

# Immersive Educational Application Based on Unity for Learning the Quechua Language

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**Abstract**—Learning indigenous languages such as Quechua helps preserve cultural identity by narrowing educational gaps, in line with Sustainable Development Goal 4, which promotes inclusive and quality education. The objective was to develop an immersive educational application based on Unity to improve the learning of the Quechua language. This was an applied research study with a quantitative approach and a pre-experimental design, in which a pre- and post-test was administered to a group of young people. The results demonstrated that the Unity-based immersive educational app significantly improved recognition of Quechua vocabulary ( $Z = -4.149$ ,  $p < 0.001$ ), increased performance on interactive activities (mean Level 2 = 15.58 vs. Level 1 = 13.17; error rate reduced from 34.17% to 22.08%), and decreased the overall error rate in language use ( $Z = -4.149$ ,  $p < 0.001$ ), demonstrating its effectiveness in language learning and accuracy. In conclusion, virtual reality proved to be an effective and motivating tool for learning Quechua, promoting quality education and an appreciation for Peruvian cultural heritage.

**Keywords**—Quechua; computer application; information technology (software)

## I. INTRODUCTION

Indigenous languages are a fundamental part of the cultural identity of indigenous peoples. However, many of them are at risk of disappearing, which jeopardizes their survival over time [1]. Although they continue to play an important role in everyday activities such as agriculture, herding, and fishing in rural areas, in urban environments, they may still be rejected or undervalued by their own speakers [2].

One of these languages is Quechua, which was spoken long before Spanish arrived and is still used and kept alive in several regions of the country [3]. Quechua is not a single language, but a linguistic family composed of various varieties spoken in seven South American countries: Peru, Ecuador, Colombia, Bolivia, Argentina, Chile, and Brazil [4].

According to the 2017 census, more than 1.6 million people learned this language as children, meaning there is a need to preserve Quechua as an essential means of accessing information in diverse contexts [5]. Unfortunately, its use has declined significantly among young people due to migration, discrimination, and a lack of support in the education system [6]. This has led to its replacement by Spanish as the main language in many regions [7]. However, it is still preserved in family environments as an important part of cultural identity [8].

Although the importance of Quechua as an indigenous language is recognized, as is the growing interest in immersive technologies for education, it is crucial to understand the current

situation in the country. There are 48 officially recognized indigenous languages, of which 27 are viable, 4 are endangered, 10 are seriously endangered, and 7 are critically endangered. In urban areas such as Metropolitan Lima, there are still Quechua speakers [9].

In the field of education, Quechua forms part of a cultural identity. Teaching it strengthens a sense of belonging and promotes inclusion [2]. It is the most widely spoken indigenous language in the country, with a strong presence in the Andean region, where 65.2% of indigenous language speakers are concentrated. Furthermore, its use is linked to the level of education attained, highlighting significant gaps within the Peruvian population [10].

Given the cultural relevance of Quechua and the contribution of immersive tools to its learning, it is key to project how these technologies will evolve in the educational field. Thus, not only is the usefulness of the application highlighted, but also the opportunities that arise in a global context of digital education in transformation, where gamification and immersive environments drive student motivation and engagement [11].

Most previous studies have focused on global languages such as English or French, leaving a gap in research applied to indigenous languages. That is why we must attach importance to these indigenous languages, as they open up new possibilities for the design of intercultural education policies. In Peru, the teaching of native languages is supported by the Indigenous Languages Act (Act No. 29735), but it often lacks modern methodological resources. Technological projects such as this one can serve as a basis for innovative pedagogical proposals that integrate ICT (Information and Communication Technologies) into intercultural bilingual education [12].

International organizations such as UNESCO point out that digital education with an intercultural approach is key to achieving the Sustainable Development Goals, especially in relation to equity and the preservation of intangible cultural heritage [13]. In this sense, this project is part of a global trend where technology not only transmits knowledge but also protects and promotes cultural diversity.

Considering the above, a solution was proposed in the form of an educational virtual reality mobile application developed in Unity, aimed at strengthening the learning of the Quechua language in an interactive environment. The application is designed with a structure of 10 progressive levels, in which the user learns greetings, everyday objects, and simple phrases through practical activities. Using a fixed pointer on the screen,

participants can interact with elements in the virtual environment, which has an eye-catching, easy-to-use video game-style design designed to capture young people's attention and keep them motivated throughout the process.

This project stems from an interest in preserving the Quechua language, an important part of our identity that many people no longer use. That is why an application was created in Unity that seeks to teach some basic Quechua words and phrases in a more accessible way, using virtual reality. The idea is for young people to learn while enjoying a different, more visual and entertaining experience. The proposal combines technology and education to make learning more accessible, visual, and interactive.

This project is linked to Sustainable Development Goal (SDG) No. 4, focused on industry, innovation, and infrastructure, as it seeks to leverage technology to promote education and social development. UNESCO [14] emphasizes that inclusive, quality education depends largely on the responsible use of technology, provided that it serves a clear and ethical pedagogical purpose.

In this vein, the development of an immersive application in Unity not only represents a technological proposal but also a way to preserve and disseminate the Quechua language through a modern and interactive experience. It is a way to combine innovation with cultural identity, bringing learning closer to young people through an attractive and accessible virtual environment, where technology is no longer just a tool but becomes a bridge between the ancestral and the digital.

This study can provide concrete evidence on the effectiveness of immersive applications developed with Unity in learning the Quechua language, which would serve as a basis for similar future educational implementations in other Quechua-speaking communities. Previous studies that have used digital tools in Quechua already show significant improvements in performance when alternative teaching methods are used, such as augmented reality applications for preschoolers, which improved learning and satisfaction compared to traditional methods [14].

The proposal was justified for theoretical, technological, and social reasons. Theoretically, virtual reality allows the creation of environments that promote language learning by representing real situations in a practical way. Technologically, an application was developed in Unity with game elements that help maintain user interest and participation. Socially, this project seeks to contribute to the preservation of Quechua by promoting its use from an early age. Carrying out this type of proposal is important because it helps keep an endangered language alive, using current tools that connect with new generations.

That is why the overall objective was defined as determining how an immersive educational application based on Unity improves Quechua language learning.

## II. LITERATURE REVIEW

Next, previous studies related to the topic are reviewed, and some important advances that help to improve understanding are

explained, all of which are brought together in the background section.

According to one study [15], which evaluated whether different levels of immersion in virtual reality influenced students' willingness to communicate in English as a second language, it was found that, although the type of virtual reality was not decisive, the order of the tasks did have an impact on confidence, with highly immersive environments reducing anxiety and increasing self-confidence.

In the work developed by [16], a comparison was made of how the use of immersive virtual reality affects adults who are learning words, including people with aphasia and others without this condition, compared to a more basic digital method. The results showed that virtual reality improved verbal ability and reduced errors, especially in people with aphasia, thanks to its immersive environment that facilitates the connection between word and meaning.

On the other hand, the research carried out in [17], focused on creating an educational tool that explains glacier retreat in the Peruvian Andes. It used a quantitative and longitudinal approach with Design Thinking, visual and satellite analysis. A loss of 32.5% and 56.9% was found in the Chicon and Pumahuanca glaciers. It was concluded that an augmented reality app can promote environmental awareness and responsible water use.

A study [18] conducted a systematic review to evaluate immersive virtual reality (IVR) interventions using the PRISMA method. Of 923 articles, 30 studies with 2,404 participants were analyzed. It was found that IVR improves declarative and procedural knowledge in active learning environments. It was concluded that IVR increases learning and participation, and its use in line with educational objectives was recommended.

In accordance with the findings of [19], the impact of virtual reality (VR) on the self-efficacy of first-year English students in Vietnam was examined using mixed methods with questionnaires and interviews. The results indicated that VR increased confidence and self-efficacy in the use of English, improving practice and communication skills, although some challenges in its use were identified.

In accordance with [20], the Satisfaction with Life Scale (SWLS) was translated and validated into the Collao variant of Quechua, using translation, back-translation, and focus groups with 242 speakers from Puno. The results indicated good validity and internal consistency, although gender invariance was not fully confirmed. This validated scale facilitates the measurement of well-being in Quechua speakers in educational contexts, including those with technology for language learning.

Finally, in accordance with [21], the WHO-5 General Well-Being Index was translated and validated into the Collao variant of Quechua with 186 speakers from Puno, using translation, back-translation, focus groups, and expert evaluation. The results showed high relevance, good internal consistency ( $\alpha = 0.88$ ), and an adequate unidimensional model. The WHO-5 is a reliable tool for measuring subjective well-being in Quechua-speaking communities, useful for primary care and future research.

In this section, the theories and conceptual framework related to the topic were developed and evaluated, based on the relationship between the independent variable and the dependent variable.

Digital image processing emerged in the 20th century thanks to advances in computing and optics. Initially, it was used in military and aerospace applications, but later it was applied in medicine, education, and entertainment [22]. With improvements in sensors, displays, and graphics engines such as Unity, virtual reality has moved beyond being just an experimental technology to become an accessible tool. This is especially important in education, where it enables more engaging and meaningful learning, particularly in cultural and language subjects.

### III. METHODOLOGY

The research was applied in nature with a quantitative approach and a single-group pre-experimental design, evaluating the effect of an immersive educational application developed in Unity for learning Quechua. Thirty young people between the ages of 12 and 22 participated, selected through non-probabilistic convenience sampling and evaluated with a pre-test and post-test.

#### A. Case Development

The Mobile-D methodology, suitable for agile mobile projects, was used to develop the application. During the exploration phase, the scope of the project was identified, aimed at creating an immersive virtual reality educational application for basic Quechua language learning. Development was carried out in Unity, complemented by free software tools, while data management and storage were implemented using Firebase (Firestore), allowing for automatic recording of user progress and interactions.

The application was developed in Unity as the main engine, using C# for internal logic and virtual reality packages compatible with mobile devices. Communication with the database was implemented using Firebase, employing Firestore for cloud storage and Firebase Authentication for secure user management. The architecture followed a client-server model, where the mobile application acts as a client handling local processing of the immersive experience, while the Firebase server manages the recording of progress, results, and usage metrics. This integration allowed for real-time data storage, synchronization of user progress, and ensured stable operation during virtual reality interaction. See Table I.

TABLE I. FUNCTIONAL REQUIREMENTS

Code	Module	Functional Requirement
RF01	Login	The application will allow users to log in.
RF02	Registration	Users will be able to register with their basic information.
RF03	Main Menu	It will display the application options upon logging in.
RF04	Lessons	Allows access to mini-games or educational activities in Quechua.
RF05	Tracking	The system will save the user's progress (e.g., levels completed)
RF06	Results	Displays the results of each lesson or educational game.
RF07	Logout	The user can log out from the menu.

Once the functional requirements have been established, the non-functional requirements that guarantee the stability and reliability of the application are described. within the application. See Table II.

TABLE II. NON-FUNCTIONAL REQUIREMENTS

Code	Category	Non-Functional Requirement
RNF01	Performance	Activities must run without noticeable delays to maintain immersion.
RNF02	Usability	The application must be intuitive, even for users with no previous VR experience.
RNF03	Compatibility	The app must work on Android devices with support for virtual reality headsets.
RNF04	Accessibility	Texts must be legible and controls accessible from VR.
RNF05	Security	Personal data must be stored securely using Firebase Authentication.

The aim was to create a virtual reality application that offers an interactive and engaging experience, helping users to learn the basics of Quechua in a dynamic and educational way. See Fig. 1.

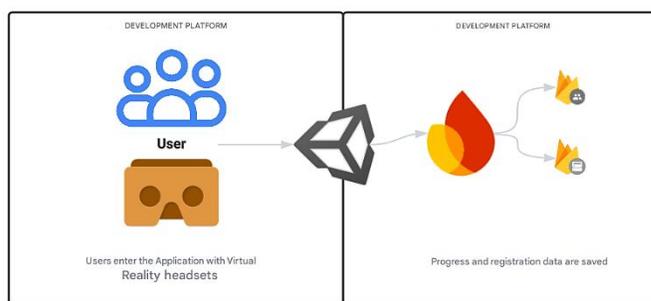


Fig. 1. Architecture, Client-Server.

During the development of the application, the phases defined by the selected methodology were followed. In the Exploration stage, the stakeholders and the scope of the project were identified. Then, in Initialization, the base architecture and necessary resources were configured. The Production phase consisted of building the system modules, prioritizing the immersive virtual reality experience. Subsequently, in Stabilization, the developed functionalities were integrated and adjusted. Finally, in the Testing phase, unit and integration evaluations were performed, verifying the correct functioning of the application and the adequate recording of user performance. See Table III.

TABLE III. METHODOLOGY PHASES

PHASE	ITERACIÓN	DESCRIPCIÓN
Exploration	Iteration 0	Study of stakeholders, project scope, and necessary requirements.
Initializa tion	Iteration 1	Configuration of the project, architecture, and resources to be used.
Production	Iteration 2	Declaration and development of each module.
Stabilization	Iteration 3	Integration of functions and recommendations for optimal operation of the mobile application.
Testing	Iteration 4	Unit and integration testing of the application, in software and real time.

During Phase 3: Production, the main components of the application were progressively built, prioritizing the immersive virtual reality experience and the inclusion of interactive elements. At this stage, the essential modules of the system were developed: user authentication, navigation through a main menu, immersive learning of Quechua in VR, and educational mini-games controlled by eye movement. In addition, a basic feedback module was incorporated to indicate correct and incorrect answers, along with a progress tracking module responsible for storing key data on user performance. These modules work together to provide a consistent and functional learning experience.

A general verification was performed to ensure that the internal modules of the application function correctly, both at the hardware and software levels. For testing, a device with 16 GB of RAM, Wi-Fi or mobile data connection, integrated gyroscope, and mobile phone-compatible virtual reality headsets was used. See Fig. 2.

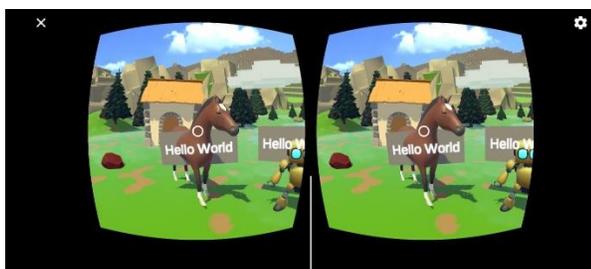


Fig. 2. Screenshot – test scene.

In terms of the software environment, the application was evaluated on devices running Android operating system version 5.0 or higher with 4G network connectivity, ensuring adequate performance and a stable immersive experience for the user.

#### IV. RESULTS

Two questionnaires were used to measure these indicators: the pre-test, administered before using the mobile application, and the post-test, administered after using it. In the case of progress in interactive activities, this was recorded directly by the application, allowing for an objective assessment of the participants' progress.

##### A. Testing of Specific Hypothesis 1

An immersive educational application based on Unity improves vocabulary recognition in the Quechua language. Table IV shows the results of this indicator, obtained from the questionnaire administered before (pre-test) and after (post-test) use of the application. The questionnaire included questions on the identification and comprehension of Quechua words, recording the answers as correct or incorrect (1 = correct, 0 = incorrect), with the aim of measuring progress in vocabulary recognition. See Table IV.

In this part, the Shapiro–Wilk normality test was applied to the vocabulary recognition scores, obtaining a significance value of 0.014 for the pretest and 0.135 for the posttest. In the initial assessment, the significance was less than 0.05, indicating that the data did not follow a normal distribution. In contrast, in

the subsequent assessment, the value was greater than 0.05, suggesting an approximation to normality.

TABLE IV. NORMALITY TEST FOR VOCABULARY RECOGNITION

	Shapiro-Wilk		
	Statistician	gl	Sig.
PRE_TEST	.909	30	.014
POS_TEST	.946	30	.135

Given that normality is not met in both measurements, the nonparametric Wilcoxon test is applied to compare the results obtained in the pretest and posttest. See Table V.

TABLE V. WILCOXON SIGN RANKS - VOCABULARY RECOGNITION

		N	Average rank	Sum of ranks
PUNTAJE_POS -	Negative ranks	2 <sup>a</sup>	2.50	5.00
	Positive ranks	22 <sup>b</sup>	13.41	295.00
Tie		6 <sup>c</sup>		
Total		30		

a. PUNTAJE\_POS < PUNTAJE\_PRE  
 b. PUNTAJE\_POS > PUNTAJE\_PRE  
 c. PUNTAJE\_POS = PUNTAJE\_PRE

The ranks obtained using the Wilcoxon test are presented. There are 22 positive ranks with an average rank of 13.41 and a sum of ranks of 295.00. Likewise, there are 2 negative ranks with an average rank of 2.50 and a total sum of ranks of 5.00. Finally, N ties are recorded, which shows a general improvement in vocabulary recognition after using the educational application.

Table VI presents the test statistics.

TABLE VI. TEST STATISTICS – WILCOXON TEST FOR VOCABULARY RECOGNITION

Test statistics <sup>a</sup>	
	PUNTAJE_POS - PUNTAJE_PRE
Z	-4.149 <sup>b</sup>
Sig. asin. (bilateral)	<.001

a. Wilcoxon signed-rank test  
 b. Based on negative ranks.

Finally, there was an increase in average vocabulary recognition scores after using the Unity-based immersive educational application. This shows a positive impact on Quechua language learning, demonstrating that participants achieved better word identification and comprehension after the intervention.

##### B. Testing Specific Hypothesis 2

An immersive educational application based on Unity increases progress in interactive activities in the Quechua language. Below are the descriptive results related to the indicator of progress in interactive activities, which reflects the level of advancement of participants within the application and the relationship with the dimensions of vocabulary retention and error rate. See Table VII.

The group with high progress (levels 8 to 10) obtained an average score of 15.58, while the group with low or medium progress (levels 1 to 7) achieved an average of 13.17. This difference reflects a positive trend: participants who advanced more levels within the interactive environment achieved better results in vocabulary retention. See Table VIII.

TABLE VII. AVERAGES (MEAN) BY LEVEL – VOCABULARY RECOGNITION

Group Level	Media	N	Desv. Deviation
1.00	13.17	6	3.488
2.00	15.58	24	3.322
Total	15.10	30	3.438

TABLE VIII. AVERAGES (MEAN) BY LEVEL – ERROR RATE

Group Level	Media	N	Desv. Deviation
1.00	34.1667	6	17.44037
2.00	22.0833	24	16.61041
Total	24.5000	30	17.18811

On the other hand, participants in group 1 (levels 1–7) had an average error rate of 34.17%, while those in group 2 (levels 8–10) had a lower average error rate of 22.08%. This indicates that the higher the level achieved, the lower the percentage of errors.

### C. Testing Specific Hypothesis 3

An immersive educational application based on Unity reduces the error rate in the use of the Quechua language. Descriptive statistics related to the participants' error rate are presented. To this end, the column showing the percentage of errors obtained in the pre-test and post-test, measured before and after using the educational application, was used. See Table IX.

TABLE IX. ERROR RATE NORMALITY TEST

	Shapiro-Wilk		
	Statistic	gl	Sig.
PRE_TEST	.909	30	.014
POS_TEST	.946	30	.135

The Shapiro-Wilk normality test was applied to the error rate scores. For the pretest, the statistic was 0.909 with a significance value of 0.014, indicating that the data are not normally distributed. For the posttest, the statistic was 0.946 with a significance value of 0.135, suggesting that the data are normally distributed.

Since at least one of the samples does not meet the normality requirement, the Wilcoxon test is performed to compare the data obtained in both measurements. See Table X.

Here are the ranks obtained using the Wilcoxon test for the error rate. There are 22 negative ranks, with an average rank of 13.41 and a sum of ranks of 295.00, indicating that most participants reduced their error rate after using the application. In addition, there are 2 positive ranks, with an average rank of 2.50 and a sum of ranks of 5.00, and 6 ties. These results show an overall decrease in the error rate in Quechua with the use of the educational application. See Table XI.

TABLE X. WILCOXON SIGN RANKS – ERROR RATE

		N	Average rank	Sum of ranks
PUNTAJE_POS -	Negative ranks	22 <sup>a</sup>	13.41	295.00
PUNTAJE_PRE	Positive ranks	2 <sup>b</sup>	2.50	5.00
	Tie	6 <sup>c</sup>		
	Total	30		

a. PUNTAJE\_POS < PUNTAJE\_PRE  
 b. PUNTAJE\_POS > PUNTAJE\_PRE  
 c. PUNTAJE\_POS = PUNTAJE\_PRE

TABLE XI. TEST STATISTICS – WILCOXON TEST FOR ERROR RATE.

Test statistics <sup>a</sup>	
	PUNTAJE_POS - PUNTAJE_PRE
Z	-4.149 <sup>b</sup>
Sig. a sin. (bilateral)	<.001

a. Wilcoxon signed-rank test  
 b. Based on negative ranks.

The Wilcoxon test shows a significant decrease in the error rate after using the application,  $Z = -4.149$ ,  $p < 0.001$ . This indicates that most participants improved in their use of the Quechua language.

## V. DISCUSSION

This section presents the results obtained from the specific and general objectives set out in the research, comparing them with the theoretical background and previous studies analyzed in the theoretical framework. This process seeks to interpret the findings, understand their relationship with the proposed hypotheses, and with the pedagogical approach to learning the Quechua language through virtual reality. In addition, this analysis in this report may contribute to future research in the area of technology in the teaching of indigenous languages, strengthening the connection between educational innovation, cultural preservation, and the quality of learning.

Vocabulary recognition is one of the first stages in language learning, as it involves identifying and understanding words within a communicative context [23]. According to Orellana-Garcia et al. (2020), the ability to recognize words visually or auditorily facilitates progressive language acquisition. In this sense, virtual reality offers an environment conducive to reinforcing this skill, allowing students to relate the terms they have learned to specific objects and situations, thereby promoting retention [24]. Unity, as a development engine, contributes to the design of these interactive immersive environments that stimulate visual and auditory memory [25]. According to the results obtained, the Wilcoxon test showed statistically significant differences between the pretest and posttest in vocabulary recognition ( $p < 0.001$ ). Participants demonstrated a notable increase in the number of words correctly identified after using the application.

In addition, the positive ranges (2) compared to only 2 negative ones reflect a clear trend toward overall improvement in learning. This confirms that the immersive application had a positive impact on the assimilation of Quechua vocabulary. These findings are in line with Yuditseva (2024) [15], who

demonstrated that immersive environments reduce communicative anxiety and increase linguistic confidence, improving vocabulary retention. Similarly, Franco et al. (2025) [16] showed that virtual reality optimizes word-image association and enhances verbal ability. Likewise, Conrad, Kablitz, and Schumann (2024) [18] pointed out that immersive virtual environments increase declarative and procedural learning through active interaction. The results suggest that the use of the immersive educational application in Unity generated a meaningful experience for participants, facilitating vocabulary recognition through interaction with cultural and visual elements specific to the Quechua language. Immersion, combined with the gamification of the environment, maintained user motivation and promoted autonomous learning. As a result, the application not only strengthened the understanding of basic words but also increased interest in the language and its cultural context.

The error rate in language learning is associated with accuracy in the comprehension and production of words or phrases within a communicative context [26]. Según Krashen (1982), los errores son parte del proceso. According to Krashen (1982), errors are part of the natural process of language acquisition, but their reduction reflects progress in the internalization of knowledge. In immersive environments, immediate feedback and the possibility of repeating actions allow students to correct errors autonomously, reinforcing procedural memory. In this sense, virtual reality is considered an effective tool for improving accuracy in language learning, as it integrates visual, auditory, and kinesthetic practice [24]. The results obtained in the pretest and posttest analysis showed a statistically significant decrease in the error rate ( $p < 0.001$ ). Most participants reduced their errors in identifying or pronouncing Quechua vocabulary, reflecting an improvement in learning accuracy. This progress indicates that constant use of the application not only reinforced knowledge but also automated correct responses to stimuli in the virtual environment. These results coincide with Conrad, Kablitz, and Schumann [17], who demonstrated that immersive environments increase declarative and procedural learning by encouraging direct interaction with content. Similarly, Alizadeh [18] argues that virtual experiences allow for more effective communicative practice, strengthening self-efficacy and reducing errors in the use of a second language. Along the same lines, Fombona et al. [20] highlight that multisensory stimulation in virtual reality generates greater retention and accuracy in language learning. The significant reduction in errors observed in this study can be attributed to the design of the application, which combines visual and auditory elements with immediate feedback. This integration allowed users to detect and correct mistakes during practice, strengthening their understanding of vocabulary and improving their overall performance. Likewise, the cultural component—Andean settings, typical sounds, and traditional characters—helped contextualize the language, facilitating more natural and lasting learning. In short, the immersive application not only reduced errors but also built confidence and autonomy in participants as they interacted with the Quechua language in a meaningful digital environment.

Progress in interactive activities is closely linked to Ausubel's (1983) theory of meaningful learning, which posits

that new knowledge is assimilated more effectively when students actively interact with the content. In the digital context, this interaction is enhanced by gamification strategies, where level advancement, rewards, and immediate feedback maintain motivation and facilitate knowledge retention. According to Ladendorf, Schneider, and Xie [14], mobile virtual reality promotes autonomous and continuous practice, allowing learning to be constant and adaptive. The results showed that users who completed a greater number of levels within the application obtained better vocabulary scores and had a lower error rate. This positive relationship shows that progress in interactive activities has a direct impact on strengthening learning. Constant practice and repeated exposure to stimuli in the immersive environment facilitated the consolidation of knowledge and familiarization with Quechua terms. The findings are consistent with the studies by Zapata-Paulini et al. [27] and Achic [28], who highlight that digital tools based on augmented or virtual reality encourage active participation and motivation, essential factors in the acquisition of communication skills. Similarly, Fernández and Calvo [29] argue that the incorporation of reward systems within digital environments stimulates curiosity and learner retention, improving the effectiveness of the educational process. This coincidence reinforces the idea that immersive environments not only teach but also encourage further learning. The progress observed shows that consistent use of the application was decisive in achieving better results. The level-based structure and immediate feedback kept participants motivated and committed to learning. In addition, the video game-like design made the educational process feel natural, eliminating the rigidity typical of traditional methods. As a result, the application not only promoted language learning but also autonomous and sustainable study habits, showing that the combination of gamification, immersion, and culture can transform the way a native language is taught and learned.

In relation to the overall objective of the research, which was to evaluate the effectiveness of an immersive educational application based on Unity for learning the Quechua language through virtual reality, the results obtained confirm that the proposal was effective and fulfilled its objectives. The integration of visual, auditory, and cultural resources within the virtual environment allowed participants to improve their vocabulary recognition, reduce errors, and make steady progress in the activities. Likewise, the immersive experience promoted more dynamic and motivating learning, strengthening language comprehension and appreciation of Andean cultural identity. Overall, the findings demonstrate that virtual reality represents an innovative pedagogical alternative for teaching indigenous languages, combining technology and culture in a balanced way, thus contributing to the Sustainable Development Goals related to quality education and the preservation of Peru's linguistic heritage.

## VI. CONCLUSION

The study demonstrates that an immersive educational app built on Unity can be an effective tool for teaching the Quechua language, validating the potential of learning in virtual environments. The quantitative results showed significant improvements in vocabulary recognition ( $Z = -4.149, p < 0.001$ ), increased performance on interactive activities (mean Level 2 =

15.58 vs. Level 1 = 13.17; error rate reduced from 34.17% to 22.08%), and an overall decrease in the error rate in language use ( $Z = -4.149, p < 0.001$ ). Beyond these results, the analysis shows that the combination of visual, auditory, and cultural elements in an immersive environment promotes motivation, facilitates retention, and reinforces the student's cultural identity. From a learning design perspective, these findings suggest that the principles of level-based progression, immediate feedback, contextualized interactive activities, and cultural stimuli are key to maximizing the effectiveness of learning in virtual reality. Overall, the study indicates that the use of well-designed virtual environments can serve as a replicable model for teaching indigenous languages, offering an inclusive, motivating, and culturally relevant approach that contributes to language preservation and quality education.

The limitations of this study are primarily related to its pre-experimental design and the use of a relatively small convenience sample, which limits the generalizability of the results. Furthermore, the evaluation was conducted at a single point in time, without longitudinal measurements to analyze learning retention over time. Additionally, the system did not include all possible levels or scenarios, which limits its scalability and the diversity of the educational experience, as well as its ability to adapt to different user profiles and devices.

For future research, it is recommended to use larger, more representative samples, as well as to include control groups and longitudinal assessments to analyze learning retention and the consistency of effects over time. Likewise, it would be valuable to expand the system with additional levels, varied scenarios, and interactive modules, adapting the content according to the user's age or level, and to evaluate it on different devices and in various educational settings, to improve accessibility, the generalizability of results, and the effectiveness of learning.

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