Mobile Application with Augmented Reality Applying the MESOVA Methodology to Improve the Learning of Primary School Students in an Educational Center

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***Abstract*—"The application was developed using the MESOVA methodology, employing technologies such as Unity, Vuforia, and Visual Studio with the purpose of enhancing the educational experience for elementary school students. This innovative tool integrates augmented reality with the pedagogical principles of MESOVA, standing out notably from other research. Focusing on topics such as scientific knowledge and design and construction skills, the application not only provides information but also includes games that encourage interaction with the universe and planets, offering a participative and meaningful educational experience. The pretest results revealed an average scientific knowledge of 9.75%, significantly increasing to 15.55% in the posttest. Similarly, design and construction skills, initially evaluated at 8.24%, experienced a remarkable increase to 14.99% in the posttest. The adaptability of the application to the specific needs of elementary school students creates a stimulating and personalized learning environment. The combination of MESOVA and augmented reality enriches the educational experience, promoting understanding, collaboration, and critical thinking among students. In conclusion, the initiative goes beyond providing basic information; it becomes a transformative educational resource that equips students with fundamental cognitive and social skills as they explore the universe through augmented reality. Ultimately, it highlights the potential of technology and pedagogy to create a dynamic and enriching educational environment for elementary school students."**

Keywords*—Augmented reality; mobile application; MESOVA methodology; Kolmogorov-Smirnov; Wilcoxon; education; Vuforia

I. INTRODUCTION

"The use of technologies in student education is considered of utmost importance worldwide, as they have widely adopted technology in the educational field. Therefore, Hernon et al. [1]. However, they face significant challenges in terms of access and resources, while in developed countries, access to technology is usually more widespread. Many schools have computers, mobile devices, and high-speed internet access.

In Spain, it is demonstrated that Augmented Reality (AR) in basic education can promote active student participation, increase their interest and motivation, improve information retention, and allow for a more practical and experiential approach to learning, according to Verónica and Sampedro [2].

In Peru, work has been done on the implementation of educational technologies, including augmented reality. One of the most prominent applications of augmented reality in Peruvian education is the development of specific educational applications. According to [3], these applications allow students to explore virtual objects and interact with them, providing a practical and participatory experience. However, there is a limited presence of augmented reality applications, and there is a rapid disappearance of these tools in the education sector due to insufficient sustainability that does not allow their integration into long-term curricula [4].

Augmented reality is considered a fairly rigorous transformation composed of a set of technologies capable of overlaying images on the world in real-time. On the other hand, augmented reality is also considered the combination of digital information during real-time and within the person's field of vision [3]. Likewise, [5] infers that augmented reality is an innovative technology that offers new opportunities for learning and how to create interactive content, setting a trend in the educational sector, providing a real experience in students' academic training.

In another study, Rusli et al., [6] aimed to design a virtual reality-based learning to model the human body in 3D in the science course. The results obtained show that the mobile application can be installed on an Android 11.0 operating system, and it can run easily as it has a user-friendly environment. Demonstrating that the AR application helps science teachers and primary school students learn about the human body.

In the same vein, Mursydun et al., [7] aimed to implement augmented reality technology in comic learning to improve metacognitive ability in students. The results showed that the teaching level increased to 97.9% using Markerless AR, and students' usability reached 98.1%, with a usage flexibility valued at 0.98. Demonstrating that the level of comic learning in students increased thanks to Markerless AR technology.

On the other hand, in the study conducted by Roncal [8] with a sample of 43 students, the proposed indicators, such as the average score of evaluations, showed an increase from 11.81% in the pretest to 12.70% in the posttest. As for the average learning time, it increased from 20.93% to 30.56% in the posttest. An increase in effectiveness per participation was also observed, going from 1.16% in the pretest to 2.6% in the posttest.

Camacho et al., [9] aimed to determine the effect of augmented reality on student learning. With a sample of 120 students, the proposed indicators, such as the motivation level (20.3), delay time in understanding classes (19.8 minutes), satisfaction level (14.4%), and performance (14.2%), showed an increase in the posttest, highlighting an increase in the level of learning the Quechua language by applying augmented reality through the Mobile-D methodology.

Martínez et al. [10] aimed to determine the influence of augmented reality on the learning process, indicating an improvement of 75.20%, allowing for the improvement of mathematical function learning. Regarding Bakkiyaraj [11], their goal was to analyze the impact of augmented reality on learning, using three different versions for different student groups, with results showing an increase of...".

II. METHODOLOGY

The research embraced a quantitative and applied approach, focusing on the application of scientific and technical findings to address specific challenges and achieve practical outcomes in real-life situations, as noted by Castro et al., [14].

Regarding the design, it was classified as pre-experimental, as it involved the manipulation of variables with the purpose of measuring their effects, in accordance with the indications of Scarno and Gilli [15].

$$GE\ O_1\ X\ O_2$$

Where:

GE: Experimental Group among 5th-grade elementary students.

O_1: Pretest administered to 5th-grade elementary students without using the mobile application.

X: Proposed strategies, mobile application applying Augmented Reality (AR).

O_2: Pretest administered after the mobile application is used, applying augmented reality.

Therefore, the general hypothesis, AR improves learning in 5th grade students of an educational institution, followed by the specific hypotheses, AR improves scientific knowledge in 5th grade students of an educational institution and, finally, AR improves the design and construction of solutions in 5th grade students of an educational institution.

The study population consisted of elementary-level students from the educational institution 1256 Alfonso Ugarte. To conduct the research, inclusion criteria were applied to the 110 fifth-grade students belonging to sections A, B, and C of the Science and Technology area in the mentioned educational institution. In contrast, other grades and areas of the educational institution 1256 Alfonso Ugarte were not considered as exclusion criteria in the development of the research.

On the other hand, the study population will consist of 110 students. Since the population is extensive, it will be calculated using the following formula.

The formula you have provided is the formula for calculating the necessary sample size (n) in a finite population, considering the confidence level (Z), the probability of the desired event occurring (p), the probability of the undesired event occurring (q), the accepted level of error (e), and the size of the population (N). The mathematical expression is as follows:

$$n = \frac{N * Z_{\propto}^{2} * p * q}{e^{2} * (N-1) + Z_{\propto}^{2} * p * q}$$

$$= \frac{110^{2} * 1.645_{\alpha}^{2} * 50 * 50}{0.5^{2} * (110-1) + 1.645_{\alpha}^{2} * 50 * 50}$$

$$= 85$$

N= Desired sample size (110)

Z= Desired confidence level (90%)

P= Probability of the desired event occurring (50%)

Q= Probability of the undesired event occurring (50%)

E= Level of error willing to commit (5%)

N= Population size

Therefore, the required sample size to achieve a confidence level of 90%, with a probability of the desired event at 50%, a probability of the undesired event at 50%, an error level of 5%, in a population of size 110, is approximately 85.

According to Park, [16], sampling is the process by which a sample is chosen, consisting of a subset of elements drawn from a previously defined population. In this study, a sample calculation was performed; thus, a simple random probabilistic sampling method was employed.

In the development of an application aimed at enhancing learning in an educational center, the following tools were used:

a) Unity: Unity is a game development engine and a versatile platform for creating interactive experiences in 2D, 3D, virtual reality (VR), and augmented reality (AR). Known for its flexibility, it enables programmers and designers in building cross-platform applications and games, being widely used in the gaming and interactive applications development industry.

b) Vuforia: It is an augmented reality (AR) development platform that blends the physical world with virtual elements. It provides object, image, and marker recognition capabilities, allowing developers to create immersive AR applications for mobile and augmented reality devices. Common uses include the development of educational, marketing, and training applications, enhancing interaction between the real and virtual worlds across various industries.

c) Visual Studio: It was developed by Microsoft, is an integrated development environment (IDE) that provides tools and services for software creation in various programming languages. It stands out for its ability to support languages such as C#, C++, and Visual Basic. With features such as debugging, graphical interface design, and version control, it facilitates the development of applications for various platforms, including desktop, web, and mobile. Widely used in the software development industry, it is known for its robustness and efficiency in the application creation process.

Likewise, the MESOVA methodology will be applied, characterized by its emphasis on code reuse, modularity, and flexibility. Furthermore, it promotes collaboration among multidisciplinary teams and continuous adaptation to changes in the project environment.

Similarly, Gamarra and Mercado, [17], state that the MESOVA methodology is particularly relevant for the development of an augmented reality application, as it focuses on the active and collaborative participation of students. Applying MESOVA in the context of an augmented reality app promotes hands-on learning and exploration. Students can interact with virtual objects in their real environment, stimulating their curiosity and creativity.

In the study, a quantitative, applied, and experimental approach was followed, involving a sample of 43 second-grade high school students. To collect data, a record sheet designed to measure proposed indicators, such as the percentage of interventions, the percentage of task resolution, and academic performance, was utilized. The results obtained before and after a 45-day period were subjected to analysis using the statistical software IBM SPSS Statistics 26. This study was framed within the MESOVA methodology during the development of the AR app. Additionally, Gamarra and Mercado, [17], mention that MESOVA consists of five phases.

According to Parra [18], the software development methodology for Virtual Learning Objects, known as MESOVA, follows a sequential structure. It is important to note that within each phase, various activities are proposed, which can be carried out in a strict sequence or in parallel, depending on the nature of the project and the team's disposition. This structure can be observed in Fig. 1.

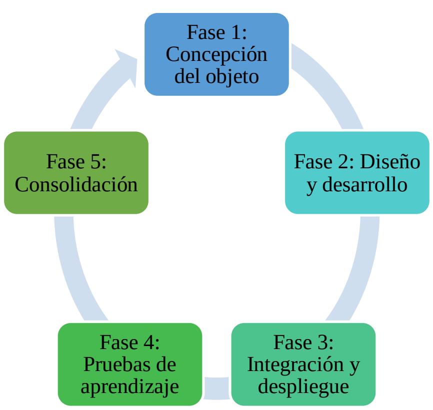

Fig. 1. Phases of the MESOVA methodology.

Similarly, Parra [18] describes the five phases of the MESOVA methodology applied to the development of the AR application.

Phase 1: Define goals and educational needs, research skills to be developed in students.

Phase 2: Create educational content, interactive activities, and augmented reality elements with an intuitive and appealing interface.

Phase 3: Integrate components, ensure cohesion, test the application, and launch it in educational environments.

Phase 4: Evaluate effectiveness through testing, gather data, analyze results, and adjust the application according to the actual needs of the students.

Phase 5: Analyze data, make final adjustments, document lessons learned, establish guidelines for future improvements, and develop strategies for long-term implementation in the educational curriculum.

Phase 1: Conception of the object

C1. Characterization of the theme and educational level

Conceptual Topics: Solar system, space debris, air pollution.

Procedure: Development of questionnaires covering the mentioned topics to record grades based on the obtained results.

Activities: Sparking curiosity and interest in the planetary system and understanding the presented topics.

C2. Pedagogical Specificity: Students acquire knowledge interactively, allowing them to experience AR for better learning and understanding.

C3. Functional and Non-functional Requirements (Table I).

C4. Use cases (Fig. 2).

C5 Software Tools: Unity and Vuforia.

TABLE I. FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

FUNCTIONAL REQUIREMENTS		
Code	**Requirement Names**	**Description**
RF-1	Camera	Enable the camera in AR scenes.
RF-2	Android operating system.	The application will run on the Android operating system (Google).
RF-3	Int & out button	The application must have a button to initiate the AR experience and a button to exit the application.
RF-4	Data access.	Provide access to the different topics established in the programmed content..
RF-5	Graphics	Drawing three-dimensional graphics focused on the theme.
RF-6	Interaction	Interaction with virtual objects.
RF-7	Monitoring	Monitoring the development of scenes.
NON-FUNCTIONAL REQUIREMENTS		
RF-1	Interface	The software's graphical interface must include logos, emblems, and colors related to the theme and dimensions.
RF-2	Development platform	The application must be developed using the UNITY 3D development platform.
RF-3	Content	The content weight should be as minimal as possible, considering that not all users have mobile devices with high capacity.
RF-4	Clarity	The information presented in AR must be clear and legible.
RF-5	Internet	Use of the application with or without internet.

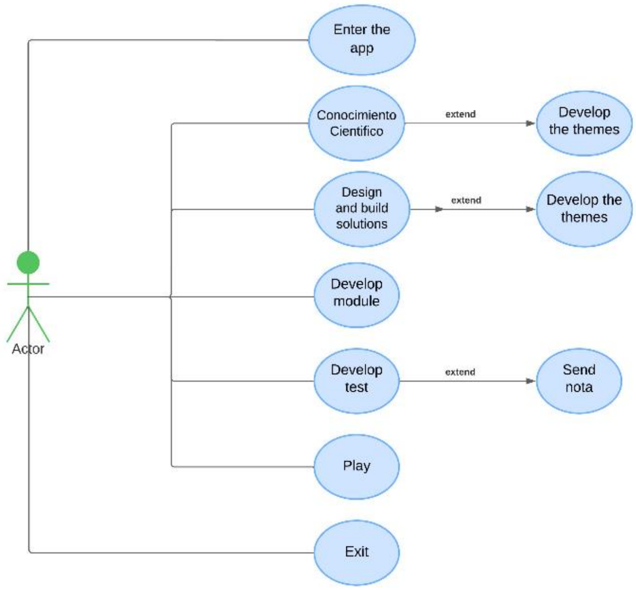

Fig. 2. Use case: student user

Phase 2: Design and Development.

Fig. 3 shows the architecture for the operation of the app. Fig. 4, 5 and 6 show the scenarios of the app operation, showing its menus, options, etc.

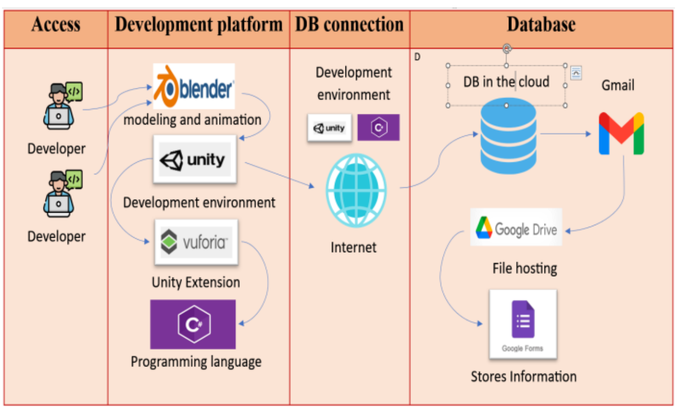

Fig. 3. App architecture

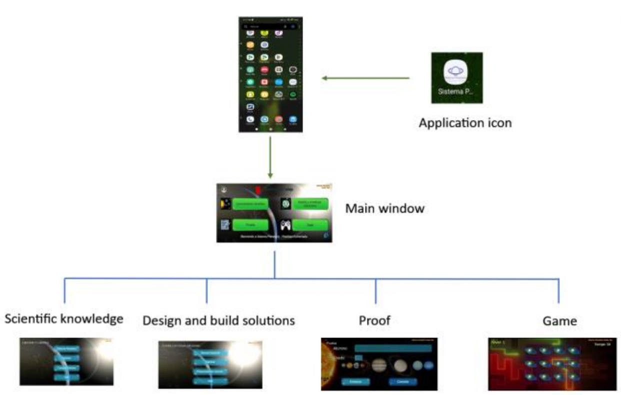

Fig. 4. Main menu scenes diagram

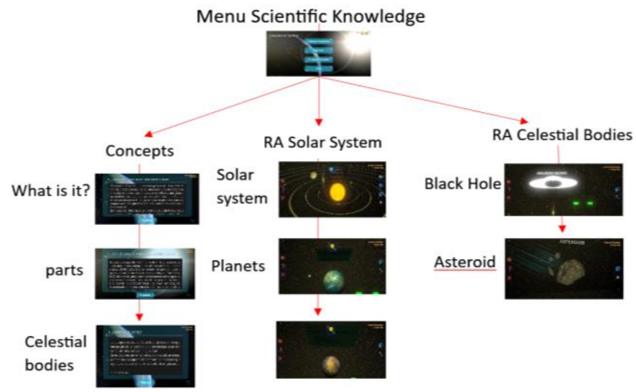

Fig. 5. Diagram of the scientific knowledge scene

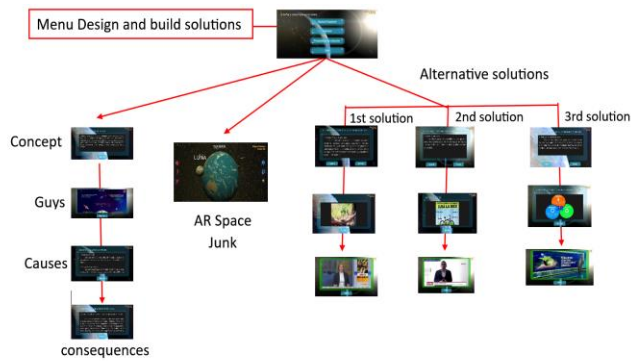

Fig. 6. Diagram of scene design and construction solutions

Phase 3: Integration and Deployment.

I1. Environment Configuration.

Technical Aspects: Android Version 9, 4GB RAM, Camera Resolution [4:3] 8 MP, CPU Speed: 1.6 GHz. Fig. 7 shows the correct installation for proper operation.

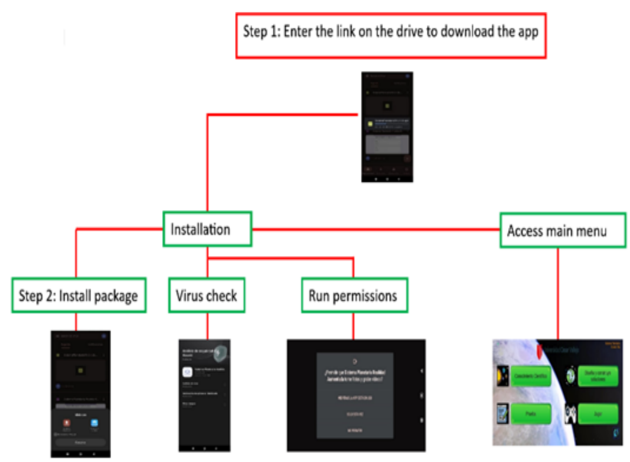

Fig. 7. App installation

I.2 Evaluation and validation of the system.

Our research methodology was validated through expert judgment in systems, who approved and endorsed the reliability and relevance of our findings, thereby strengthening the article's contribution. Table II.

TABLE II. SYSTEM VALIDATION

N.°	Questions	Answers		
		Poor	Good	Excellent
1	The mobile application was easy to use.	-	10	75
2	Are the presented concepts understandable?	-	5	80
4	Are the graphics presented in the app ideal?	-	-	85
5	Is the design, colors, and backgrounds attractive?	-	-	85
6	Overall, is the app interactive?	-	-	85
7	Do the virtual buttons function efficiently?	-	-	85
8	Do you consider that the test presented in the app is related to the provided information?	-	-	85

The rating scale is an essential component of the educational system, used to assess and communicate students' academic performance (Table III). Furthermore, it is qualitatively graded.

TABLE III. RATING SCALE

Escala de calificación (Rating scale)	
AD	Logro destacado (Outstanding achievement)
A	Logro esperado (Expected outcome)
B	En proceso (In process)
C	Inicio (Start)

Phase 4: Learning Test

P1. Population Selection, while Fig. 8 illustrates the surveys that students can take to diagnose their level of learning in relation to the topics addressed in the application (Table IV).

TABLE IV. TEST STUDENTS

Characteristics	Description
Number of Users	85 students
Grade	5th grade
Course	Science and Technology
Educational Institution	I.E 1256 Alfonso Ugarte
Evaluation	Knowledge Questionnaire

Phase 5: Reconciliation:

The culmination of the project 'Exploring the Universe with Augmented Reality' marks the peak of an innovative and exciting educational effort. During the phases of conception, design, and development, we created a mobile application with augmented reality technology based on the MESOVA methodology.

This application has been specifically designed to broaden the understanding of the universe and foster creative and scientific skills in elementary school students.

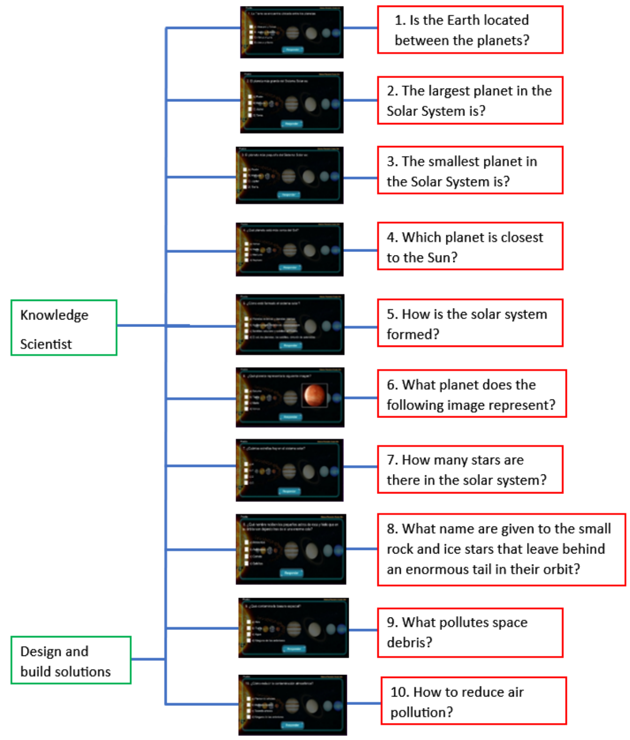

Fig. 8. Learning

Achievements and Results. During the learning tests, we observed a significant increase in students' interest in science and technology. The application has enhanced the understanding of complex scientific concepts and empowered students' ability to design and build creative solutions based on their acquired knowledge. Additionally, educators have reported improvements in student engagement and participation in the classroom, leading to a more interactive and collaborative learning environment.

Long-Term Impact. The application has not only provided immediate results but also lays the foundation for continuous learning. With the collected feedback, we have identified areas for improvement and developed strategies for future updates. Additionally, we have created complementary educational materials for educators, enabling them to effectively integrate the application into their curriculum and maximize its utility in the classroom.

Sustainability and Growth. To ensure the sustainability of the project, we have established collaborations with local educational institutions to provide continuous access to the application and technical support. Additionally, we have initiated training programs for educators, equipping them with effective use of the application and enabling them to adapt lessons according to the changing needs of students.

III. Results

In a study conducted in Quito in elementary schools, an Augmented Reality (AR) application was introduced to enhance the learning of fifth-grade students. The application allowed students to interact with scientific knowledge and undergo assessments. A pretest was conducted to evaluate students without the application, and in the posttest, the assessment was repeated with the AR application. This allowed for the comparison of results and analysis of the improvement in learning.

A. Descriptive Statistical Analysis

When examining descriptive measures related to the dimension of scientific knowledge, significant results were obtained that provide a detailed insight into the level of students' understanding. These data reveal relevant patterns and trends, providing a deeper understanding of the effectiveness of the applied educational methods.

Dimension 1: Scientific Knowledge (Table V)

TABLE V. Descriptive Measures of Scientific Knowledge

Statistics		
Pre Scientific Knowledge	Mean	9.759
	Standard Deviation	3.5369
	Minimum	2.5
	Maximum	17.5
Post Scientific Knowledge	Mean	15.55
	Standard Deviation	2.679
	Minimum	6
	Maximum	20

In the pretest, an average scientific knowledge of 9.75% was observed, which significantly increased to 15.55% in the posttest. Before the implementation of AR, the minimum knowledge was at 2.5%, whereas after its implementation, it rose to 6%. These results highlight the significant impact that the AR application has on student learning.

Dimension 2: Design and Build Solutions (Table VI)

TABLE VI. Descriptive Statistics of Design and Build

Statistics		
Designs and Builds Solutions Pre	Mean	8.241
	Standard Deviation	4.4898
	Minimum	0
	Maximum	20.0
Designs and Builds Solutions Post	Mean	14.99
	Standard Deviation	2.926
	Minimum	8
	Maximum	20

In the pretest, the ability to design and build solutions was observed at 8.24%, which significantly increased to 14.99% in the posttest. Before the implementation of AR, the minimum knowledge was at 0%, whereas after its implementation, it rose to 8%. These results highlight the significant impact that the AR application has on student learning.

B. Inferential Analysis

The Kolmogorov-Smirnov test was applied to evaluate the normality of the relationship according to the dimension, given that the sample size exceeds 50 units of analysis. The reliability level of 95, which is equal to 0.05, was taken into account for the test.

Dimension 1: Scientific Knowledge (Table VII)

TABLE VII. Normality Test of Scientific Knowledge

	Kolmogorov-Smirnov		
	Statistician	gl	Sig.
DDIFF Scientific knowledge	,100	85	,036

The results of the Kolmogorov-Smirnov test represented in Table VI, for the scientific knowledge dimension was 0.036, which indicates that it is greater than 0.05, indicating that the data do not follow a normal distortion, and the Wilcoxon test had to be applied.

TABLE VIII. Wilcoxon Test of the Scientific Knowledge Dimension

Test statistics	
	Post scientific knowledge - Pre scientific knowledge
Z	-7,417
Sig. asin. (bilateral)	,000

The results of the Wilcoxon test for the scientific knowledge dimension was 0.000, which indicates that it is less than 0.05, indicating that the data follow a normal distortion (Table VIII).

Ha: AR improves scientific knowledge in 5th grade students of an educational institution.

Ho: AR does not improve scientific knowledge in 5th grade students of an educational institution.

Based on the results of the Wilcoxon test, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected.

Dimension 2: Design and build

To carry out the hypothesis testing analysis, the data were subjected to the Kolmogorov-Smirnov test to determine whether the data collected in the design and construct dimension exhibit a normal distribution (Table IX).

TABLE IX. Kolmogorov Test of Dimension Design and Construction

	Kolmogorov-Smirnov		
	Statistician	gl	Sig.
DIFF Designs and builds solutions	,114	85	,008

The results of the Kolmogorov-Smirnov test represented in Table VIII, for the scientific knowledge dimension was 0.08, which indicates that it is greater than 0.05, indicating that the data do not follow a normal distortion, and the Wilcoxon test had to be applied (Table X).

TABLE X. Wilcoxon Test of the Design and Build Dimension

Test statistics	
	Designs and builds post - designs and builds pre - designs and builds pre - designs and builds post solutions
Z	-7,803
Sig. asin. (bilateral)	,000

The results of the Wilcoxon test for the design and construct dimension was 0.000, which indicates that it is less than 0.05, indicating that the data follow a normal distortion.

Ha: AR improves when designing and constructing solutions in 5th grade students of an educational institution.

Ho: AR does not improve when designing and constructing solutions in 5th grade students of an educational institution.

Based on the results of the Wilcoxon test, the alternative hypothesis (Ha) is accepted and the null hypothesis (Ho) is rejected.

IV. Discussion

For the dimension of scientific knowledge, evaluations were conducted on students through practical exams related to indicators such as understanding and using knowledge about living beings, assessing the implications of scientific and technological knowledge and actions. In the pretest, the average result was 9.75%, while for the posttest, it was 15.55%, showing an increase of 5.8%. In another study, Rusli et al., [6] obtained results indicating that the mobile application that can be installed must have the Android 11.0 operating system, and it can run easily as it has a user-friendly interface. They demonstrated that the AR application helps science teachers and elementary school students teach about the human body.

Similarly, Mursydun et al., [7], achieved increased teaching levels, with a result of 97.9% implementing Markerless AR. The usability of students resulted in 98.1%, and flexibility had a result of 0.98%. On the other hand, Roncal [8] reported a lower average grade on evaluations with a result of 12.70%, a lower average grade obtained with 14.11%, and a higher measurement of average time with 30.56%. The measurement of task resolution time showed a higher result with 22.26%, and the effectiveness measurement by participation obtained 2.6%. Camacho et al., [9], proposed the following indicators, for the motivation level is 20.3, delay time in understanding classes is 19.8 minutes, satisfaction level is 14.4%, and a performance level of 14.2%. In the posttest, the motivation level is 20.8, delay time in understanding classes is 16.4 minutes, satisfaction level is 17.4%, and a performance level of 17.0%.

On the other hand, in the dimension of designing and building solutions, evaluations were conducted on students through practical exams related to indicators such as determining a technological solution alternative, designing the technological solution alternative, and implementing the technological solution alternative. In the pretest, the average result was 8.24%, while for the posttest, it was 14.99%, showing an increase of 6.55%. Martinez et al. [10] in the learning process indicated a higher result, achieving 75.20%. Bakkiyaraj [11], regarding the level of student retention, reported a higher result, reaching 77.5%. Pretell et al. [12], demonstrating the use of these tools, showed a higher result, reaching 82.18%. AlNajdi [13] observed in their research that the result was higher, with 91% of students successfully passing the self-assessment.

V. Conclusions

1) The application of augmented reality (AR) for educational purposes has demonstrated a significant positive impact on the scientific knowledge of the participants, recording an increase of 15.55% after two weeks of continuous use. These results highlight a slightly lower increase in the mobile application compared to previous research, as it was conducted with a sample of 85 fifth-grade students. Additionally, three-dimensional models of the planetary system were presented, further enriching the learning experience.

2) The application of augmented reality (AR) for educational purposes has demonstrated a significant positive impact on designing and building solutions, recording an increase of 14.99% after two weeks of continuous use. These results highlight a slightly lower increase in the mobile application compared to previous research, as it was conducted with a sample of 85 fifth-grade students. Additionally, three-dimensional models of the planetary system were presented, further enriching the learning experience.

3) For future projects, it would be essential to integrate artificial intelligence to enhance the learning experience of elementary school students. This would involve developing AI algorithms that analyze each student's individual progress and provide personalized recommendations to optimize their learning. Additionally, exploring how AI can improve the interactivity and adaptability of augmented reality applications could allow for an even more dynamic and effective educational experience.

Acknowledgments

We want to express our gratitude to everyone involved: educators, students, and developers. Your collaboration and enthusiasm have been crucial to the success of this project. We hope that 'Exploring the Universe with Augmented Reality' continues to inspire young minds and foster a lasting passion for science and exploration.

References

[1] Hernon [et al.], The use of educational technology in teaching and assessing clinical psychomotor skills in nursing and midwifery education: A review of cutting-edge literature, 2023.

[2] V. MAÍN and B. SAMPEDRO, "Augmented Reality in Primary Education since students' visions," 2020.

[3] E. Flores, "Augmented reality technology for the teaching-learning process in Peru," Cátedra Villarreal, vol. 6, pp. 175-187, 2018.

[4] A. Calli and L. Puño, "Application of augmented reality in the perception of learning in elementary school students," Scielo Preprints, vol. 1, pp. 1-15, 2022.

[5] C. Cerón, E. Archundia, A. Cervantes and D. Cervantes, "Mobile app for the learning of the Cellular Biology with Augmented Reality," EDUCATECONCIENCIA, 6-19. doi:10.58299/edu.v26i27.34, vol. 26, pp. 6-19, 2020.

[6] Rusli [et al], "Augmented reality for studying hands on the human body for elementary school students," pp. 1-8, 2023.

[7] Mursydun [et al.], "Markerless Augmented Reality (MAR) through Learning Comics to Improve Student Metacognitive Ability," 2019.

[8] RONCAL, Alfredo, Augmented Reality in the Learning of Physical Sciences Students at the Faculty of Engineering of UPSJB 2021., 2022.

[9] Camacho [et al.], "Augmented reality mobile application and its augmented reality mobile application and its," 2020.

[10] O. M. Martínez, E. Mejía, W. R. Ramírez and T. D. Rodríguez, "Incidence of augmented reality in the learning process of mathematical functions," Información tecnológica, pp. 3-14, 2021.

[11] M. Bakkiyaraj, G. Kavitha, G. Sai Krishnan and S. Kumar, "Impact of Augmented Reality on learning Fused Deposition Modeling based 3D printing Augmented Reality for skill developmen," Materials Today: Proceedings, pp. 2464-2471, 2021.

[12] J. Pretell Cruzado, T. Llajaruna Céspedes, G. P. Bohorquez Coria and J. L. Herrera Salazar, "Geobook: Mobile App with Augmented Reality for Learning Geometry," 2020 IEEE Engineering International Research Conference (EIRCON), pp. 1-4, 2020.

[13] S. M. AlNajdi, "The effectiveness of using augmented reality (AR) to enhance student performance: using quick response (QR) codes in student textbooks in the Saudi education system," Educational technology research and development volume, p. 1105–1124, 2022.

[14] Castro [et al.], "Applied research and experimental development in strengthening the competences of the 21st century society," 2022.

[15] E. SCARNO and J. GILLI, The experimental research by Alfredo Palacios at the Faculty of Economic Sciences of the University of Buenos Aires, CONICET. 9, 1-10, 2022.

[16] H. Park, "McCARD/MIG stochastic sampling calculations for nuclear cross section sensitivity and uncertainty analysis," Nuclear Engineering and Technology, vol. 54, pp. 1-8, 16 Junio 2022.

[17] GAMARRA, Jairo; MERCADO, Sarai, Mobile Application of Augmented Reality with Unity and Vuforia for Science and Technology Learning at Colegio América 2021.

[18] PARRA, Eucario, Proposal for a software development methodology for virtual learning objects - MESOVA. 2019.