for their learning and growth. Its implementation in healthcare and educational settings could have a significant impact on the quality of life and development of these children.

Corresponding Author:

Meyluz Monica Paico Campos
Facultad de Ciencias e Ingeniería, Universidad de Ciencias y Humanidades
Lima, Perú
Email: mpaico@uch.edu.pe

1. INTRODUCTION

The language disorder better known as dysphasia, impacts the ability to communicate effectively, manifesting itself through challenges in both understanding and expressing language. Frequently diagnosed in childhood, this condition is often linked to neurological disorders such as autism spectrum disorder. Early identification of dysphasia is crucial for effective management, as it allows for targeted interventions to be implemented. Treatment of dysphasia usually involves speech and language therapy, designed to address the individual needs of each affected person. This therapeutic approach seeks to improve both language comprehension and expression by providing tools and strategies tailored to each individual's abilities and challenges. As research advances, understanding of the underlying factors of dysphasia is deepening, contributing to the development of more personalized and effective therapeutic approaches [1]–[3].

In the United States, dysphasia is recognized and addressed in the health and education system, allowing for early identification and intervention through professionals such as speech pathologists and psychologists. Special education laws, such as IDEA, support individualized services, including speech therapy and curricular accommodations. In addition, health services, covered by insurance, play a crucial role in the treatment of dysphasia. Collaboration between parents, educators and healthcare professionals is essential to support these children and improve their language skills [4], [5]. In Finland, dysphasia is recognized and addressed in the health and education system, with an early and structured approach. Children

with dysphasia receive assessment and support through educational and health services, with an emphasis on inclusion and individualized services. Collaboration between professionals such as speech pathologists, psychologists and teachers is essential for comprehensive care. Finland offers accessible health services for therapies and medical support, addressing the clinical aspects of dysphasia. In short, the Finnish approach focuses on the overall well-being of children, seeking not only to overcome language difficulties, but also to support their holistic development [5]–[7].

In South America, care for dysphasia varies according to the health and education systems in each country. Although efforts are made in many places to address language disorders such as dysphasia, the availability of resources and services can be uneven. In some places, early identification and intervention are challenging due to limitations in services [8], [9]. However, in other countries, programs have been implemented to support children with language disorders. Collaboration between health professionals, educators and families is essential, as is awareness and understanding of dysphasia to ensure appropriate care. In Peru, the situation of dysphasia is influenced by factors such as the health and education systems, as well as awareness and access to specialized services. Despite efforts to improve health care and education, disparities between urban and rural areas can affect access to services. Although educational programs exist to address language disorders such as dysphasia, early identification and intervention face challenges, especially in areas with limited resources. Collaboration between health professionals, educators, and families is crucial to provide comprehensive support. It is expected that, with increased awareness, more resources and services will be implemented to address the specific needs of children with dysphasia in the country [10], [11].

The introduction focuses on the crucial identification of people's needs, with a particular focus on addressing the main problem. The primary objective is set to develop a visual treatment with augmented reality (AR) for children with dysphasia. The aim is to significantly improve the quality of care provided in health centers. In addition, the purpose of incorporating innovative ideas that can have a positive impact on the Peruvian state is highlighted. This innovative approach seeks not only to address the communication difficulties of children with dysphasia, but also to contribute to the advancement and efficiency of health services in the Peruvian context. The implementation of technologies such as AR in the treatment of dysphasia represents a novel strategy to address these challenges.

2. LITERATURE REVIEW

AR is essential to capture the attention of children being able to bring a great impact on society, this author develops an AR that integrates virtual objects to the real world where it supports dyslexia with communicative instructions, social interactions, writing and learning. his research focuses on designing a framework based on cognitive learning for an interactive AR application focused on children with autism, offering them a new dimension to overcome their disabilities [12]. Another author investigates trends in the use of AR as a learning tool for kindergarten children, observing that these applications cover areas such as mathematics, reading, writing, letter, number and sentence recognition, improving cognitive and social skills, as well as motivating children towards learning, these applications include 3D images, videos, animations and symbols, with interactivity through sensors and marker-based systems that are efficient in enhancing their development [13]. This same author develops an application for dyslexia in Hong Kong children aged 4-6, presenting a web-based game and training platform called "Writing Fun" designed to help dyslexic children with Chinese literacy. The platform includes an AR game for writing tests and four non-AR games, which aim to improve reading and writing skills, as well as train visual, auditory and kinesthetic movements [14].

In order to develop these applications there are different methods as well as this author who develops an application that revives the Indian culture showing these elements through an AR application on phones, allowing to experience heritage properties from anywhere. The application uses AR markers at important tourist spots, eliminating the need for third parties to display the attractive monuments, tools such as unity, blender, python and visual studio for C# are mentioned in the software development, with the use of Vuforia AR SDK and Mapbox SDK as development kit for the AR application [15]. This author uses AR for special education, in which he highlights the fusion of the real and virtual worlds as an advantage of AR as development uses Unity3D, Vuforia and Adobe Illustrator tools obtaining as evaluation an efficient acceptance in its improvement cognitively [16]. Finally this author shows the development of AR for learning the subject of chemistry, the tools such as Vuforia, Unity and Blender were employed in the development of the application , this app shows the successful score for its usability indicating that the effective, light and beneficial to understand the subject [17].

The authors of the literature review comprehensively address the challenges and solutions identified, providing significant motivation and confidence in the successful implementation of this project. Their consistent approach helps to ensure the achievement of the stated main objective. In addition, the meticulous

consideration of the tools and methods essential to the development of the project is highlighted, further reinforcing the soundness and feasibility of the proposal. The authors' ability to address the inherent complexities of the subject matter is reflected in the robustness of their approach, which strengthens the credibility of the project as a whole.

3. METHOD

3.2. Analysis, design, development, implementation, and evaluation

The analysis, design, development, implementation, and evaluation (ADDIE) methodology, a robust approach to instructional design, is used to structure training and development programs. The five key phases of this model, represented by the acronym ADDIE, provide a systematic guide for the effective creation of educational content as shown in Figure 1. In the context of innovative AR, the adaptability of ADDIE is manifested by enabling its integration [18]. The design phase assumes a crucial role in addressing how AR will be incorporated to achieve learning objectives, structuring impactful and pedagogically sound user experiences. During the development phase, AR components such as applications, virtual objects, and immersive experiences are materialized. The implementation phase focuses on providing these experiences to those involved, while evaluation focuses on measuring the effectiveness of AR in achieving educational objectives, reflexively closing the cycle and iteratively improving the educational process [19], [20].

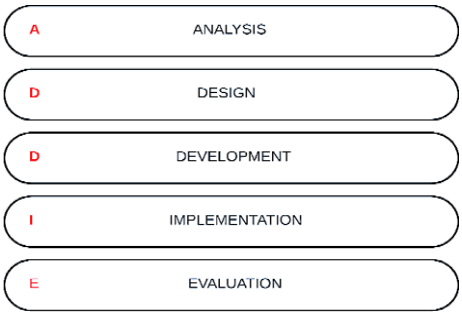


Figure 1. Methodology ADDIE

3.2.1. Analysis

During the analysis phase in the ADDIE methodology, a thorough review is conducted to identify learning needs, analyze the target audience in detail and precisely define educational objectives. This process involves a deep dive into the educational context, allowing for a thorough understanding of the particular challenges that the program design will need to address. The characteristics and requirements of the learners, as well as the conditions and constraints of the learning environment, are carefully examined. This analytical and reflective approach lays the essential foundation for subsequent instructional design, ensuring that the resulting programs are tailored and effective in achieving specific educational goals [21], [22]. Table 1 provides a comprehensive description of the difficulties experienced by children with dysphasia between the ages of 6 and 7 years. It presents a detailed analysis of their main problems, which facilitates assessment and decision making regarding their situation. This information is crucial to understand the specific needs of this group of children and to provide them with the necessary support for their cognitive and linguistic development.

Table 1. Results of the analysis

Problems	6 years old	7 years old	8 years old
Difficulties in language comprehension	High level	Medium level	Medium level
Delayed speech development	High level	Medium level	High level
Limitations in verbal expression	Medium level	High level	High level
Grammar problems	Medium level	High level	Medium level
Challenges in socialization	Low level	Medium level	Low level
Problems in reading and writing	High level	High level	High level
Low self-esteem	Low level	Medium level	Medium level
Frustration and anxiety	Medium level	High level	Medium level
Difficulties in academic performance	Medium level	High level	Medium level

3.2.2. Design

After meticulously gathering the information during the analysis phase in the ADDIE methodology, the design stage is followed by the development of a detailed plan for the training program. This plan covers several essential aspects, such as the detailed structure of the educational content, pedagogical strategies adapted to the identified needs, evaluation systems to measure progress and learning effectiveness, as well as the identification of the necessary resources for the successful implementation of the program [23]. The Figure 2 presents in detail the design that will be followed to achieve the proposed objective, providing a clear and understandable vision of the planned implementation. This visual schematic provides essential guidance for the successful execution of the project.

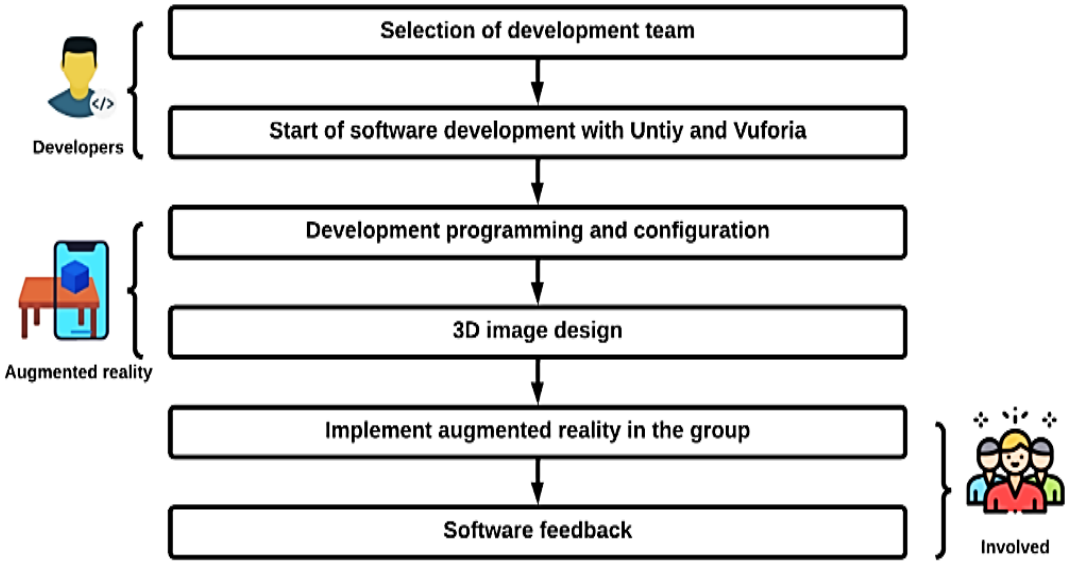
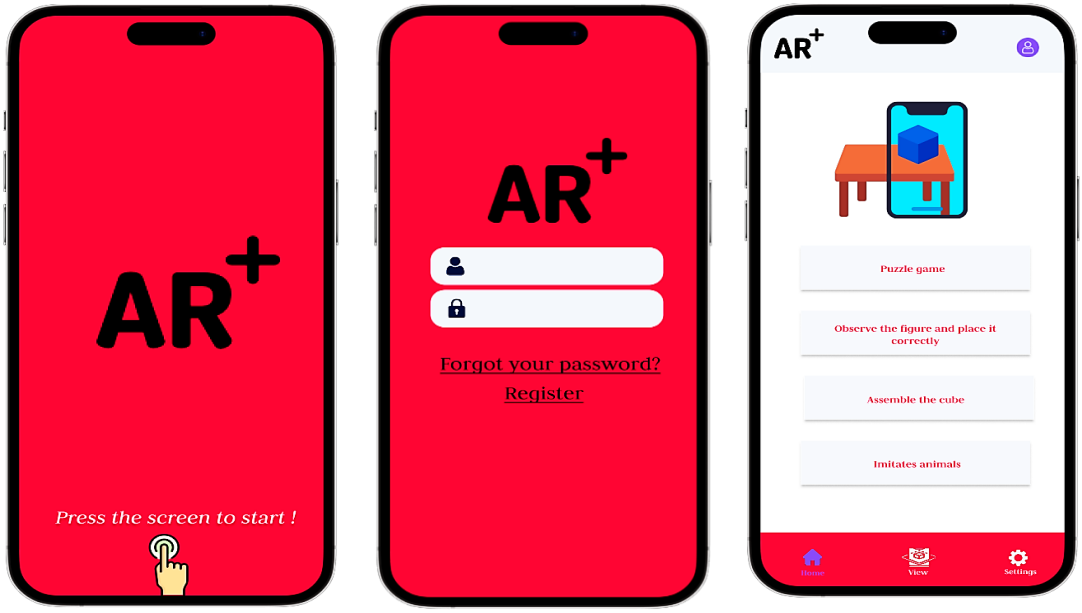


Figure 2. Visual scheme of the project

3.2.3. Development

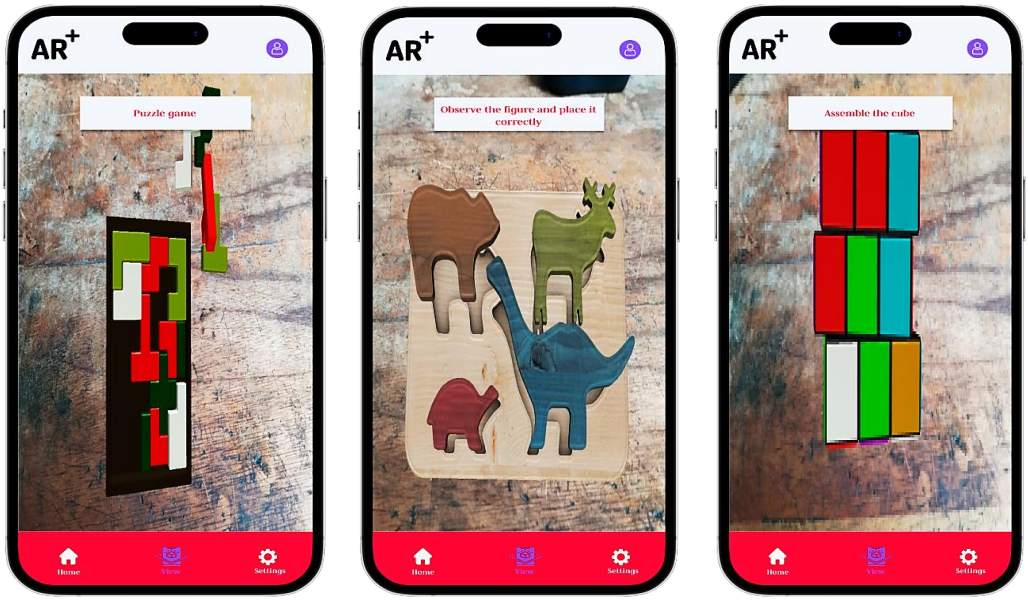
In the development phase of the ADDIE methodology, the previously designed plan is materialized, giving life to the conceived educational material. This process involves the creation of various elements, such as interactive presentations, learning modules, and rich multimedia content. The implementation of advanced educational technologies, such as simulations and digital resources, may also be included to optimize the learning experience. Creativity and attention to detail are critical at this stage, as the goal is to produce effective and immersive educational resources that support the pedagogical objectives established in the previous phases of the ADDIE model [24], [25]. In the Figure 3 representation provided, the initial actions to launch the application are detailed, highlighting the key access options. The first interface, denoted as Figure 3(a), shows the initial screen where the user interacts by touching the screen to enter the system. Figure 3(b) illustrates the login screen, indicating that users must log in with their registered accounts to begin the experience. Figure 3(c) presents a detailed list of the main game options designed to address dysphasia, with the specific objective of improving concentration and attracting the child's attention, thus fostering a collaborative environment conducive to cognitive development.

The Figure 4 provides a detailed overview of fundamental games designed to enhance the concentration and skills of children with dysphasia. In Figure 4(a), an intriguing puzzle game is highlighted, challenging the child to complete the picture by filling in the blanks, which not only encourages fun, but also cognitive development. Figure 4(b) presents a game that requires the child with dysphasia to concentrate and look closely at the correct figure and then place it in the corresponding position, thus promoting visual recognition and coordination. In Figure 4(c), the classic cube is displayed, where children must use their dexterity and skills to complete the game, stimulating crucial aspects of motor and cognitive development. These games not only entertain, but also offer a valuable therapeutic tool for advancing the skills of the child with dysphasia.



(a) (b) (c)

Figure 3. Application of AR: (a) application home (b) application login, and (c) list of games



(a) (b) (c)

Figure 4. Concentration games: (a) set of figures, (b) puzzle, and (c) classic cube

The game depicted in the Figure 5 is distinguished by its innovative AR approach, which projects images onto the screen for the child to imitate both the appearance and the corresponding sound. The central objective is to carry out exercises that enhance facial expressions and mouth movements in an interactive way. In Figure 5(a), the child is immersed in the experience of imitating a dog, capturing both the visual features and the characteristic sounds of this animal. Figure 5(b) introduces the representation of a duck, challenging the child to replicate its peculiarities and specific vocalizations. Likewise, Figure 5(c) presents the figure of a cow, offering the child the opportunity to explore and emulate the associated facial movements and sounds.

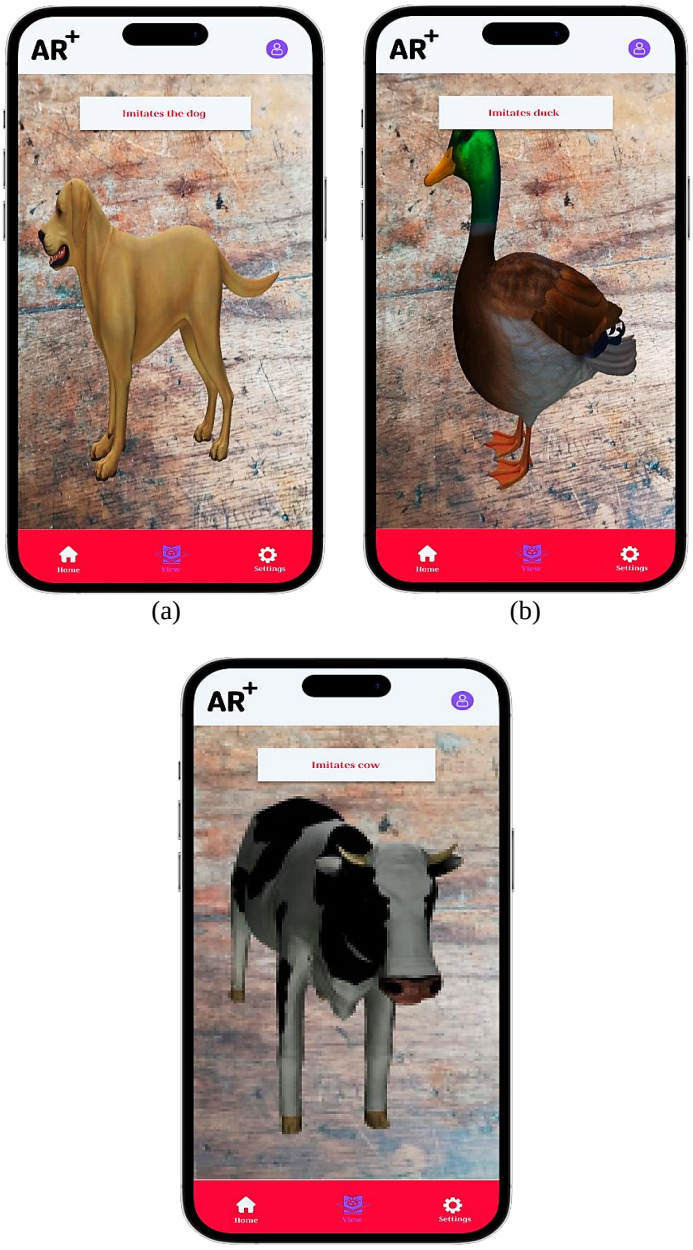


Figure 5. Animal AR: (a) dog game, (b) duck game, and (c) cow game

3.2.4. Implementation

During the implementation phase in the ADDIE methodology, the actual execution of the training program takes place. Instructors play a crucial role by using the previously developed educational material in direct interaction with the students. In this context, the planned learning activities are carefully carried out, promoting active participation and deep understanding. Implementation focuses not only on content delivery, but also on adaptability to address individual student needs and respond effectively to challenges that may arise. This dynamic and participatory process ensures effective application of the pedagogical principles designed in the previous phases of the ADDIE model [26]. The Figure 6 illustrates in detail the proper AR implementation process, highlighting the use of Unity Vuforia as the main platform for its development. To carry out this task, it was essential to have a complete directory of files and a detailed list of databases for the registration of users and processes, as well as to properly configure the Android operating system environment. This whole system will culminate in a seamless connection with the camera of the mobile device, be it a smartphone or any other compatible device.

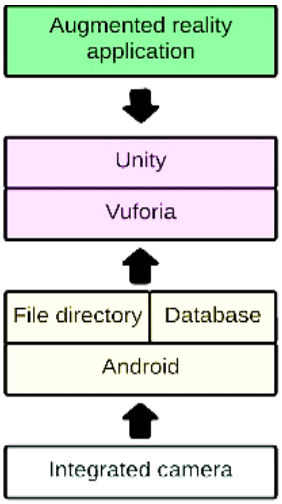


Figure 6. Implementation

3.2.5. Evaluation

The evaluation phase in the ADDIE methodology is a crucial moment in measuring the effectiveness of the training program. During this stage, comprehensive data is collected on student performance, assessing the achievement of established educational objectives. This information not only informs the success of the current program, but also serves as a basis for adjustments and improvements. Feedback obtained during evaluation is used strategically to refine future implementations, ensuring a continuous cycle of improvement and adaptation. This reflective and results-oriented approach to the evaluation phase contributes to the ongoing evolution of educational programs, optimizing their impact and effectiveness over time [27].

4. RESULTS

The results present in detail the evaluations carried out by both developers and experts regarding the mobile application that integrates AR, specifically focusing on its effectiveness for children with dysphasia. These evaluations address crucial aspects such as usability, accessibility and adaptability of the system to meet the particular needs of children with dysphasia. In addition, both areas of positive acceptance and those that could benefit from improvement have been highlighted. This comprehensive analysis provides valuable insight into how the system aligns with therapeutic goals, allowing for necessary adjustments to further enhance its positive impact on the communicative and cognitive development of children with dysphasia. This thoughtful approach ensures a more effective and end-user focused implementation.

4.1. Evaluation by developers

During this evaluation, the developers embarked on a rigorous process aimed at thoroughly validating the AR system. They will focus on demonstrating efficient development, the result of meticulous work throughout the project process. This work is reflected in a high level of completeness, backed by tangible evidence of progress and achievement. The primary objective will be to achieve a significantly high acceptance rate, which will serve as a key indicator of the success and effectiveness of the developed system. This process will not only ensure the quality of the final product, but will also reinforce confidence in the development team's ability to meet the highest standards. The evaluation will be a key step towards achieving the objectives set and meeting stakeholder expectations as shown in Table 2.

Table 2. Results of the evaluation

Developers	User experience	Functionality	Yield	Visual quality	Interactivity	Stability	Innovation
Developer 1	95%	97%	98%	95%	92%	92%	97%
Developer 2	95%	97%	95%	95%	97%	98%	98%
Developer 3	97%	95%	97%	99%	94%	95%	97%
Developer 4	98%	96%	97%	95%	98%	95%	95%
Developer 5	97%	96%	94%	96%	94%	97%	95%

4.2. Evaluation by specialists

During this evaluation, dysphasia specialists will offer their in-depth analysis of the system, providing crucial insight into its effectiveness and usefulness in the treatment of this condition. Their experience and expertise will allow them to evaluate in depth how the application responds to the specific needs of people with dysphasia, highlighting aspects such as ease of use, accessibility and effectiveness in improving language skills. Validation by these experts will be critical to support acceptance of the system, as their endorsement will provide credibility and confidence in its efficacy in clinical and educational settings. In addition, their viewpoint will identify potential areas for improvement or adjustment to further optimize the performance and utility of the application in the context of dysphasia. This endorsement by specialized professionals will reinforce the system's position as a valuable and reliable tool in the treatment and management of dysphasia, potentially leading to wider adoption and use in the medical and therapeutic community, as shown in Figure 7.

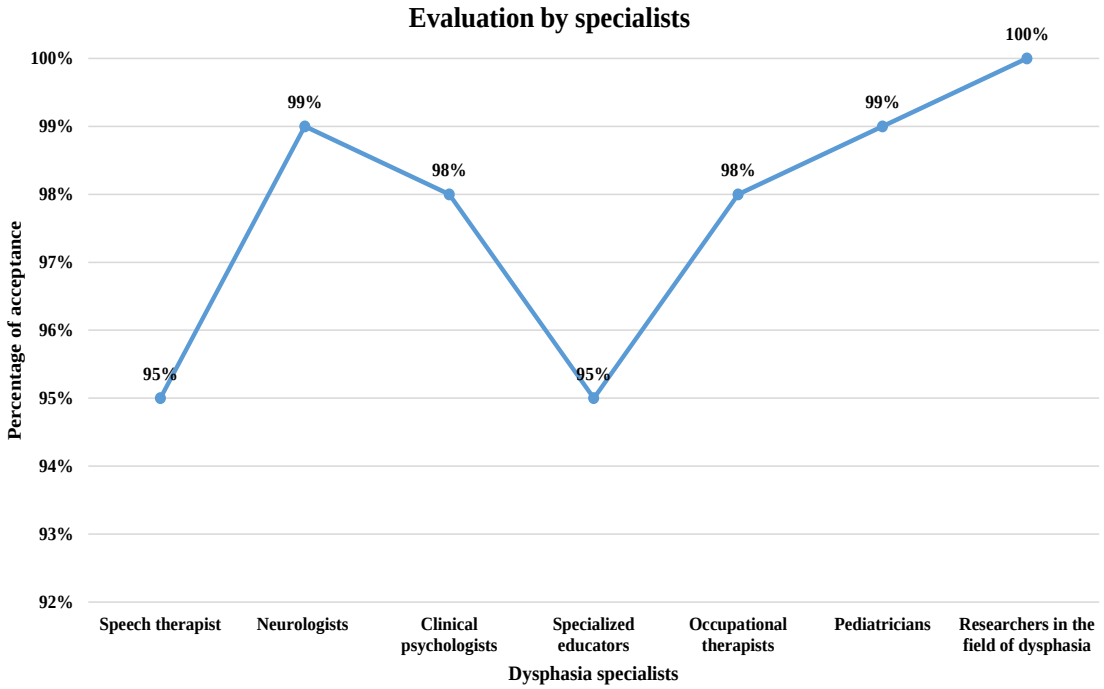


Figure 7. Evaluation by specialists

5. DISCUSSIONS

Previous research reveals a similar development to ours in the field of AR to address conditions such as dyslexia, although it also highlights some key differences that are relevant to our project. For example, one of the previous authors focused primarily on the technical development of AR for dyslexia, presenting solutions involving social interaction and writing. However, this approach may have neglected the importance of actively involving end users and obtaining meaningful feedback from them, which could have resulted in potential risks to system acceptance and effectiveness. On the other hand, another author explored a list of AR computer applications focused on using 3D images to motivate children's learning. While this approach may have been efficient from a technological development standpoint, consultation and collaboration with educational specialists or teachers to assess the pedagogical appropriateness of these applications and to incorporate new teaching methods that may enrich the learning experience of children may have been neglected. This project, we strive to address these differences by combining both technical development of AR and active consultation with experts in the field of dysphasia. Our comprehensive approach seeks to ensure that the system is not only technologically sound, but also effective and appropriate from a pedagogical and clinical perspective. By working closely with end users and relevant professionals, we hope to maximize the project's potential to make a positive difference in the lives of children with dysphasia and their educational experiences.

6. CONCLUSION

In conclusion, an innovative AR system specifically designed to address the needs of children facing the challenge of dysphasia has been established. This project has fulfilled its main objective by providing an effective method to analyze the problems associated with dysphasia, developed with an easy-to-use interface to guarantee the participation and understanding of all those involved in the process. In addition, it meets the importance of supporting the needs of specialists dedicated to treating dysphasia, showing a great technological contribution with efficient results. The system has undergone constant evaluation in order to collect valuable information for its continuous improvement and its adaptation to the changing needs of users. This continuous feedback approach ensures that the system can evolve over time and remains relevant and effective in addressing the challenges of dysphasia. The results obtained from this evaluation have been extremely positive, and experts in the field of development and specialists in dysphasia have expressed their highest appreciation for the AR system. They have highlighted the effectiveness of the software in providing an interactive and adaptive learning environment that adjusts to the individual needs of children with dysphasia, making it a very effective and valuable tool for their development and progress. This investigative and innovative work should have the support of specialists dedicated to dysphasia and health centers in order to generalize this project and help children with dysphasia around the world. This AR application project will be the beginning of future projects aimed at treating the problems of learning disorders and other disorders, marking an important innovation in the field of education and technology applied to children's health.. This implementation is expected to facilitate quick and accurate consultations about the child's evaluation through the application, providing a more agile and efficient experience for both users and professionals involved in the care process. This improvement in efficiency will allow health professionals to dedicate more time to direct care of children, reducing the time spent on administrative and preliminary evaluation tasks. As part of future work, it is planned to incorporate advanced technologies such as artificial intelligence to further improve the system. The integration of artificial intelligence will allow us to offer more complete and efficient support by providing advanced data analysis and processing capabilities, allowing for more precise personalization of treatments. In addition, artificial intelligence will allow the incorporation of expert systems that will facilitate a deeper understanding of the problems diagnosed in children, recognizing that each child has unique abilities and needs. These expert systems will be able to analyze large volumes of data and detect patterns that could go unnoticed by the human eye, thus offering a more detailed and precise evaluation. The ability of artificial intelligence to continually learn and adapt will ensure that the system evolves and stays up to date with the latest advances in the field of health and education.

REFERENCES

[1] P. Voskou, "Dysphasia after stroke and legal capacity," *Alzheimer's & Dementia*, vol. 19, no. S18, Dec. 2023, doi: 10.1002/alz.070916.

[2] D. Koyel, H. B. Nongrum, M. Ruchira, and B. Dinesh, "A case report in the management of dysphagia in osmotic demyelination syndrome using mann assessment of swallowing ability (MASA)," *Indian Journal of Otolaryngology and Head and Neck Surgery*, vol. 76, no. 3, pp. 2755–2760, Jun. 2024, doi: 10.1007/s12070-023-04457-y.

[3] K. Das, H. B. Nongrum, R. Mukherjee, S. Bhattacharjee, and D. Bhatia, "A case presentation in management of dysphagia and dysarthria caused due to organophosphorus and carbamate insecticide poisoning," *Indian Journal of Otolaryngology and Head and Neck Surgery*, vol. 76, no. 5, pp. 4717–4723, Oct. 2024, doi: 10.1007/s12070-024-04794-6.

[4] G. M. Pereira, N. M. Soares, C. R. de M. Rieder, and T. A. P. Alva, "Stereotatic radiosurgery for the treatment of motor symptoms in Parkinson's disease: A systematic review," *Journal of Medical Imaging and Radiation Sciences*, vol. 55, no. 1, pp. 146–157, Mar. 2024, doi: 10.1016/j.jmir.2024.01.001.

[5] A. Aghaz, L. Ghelichi, A. Shahriyari, S. Noori, and A. Banari, "The prevalence of dysphagia in parkinson's disease: a systematic review and meta-analysis," *Journal of Iranian Medical Council*, vol. 7, no. 3, pp. 414–429, Jun. 2024, doi: 10.18502/jimc.v7i3.15719.

[6] K. D. O'Leary, A. J. Philippopoulos, A. Koslofsky, and Y. Ahmed, "How often do awake craniotomies in children and adolescents lead to panic and worry?," *Child's Nervous System*, vol. 40, no. 2, pp. 359–370, Aug. 2024, doi: 10.1007/s00381-023-06117-6.

[7] M. K. Arıkan, R. İlhan, M. T. Ozulucan, and M. Aşık, "qEEG in the Diagnosis and prognosis of a case with delusional infestation," *Clinical EEG and Neuroscience*, vol. 55, no. 2, pp. 214–218, Mar. 2024, doi: 10.1177/15500594231163383.

[8] J. P. Toro, C. L. Muñoz-García, and R. M. Escobar-Pérez, "Evaluating the efficacy and safety of laparoscopic heller myotomy in treating achalasia," *Revista Colombiana de Gastroenterologia*, vol. 38, no. 2, pp. 131–137, Jun. 2023, doi: 10.22516/25007440.970.

[9] M. C. Rivelsrud, L. Hartelius, R. Speyer, and M. Løvstad, "Qualifications, professional roles and service practices of nurses, occupational therapists and speech-language pathologists in the management of adults with oropharyngeal dysphagia: a Nordic survey," *Logopedics Phoniatrics Vocology*, vol. 49, no. 3, pp. 137–149, Jul. 2023, doi: 10.1080/14015439.2023.2173288.

[10] M. D. M. Marsool *et al.*, "Exploring the landscape of intracranial aneurysms in South America: a comprehensive narrative review intracranial aneurysms in South America," *World Neurosurgery*, vol. 185, pp. 3–25, May 2024, doi: 10.1016/j.wneu.2024.01.108.

[11] C. Manzano-Aquiahuatl *et al.*, "Position statement of the Latin American Dysphagia Society for the management of oropharyngeal and esophageal dysphagia during the COVID-19 pandemic," *Revista de Gastroenterología de México (English Edition)*, vol. 87, no. 1, pp. 63–79, Jan. 2022, doi: 10.1016/j.rgmxen.2021.12.004.

[12] Alfian, A. E. Permanasari, and S. Fauziati, "AR technology in education: kindergarten education content trends," in *Proceedings - 2023 3rd International Conference on Electronic and Electrical Engineering and Intelligent System: Responsible Technology for Sustainable Humanity, ICE3IS 2023*, IEEE, Aug. 2023, pp. 305–310. doi: 10.1109/ICE3IS59323.2023.10335444.
[13] Z. Bhatti, M. Bibi, and N. Shabbir, "AR based multimedia learning for dyslexic children," in *2020 3rd International Conference on Computing, Mathematics and Engineering Technologies: Idea to Innovation for Building the Knowledge Economy, iCoMET 2020*, IEEE, Jan. 2020, pp. 1–7. doi: 10.1109/iCoMET48670.2020.9073879.
[14] M. C. Yuen *et al.*, "Web-based training platform with AR games for dyslexic children," in *2023 15th International Conference on COMmunication Systems and NETworkS, COMSNETS 2023*, IEEE, Jan. 2023, pp. 1–6. doi: 10.1109/COMSNETS56262.2023.10041268.
[15] S. D. Sorna, B. Bhuvaneswaran, A. R. Manoj, and S. Pooja, "MonuAR:M.A.R application for visualising 3D monuments," in *Proceedings of the 1st IEEE International Conference on Networking and Communications 2023, ICNWC 2023*, IEEE, Apr. 2023, pp. 1–10. doi: 10.1109/ICNWC57852.2023.10127425.
[16] A. N. Khoirunnisa, A. N. Munir, and L. Dewi, "Design and prototype development of AR in reading learning for autism," *Computers*, vol. 12, no. 3, p. 55, Feb. 2023, doi: 10.3390/computers12030055.
[17] M. Nazar *et al.*, "Development of AR application for learning the concept of molecular geometry," *Journal of Physics: Conference Series*, vol. 1460, no. 1, p. 012083, Feb. 2020, doi: 10.1088/1742-6596/1460/1/012083.
[18] A. G. Spatioti, I. Kazanidis, and J. Pange, "A comparative study of the ADDIE instructional design model in distance education," *Information (Switzerland)*, vol. 13, no. 9, p. 402, Aug. 2022, doi: 10.3390/info13090402.
[19] E. N. F. T. Sari, M. Amin, A. M. Hudha, D. Fatmawati, and A. Fauzi, "Development of HOTS-based biology learning documents using ADDIE Model," *Research and Development in Education*, vol. 1, no. 2, pp. 61–70, Dec. 2021, doi: 10.22219/raden.v1i2.19049.
[20] D. Misesani, W. O. Janggo, and M. S. N. Wuwur, "Need analysis in ADDIE model to develop academic speaking materials," *Ethical Lingua: Journal of Language Teaching and Literature*, vol. 7, no. 2, pp. 438–446, Oct. 2020, doi: 10.30605/25409190.226.
[21] N. Najuah, R. Sidiq, and P. S. Lukitoyo, "The development electronic module of history using ADDIE model," *International Journal of Educational Research and Social Sciences (IJERSC)*, vol. 2, no. 6, pp. 1658–1663, 2021, doi: 10.51601/ijersc.v2i6.168.
[22] H. Crompton *et al.*, "Examining technology use within the ADDIE framework to develop professional training," *European Journal of Training and Development*, vol. 48, no. 3–4, pp. 422–454, Mar. 2024, doi: 10.1108/EJTD-12-2022-0137.
[23] C. Ikram, E. Mohamed, and K. Mohamed, "Enhancing adaptive pedagogical content development with ADDIE and scrum in hypermedia environments," *DIROSAT: Journal of Education, Social Sciences & Humanities*, vol. 2, no. 2, pp. 63–72, Feb. 2024, doi: 10.58355/dirosat.v2i2.64.
[24] J. Zhang, H. Chen, X. Wang, X. Huang, and D. Xie, "Application of flipped classroom teaching method based on ADDIE concept in clinical teaching for neurology residents," *BMC Medical Education*, vol. 24, no. 1, p. 366, Apr. 2024, doi: 10.1186/s12909-024-05343-z.
[25] A. Wibawa, P. D. Ashrianto, and S. T. Pambudi, "Implementation of ADDIE Model in improving the ability of lecturers to write scientific articles in accredited journals," *RSF Conference Series: Business, Management and Social Sciences*, vol. 1, no. 4, pp. 124–133, Oct. 2021, doi: 10.31098/bmss.v1i4.353.
[26] R. E. A. Rahim, C. S. Der, and N. M. Din, "Development of an interdisciplinary blended learning module for postgraduate research methodology course," in *ACM International Conference Proceeding Series*, New York, NY, USA: ACM, Jan. 2020, pp. 15–19. doi: 10.1145/3377571.3379435.
[27] A. Nuryadin, D. A. M. Lidinillah, and M. R. W. Muharram, "Pre-service teachers' experiences in developing digital learning designs using ADDIE model amid COVID-19 pandemic," *Jurnal Basicedu*, vol. 5, no. 5, pp. 4013–4025, Sep. 2021, doi: 10.31004/basicedu.v5i5.1446.

BIOGRAPHIES OF AUTHORS

Misael Lazo Amado holds a bachelor's degree in Systems Engineering and Computer Science, and is a researcher at the University of Sciences and Humanities. He propose technological and innovative solutions to address various problems. He has published in journals indexed in Scopus. He can be contacted at email: jerlazoa@uch.pe.

Meyluz Monica Paico Campos has a degree in Systems Engineering and Computer Science, and is a researcher at the University of Sciences and Humanities. She propose technological and innovative solutions to address various social problems in inclusive education. She has published in journals indexed in Scopus. She can be contacted at email: mpaico@uch.edu.pe.