International Journal of Learning, Teaching and Educational Research
Vol. 24, No. 2, pp. 352-374, February 2025
https://doi.org/10.26803/ijlter.24.2.18
Received Nov 25, 2024; Revised Feb 3, 2025; Accepted Feb 12, 2025

Implementation of a Digital Educational Tool in the Quechua Language for Learning Mathematics among Quechua-Speaking Children

Luis Alberto Saldivar , **Hesmeralda Rojas***
Universidad Nacional Micaela Bastidas de Apurímac, Perú
Escuela Académico Profesional de Ingeniería Informática y Sistemas

Franklin Yanqui Diaz
Universidad Tecnológica de los Andes, Perú

Abstract. This study investigated the impact of a digital educational tool developed in the Quechua language on the mathematical learning of second-grade Quechua-speaking children in Apurímac, Peru. Employing a quasi-experimental design, the research compared the performance of an Experimental Group (EG) using the Quechua-language tool with a Control Group (CG) receiving traditional instruction. The tool was designed to address linguistic, pedagogical, technological, and evaluative dimensions of learning. Pre- and post-test results revealed significant improvements in the EG across all dimensions ($p < 0.05$), with post-test scores in the EG ($M = 32.13$) substantially higher than those in the CG ($M = 19.47$). The study underscores the efficacy of digital tools in fostering active and contextualized learning, particularly in linguistically diverse settings. However, challenges such as insufficient teacher training and lack of culturally adapted materials persist, highlighting the need for comprehensive strategies to support bilingual education. The results advocate the integration of native language-based digital tools in educational curricula to promote equity, cultural preservation, and academic success among Indigenous populations. This research contributes to the growing body of evidence supporting Intercultural Bilingual Education as a means to address linguistic and cultural disparities in educational outcomes and can be replicated in other contexts.

Keywords: first language; bilingual; native language; educational software; intercultural bilingual education

*Corresponding author: Hesmeralda Rojas, *hrojas@unamba.edu.pe*

1. Introduction

The study of mathematics fosters the development of analytical and logical problem-solving skills, enhances reasoning power, spatial thinking, and creativity, and even contributes to effective communication skills; thus, it is considered one of the indispensable skills in the global economy of the 21st century. This skill shows rapid growth during primary school, coinciding with the rapid increase in intelligence scores, cortical maturation, and exposure to academic content through formal education (McArdle et al., 2002). There is extensive literature highlighting the direct relationship between mathematical cognitive skills and a country's economic growth (Hanushek & Kimko, 2000; Hu et al., 2018; Hynsjö & Damon, 2016; Opfer et al., 2018).

The development of mathematics worldwide has been evaluated over several years through the PISA test (Organisation of Economic Development, 2019), and Latin America consistently ranks among the lowest in performance. In Peru, there is a marked differentiation in student performance based on their native language, such as Quechua. It has been shown that students from Indigenous communities have lower performance in standardized national evaluations, such as the Student Census Evaluation (SCE), consistently obtaining results below the national average (Garcés & Hidalgo, 2019; Ministry of Education, 2018). Studies indicate that children whose native language is an Indigenous language tend to have less satisfactory mathematical performance compared to their peers who speak Spanish (Chávez-Epiquén et al., 2021; Holguin-Alvarez et al., 2019). "The persistent achievement gap between Indigenous and non-Indigenous children thus likely has long-run effects for the economic welfare of Indigenous peoples and communities and has the potential to reinforce social inequities" (Hynsjö & Damon, 2016, p. 116).

Intercultural bilingual education (IBE) aims to address these disparities by integrating cultural and linguistic knowledge into mathematics teaching. However, the effective implementation of this approach faces challenges, such as insufficient teacher training, a sociocultural context that stigmatizes its use, inadequate educational infrastructure, and a lack of educational materials, among others (Cama Alanoca, 2023; Ministry of Culture, 2023, 2024; Tranca, 2023).

Didactic resources adapted to Indigenous languages are limited, therefore creation is necessary because they promote educational efficiency by connecting mathematical concepts with students' cultural and daily practices (Huaman, 2021; Saldivar et al., 2021). This leads to teacher training in the use of Quechua and active, participatory methodologies for teaching mathematics in bilingual contexts (Huayta, 2022), allowing for greater equitable access to education and reducing educational gaps (Ministry of Education, 2015). These resources must correctly use mathematical vocabulary and cultural adaptation of terms, offer a variety of pedagogical strategies, and enable adequate evaluation.

The objective of this study was to evaluate the effect of implementing a digital educational tool in the Quechua language on the learning of mathematics by

Quechua-speaking children. For this purpose, the following research questions were posed:

1. RQ1. What are the pre-test mathematics performances of the control and experimental groups of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before implementing a digital educational tool in the Quechua language?
2. RQ2. What are the mathematics pre-test and post-test performances of the control group of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before and after implementing a digital educational tool in the Quechua language?
3. RQ3. What is the mathematics pre-test performance of the experimental group and post-test of the experimental group of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before and after implementing a digital educational tool in the Quechua language?
4. RQ4. What are the mathematics post-test performances of the control and experimental groups of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions after implementing a digital educational tool in the Quechua language?

2. Context of the Research Study

2.1 Context of Native Languages

Preserving Indigenous languages and cultures is a concern shared by countries worldwide, leading to various initiatives for their revaluation. Among these are the International Labour Organization's Convention 169 on Indigenous and Tribal Peoples in Independent Countries was consolidated in 1989, and the United Nations Declaration on the Rights of Indigenous Peoples in 2007, Articles 14 and 15, which recommends that states or provinces should take effective measures to ensure that people have access, when possible, to education in their own culture and language (Álvarez et al., 2019; United Nations, 2007).

In Peru, the Sectoral Policy of Intercultural Education and Intercultural Bilingual Education (EIB) was created in 2016 under Article 17 of the Peruvian Constitution, along with other specific regulations on intercultural education policies, such as the General Education Law (Ministry of Education, 2003). In July 2021, the Ministry of Culture approved the National Policy on Indigenous Languages, Oral Tradition, and Interculturality (President of Perú, 2021). This policy aims primarily to improve access to public services in Indigenous languages and reduce discrimination against their use. Among its recommendations is the development of didactic materials with an intercultural focus to facilitate meaningful learning by incorporating culturally relevant elements for Quechua-speaking students (Schroeder, 2005).

Despite these guidelines, the results have been meager, as corroborated in the research by Álvarez et al. (2019), which evaluated the perception of directors of educational institutions regarding the implementation of IBE in Apurímac. Similarly, the work by Añaños and Herreras (2023) concludes that many educational institutions lack the necessary resources and trained teachers.

2.2 Mathematics Performance in Peru

Year after year, the Student Census Evaluation (SCE) is conducted in all public and private schools in Peru to assess the extent to which students achieve the expected learning outcomes for their grade level (Ministry of Education, 2023). This evaluation applies to the areas of mathematics and reading. The results indicate that, nationally, for the year 2019, only 17% achieved the expected learning outcomes in mathematics, while in reading, 37.6% achieved (Ministry of Education, 2019).

Moreover, a marked difference was observed between regions, influenced by socioeconomic inequality, where students from urban areas and higher socioeconomic levels tend to obtain better results than those from rural areas or lower income levels (Berríos, 2023). These gaps are widely corroborated by literature over the years in studies such as those by Betts and Roemer (2005); Checchi and Peragine (2010) and Cabrera et al. (2020), which affirms how inequality of opportunities damages individuals and, consequently, national economic growth (Ministry of Education, 2019). The Apurímac region currently faces a critical situation, with a poverty incidence of 29.1%, above the national average of 20.1%, and a vulnerability to poverty of 53.6% (Ministry of Development and Social Inclusion, 2021); similarly, the SCE results were detrimental for the lowest socioeconomic levels, with only 13.7% achieving satisfactory performance, while students from medium and high socioeconomic levels obtained 23.3% satisfactory performance (Ministry of Education, 2023).

The report on the SCE results also details the achievements of students based on their native language, resulting in a nearly double gap in satisfactory performance for students speaking Spanish compared to those speaking Indigenous languages (Ministry of Education, 2023). These results could be explained by various factors, including the direct correlation between academic performance and poverty rates in rural areas, which presents a poverty gap nearly four times greater than in urban areas (National Institute of Statistics and Information, 2017), precisely where most children speak Indigenous languages. It has also been observed that the SCE is not always conducted in the student's native language but in Spanish. In addition, academic performance was influenced by access to adequate educational resources, as regions with better didactic materials tend to show superior performance (Berríos, 2023; Prensa Regional, 2023).

3. Related Works

The relationship between native language proficiency and mathematics performance is complex and multifaceted. This relationship is influenced by various factors, including linguistic clarity, cognitive processing, and language proficiency, which collectively impact mathematical understanding and problem-solving abilities (Han & Ginsburg, 2001; Peng et al., 2020).

Numerous studies indicate that studying mathematics in a student's native language generates more meaningful learning outcomes. In this regard, the findings of Bouhlila and Hentati (2022) reported that nine-year-old students who received instruction in their first language achieved higher performance in mathematics, while those who received instruction in a second language achieved significantly lower performance, along with a reduction in their overall cognitive and content scores. This is related to the mastery of linguistic skills required for understanding the real world through statements (Ferrari, 2003; Prediger et al., 2018).

Similarly, Outhwaite et al. (2020) found that children aged five to six who worked on mathematics in their first language made better progress in completing tasks. The study suggests that children need to have sufficiently developed linguistic competence to access curriculum content and respond to instruction (Cummins, 2008; Peng et al., 2020) as it facilitates better understanding and participation among young students (Espada, 2012). Kung et al. (2019) also agree that language, specifically mathematical language, is a predictor of mathematical skills in the preschool stage, with mathematics and language being implicitly and explicitly integrated and inseparable in teaching (Martínez & Dominguez, 2018).

Furthermore, Spiridonova and Savvinova (2015) concluded that interference from instructional languages should be strictly avoided during the basic formation of mathematical language, and a progressive bilingual education system should be followed. In this system, the first years (1st to 4th grade) should be taught exclusively in the native language, followed by progressive transition stages until reaching the 10th and 11th grades, where the second language is used as the sole medium of instruction. This bilingual transition model results in more optimal mathematics learning.

From another perspective, various studies have explored the significance of learning and teaching mathematics in bilingual contexts of linguistic minorities by area. These works indicate that students in rural areas face more difficulties in numeracy and problem solving compared to their urban peers (Holguin-Alvarez et al., 2019), which complicates learning specialized vocabulary and structures that are part of mathematical science, as well as reading, writing, and critical thinking in general (Vukovic & Lesaux, 2013). They also have a two to three times higher risk of repeating grades compared to their monolingual peers (Klieme, 2001).

Regarding the benefits of learning a second language, the creation of new skills such as improved working memory (Bialystok et al., 2006), cognitive flexibility, and inhibitory control (Park et al., 2023), attentional control processes (Kempert et al., 2011), and mathematical coding and processing in tasks not directly related to language (González-Martín et al., 2024) are highlighted. In addition, there is better comprehension and retention of mathematical concepts (Park et al., 2023). However, these skills derived from bilingualism are guaranteed only with mastery of the second language; otherwise, they may be counterproductive, as deficits in mastering an instructional language generate a cumulative effect in all subjects, leading to a deterioration of competencies in all academic fields (Saalbach et al., 2013).

Under these premises and contextualizing the reality of students of Indigenous languages in Latin America who generally only have access to education through the dominant language (Pérez, 2015), disadvantages are observed in achieving optimal performance due to difficulties in understanding the language of instruction (Suppiah Shanmugam et al., 2021). They have a higher cognitive load that forces them to think and use their knowledge in their native language before responding in the second language, resulting in lower precision and processing speed, which can detract from the ability to focus on solving real mathematical problems (Saalbach et al., 2013; Sicat & David, 2016).

Based on the findings, there is a greater consensus on not applying mathematics instruction in a second language at an early age, as the child has not yet fully acquired the skills of the first language. In this context, Han and Ginsburg (2001) emphasize that the clarity of mathematical terms in a native language improves mathematical performance. Holguin-Alvarez et al. (2019) indicate that it can facilitate problem solving when active and contextual strategies are employed. Prediger et al. (2018) and Wanjiru et al. (2021) show that linguistic factors explain a substantial percentage of the variation in mathematics performance, suggesting that mastery of the native language should be considered in educational assessments to address social disparities and improve mathematical literacy.

4. Construction of Educational Materials in the Indigenous Quechua Language

The Quechua language is the Indigenous language of Peru, having been the language of the Inca Empire, and is deeply rooted in other South American countries. Currently, it has over 10 million speakers (Adelaar, 2004) and is an official language in Peru.

To preserve culture, promote learning, or improve education, personalized technological solutions are being developed (Poonpon et al., 2024; Rojas et al., 2020). In this context, to support the learning process and preserve the language of Quechua-speaking students, various educational and technological strategies have been implemented. These include digital educational materials in the Quechua language, developed by the governing body of Peru's national education system. These materials are designed to address mathematical concepts and problems, incorporating games and activities focused on problem solving, adapted to contexts of cultural and linguistic diversity (Ministry of Education, 2004, 2015, 2021, 2024). Among mobile and web applications, the Warma project stands out, presenting numbers, ordinal numbers, geometric shapes, colors, and mathematical signs (Gutiérrez Gómez et al., 2019), implemented under the evaluation framework of the SCE by Saldivar et al. (2021).

However, digital literature is scarce for mathematics in the Quechua language and few technological solutions allow interactivity for students such as mobile or web applications.

5. Methodology

5.1 Research Design

The research employed an applied design with a quasi-experimental approach and evaluated the impact of an intervention or treatment without controlling all elements affecting the experiment. In addition, participants were not randomly assigned to experimental and control groups (Fernández et al., 2014).

5.2 Research Locale and Participants

The study was conducted in the district of Lambrama, located in the department of Apurímac, which has a population of over 200 inhabitants. The research took place at the Virgen de Fátima Educational Institution, which has a total of 30 second-grade primary students.

This educational institution is classified as a strengthening IBE school, resulting in a limited number of students and preventing the randomization of the sample. The small population is very similar in many rural Quechua-speaking population centers and annexes due to migration to the cities (International Organization for Migration, 2015). Students were divided into two groups of 15 participants, following an existing division used by the teacher for classroom activities.

5.3 Research Instruments

5.3.1 Observation Checklist

An observation checklist was developed to comprehensively evaluate student performance in mathematics learning, considering their interaction with mathematical content and their use of language, active participation, familiarity with technology, and the impact of evaluative activities. This instrument was reviewed and validated by two teachers from the educational institution.

1. Linguistic dimension: The tool must be fully developed in the Quechua language, ensuring that all content, instructions, and examples are accessible to Quechua speakers. This includes the correct use of mathematical vocabulary in Quechua and the cultural adaptation of terms.
2. Pedagogical dimension: The tool should promote active learning where students construct their knowledge through exploration and problem solving. This can include practical activities, games, and interactive exercises that foster critical thinking.
3. Technological dimension: The tool includes interactive elements that allow students to practice mathematics playfully and engagingly, through practical exercises that maintain student interest.
4. Evaluative dimension: The tool includes mechanisms to evaluate student progress and performance in real time.

5.3.2 Digital Educational Tool

The educational material was developed using Ardora version 8.4, which allows the creation of web content from 35 different activity types (Bouzan, 2024). This software is freely accessible, has minimal technical requirements, and allows users to create web content straightforwardly, without requiring technical knowledge of design or web programming. Consequently, it can be applied to various projects tailored to the specific context of each region of the country.

The objectives of constructing this educational resource were: i) developing an educational tool for the SCE in the Quechua language, and ii) conducting a quantitative evaluation of student performance using educational software.

The software allows user account creation and login access, as well as a help section to guide users through the questions presented in the evaluation. This help section is built on an additional platform directly linked to each question. In addition, there is a results section accessible to each teacher, allowing them to view student performance. This section displays the student's name, the number of times they accessed the application, access dates, the number of correct responses achieved out of the total, and the average score obtained.

One of the primary obstacles observed was the difficulty students faced in reading the prompts within the application. This challenge arose because the children spoke the language but did not write it, having had limited exposure to their language through written forms. Consequently, an audio reading option for the prompts was implemented as shown in Figure 1, allowing students to either read the question themselves or activate the audio reading feature to listen to.

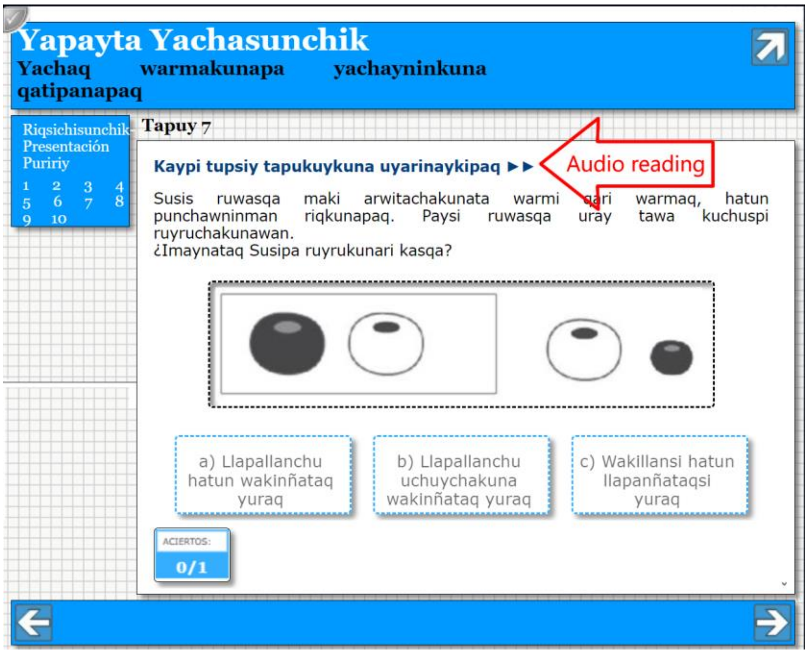

Figure 1: Structure of the SCE questions page, with the option of reading the statements by audio included

5.4 Data Collection

Data collection was done using a checklist and educational software in Quechua to assess second-grade students' mathematics learning. The checklist evaluated pedagogical, technological, and linguistic dimensions, focusing on teaching methods, engagement, technology usability, and language integration. The classroom teacher recorded observations during classroom sessions. The software provided interactive exercises, capturing student responses to assess the evaluative dimension.

5.5 Data Analysis
To statistically verify each hypothesis derived from the research questions, statistical tests were performed to check essential assumptions in data analysis. These tests included the Shapiro-Wilk normality test to verify if each dataset had a normal distribution and the Levene test to check for equality of variances between two or more groups. The results indicated that Mann-Whitney U tests and student t-tests would be applied according to each evaluated dataset. This research was conducted using SPSS software.

5.6 Ethical Considerations
Technical assistance and equity in access and use of the tool were ensured for all students, regardless of their technological capabilities or socioeconomic context. The translation of academic material was performed by professionals from the area to ensure that the software used precise Quechua, respecting local dialects and avoiding inappropriate translations or decontextualized terms.

Regarding consent for the application of tests, the teaching staff evaluated the tool beforehand as a means of support in their didactic sessions. Although participants were minors, the tool was explained to them so they could voluntarily express their desire to participate.

6. Results
The second version of the educational tool was implemented with students from the Educational Institution 54028 – Virgen de Fátima, at the end of October and during the first half of November 2023. Throughout the process, the classroom teacher, with the technical and development team of the application, provided support by introducing the tool to the students and addressing their queries. Subsequently, each student was able to access the application independently. The data evaluated were generated until the first half of November 2023. In Figure 2, one of the students uses the application to perform mathematical operations.

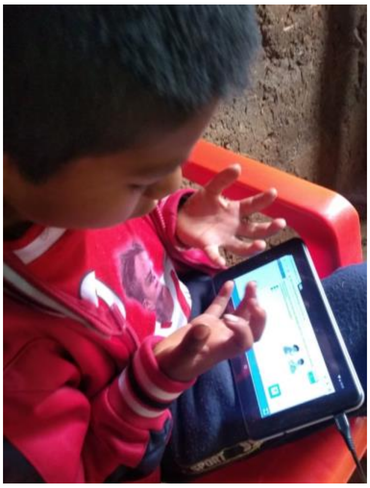

Figure 2: Student performing calculations with their hands

6.1 RQ1. What are the pre-test mathematics performances of the control and experimental groups of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before implementing a digital educational tool in the Quechua language?

Table 1 displays the average scores obtained in the pre-test for both the CG and EG across each dimension of mathematics learning for Quechua-speaking children. The results indicated that both groups had a similar initial performance level before the intervention with the digital educational tool. This suggested that both groups possessed comparable learning levels before the digital tool's implementation.

Table 1: Averages of the scores achieved in the pre-test CG and pre-test EG evaluations

Dimensions	Group	Mean	SD	SE
Linguistic dimension	Pre-test CG	4.20	1.32	0.341
	Pre-test EG	4.00	1.195	0.309
Pedagogical dimension	Pre-test CG	3.73	1.44	0.371
	Pre-test EG	3.73	1.033	0.267
Technological dimension	Pre-test CG	3.60	1.24	0.321
	Pre-test EG	3.47	0.990	0.256
Evaluative dimension	Pre-test CG	4.07	1.16	0.300
	Pre-test EG	3.80	1.265	0.327
Learning variable	Pre-test CG	15.60	3.11	0.804
	Pre-test EG	15.00	2.646	0.683

After having carried out a study of normality (Shapiro-Wilk) and homogeneity of variances (Levene) on the scores obtained in the post-test CG and post-test EG evaluations for each dimension, it was determined whether parametric or non-parametric statistics would be used to contrast the hypotheses that were derived from the research questions – it was determined that the linguistic, pedagogical and technological dimension should work with the Mann-Whitney U test and the remaining dimensions with the student T-test. This same procedure was applied to contrast all the hypotheses.

Table 2 presents the results of the T-test to compare the average scores in the pre-test between the CG and the EG in each dimension of mathematics learning in Quechua-speaking children. The results reveal the initial performance levels of both groups before the intervention with the digital educational tool. In the linguistic dimension, the CG had a pre-test average of 4.20, while the EG scored 4.00, indicating comparable levels. Both groups achieved a mean of 3.73 in the pedagogical dimension, suggesting similar starting points. In the technological dimension, CG averaged 3.60, slightly higher than EG's 3.47, reflecting minimal differences. For the evaluative dimension, CG had an average of 4.07 compared to EG's 3.80, indicating comparable initial evaluative capacities. Overall, the pre-test averages of 15.60 for CG and 15.00 for EG suggest similar learning levels before implementing the digital tool.

Table 2: T-Test for the averages of the scores achieved in the pre-test CG and pre-test EG evaluations

Dimension/variable	Test	statistical	df	p
Linguistic dimension	Mann-Whitney U	103.0		0.700
Pedagogical dimension	Mann-Whitney U	108.5		0.877
Technological dimension	Mann-Whitney U	105.5		0.780
Evaluative dimension	Student T	0.601	28.0	0.553
Learning variable	Student T	0.569	28.0	0.574

Note. H_a μPre-test CG ≠ μPre-test EG

6.2 RQ2. What are the mathematics pre-test and post-test performances of the control group of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before and after implementing a digital educational tool in the Quechua language?

Table 3 presents the average scores obtained in the pre-test and post-test of the CG in each dimension of mathematics learning for Quechua-speaking children. The results show changes in each dimension after the intervention. In all dimensions, an increase in the results of the pre-test versus the post-test was observed. Even though there was an increase, the difference did not seem to be very marked, which suggests that the CG showed expected progress, typical of natural learning over time in all dimensions without using the digital educational tool.

Table 3: Averages of the scores achieved in the pre-test CG and post-test CG evaluations

Dimensions	Group	Mean	SD	SE
Linguistic dimension	Post – test GC	5.00	1.31	0.338
	Pre – test GC	4.20	1.32	0.341
Pedagogical dimension	Post – test GC	4.87	1.85	0.477
	Pre – test GC	3.73	1.44	0.371
Technological dimension	Post – test GC	4.73	1.67	0.431
	Pre – test GC	3.60	1.24	0.321
	Post – test GC	4.87	1.60	0.413

Evaluative dimension	Pre – test GC	4.07	1.16	0.300
Learning variable	Post-test GC	19.47	3.34	0.861
	Pre-test GC	15.60	3.11	0.804

Table 4 presents the results of the T-test that compared the average scores obtained in the pre-test and post-test of the CG in each dimension of mathematics learning in Quechua-speaking children. These results indicated whether there were significant changes in the different dimensions without the intervention of the digital educational tool.

In the linguistic, pedagogical and evaluative dimensions, there was no statistically significant difference between the pre-test and the post-test. However, in the technological dimension, the p-value was 0.044, which showed a statistical difference and suggested an improvement in CG, even though the magnitude of the change was probably modest. For the global learning variable, the statistical value was 3.28 with 28 df and a p-value of 0.003. This result was statistically significant ($p < 0.05$), suggesting an improvement in the CG's global learning between the pre-test and post-test, even though it is important to note that these changes occurred without the digital intervention.

In conclusion, the results show that, even though there was some progress in the CG, especially in the technological dimension and in global learning, these changes were limited and not as consistent as those observed in the experimental group with the digital intervention.

Table 4: T-Test for the averages of the scores achieved in the pre-test CG and post-test CG evaluation

Dimension/variable	Test	statistical	df	p
Linguistic dimension	Student T	1.67	28.0	0.107
Pedagogical dimension	Student T	1.88	28.0	0.071
Technological dimension	Student T	2.11	28.0	0.044
Evaluative dimension	Student T	1.57	28.0	0.128
Learning variable	Student T	3.28	28.0	0.003

Note. H_a μPre-test CG ≠ μPost-test CG

6.3 RQ3. What is the mathematics pre-test performance of the experimental group and post-test of the experimental group of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions before and after implementing a digital educational tool in the Quechua language?

Table 5 shows a notable increase in the average scores achieved in each dimension of mathematics learning in the EG after the implementation of the digital educational tool in Quechua. When considering the general learning variable, the results in all dimensions show a substantial improvement in the average, which went from 15.00 in the pre-test to 32.13 in the post-test. This overall increase in learning suggested that the educational tool in Quechua had a generalized positive impact on the mathematical skills of Quechua-speaking children.

Table 5: Averages of the scores achieved in the pre-test EG and post-test EG evaluations

Dimensions	Group	Mean	SD	SE
Linguistic dimension	Post-test EG	7.93	0.961	0.248
	Pre-test EG	4.00	1.195	0.309
Pedagogical dimension	Post-test EG	8.20	1.320	0.341
	Pre-test EG	3.73	1.033	0.267
Technological dimension	Post-test EG	7.80	1.373	0.355
	Pre-test EG	3.47	0.990	0.256
Evaluative dimension	Post-test EG	8.20	1.146	0.296
	Pre-test EG	3.80	1.265	0.327
Learning variable	Post-test EG	32.13	2.100	0.542
	Pre-test EG	15.00	2.646	0.683

Table 6 shows that the most notable finding is that all dimensions exhibited significant improvements, with p-values < 0.05 for each. The learning variable demonstrated the most substantial increase, while the technological dimension showed the second-highest improvement. The pedagogical and evaluative dimensions also revealed positive results, though not as pronounced as the learning and technological variables. The linguistic dimension, while showing improvement, did not reach the same level of statistical significance as the other dimensions. All in all, these findings support that the tool had a positive impact on the development of mathematical skills, strengthening each of the dimensions evaluated and contributing to an overall improvement in the learning of Quechua-speaking children.

Table 6: T-test for the averages of the cores achieved in the pre-test EG and post-test EG evaluation

Dimension/variable	Test	statistical	df	p
Linguistic dimension	Mann-Whitney U	1.00		0.000
Pedagogical dimension	Student T	10.32	28.0	0.000
Technological dimension	Student T	9.91	28.0	0.000
Evaluative dimension	Student T	9.98	28.0	0.000
Learning variable	Student T	19.65	28.0	0.000

Note. H_a μPre-test EG ≠ μPost-test EG

6.4 RQ4. What are the mathematics post-test performances of the control and experimental groups of students in a primary school in Apurímac regarding the linguistic, pedagogical, technological, and evaluative dimensions after implementing a digital educational tool in the Quechua language?

Table 7 presents the averages obtained in the post-test by the CG and the EG in each dimension of mathematics learning in Quechua-speaking children. It was observed that, in all dimensions, the EG achieved a higher average of 32.13, compared to the average of 19.47 of the CG. In the linguistic dimension, it suggests a significant improvement in the performance of children in aspects related to language, possibly due to the use of the digital educational tool in the Quechua language. In the pedagogical dimension, the result indicates that the use of the digital tool may have facilitated better pedagogical development in the EG. Regarding the technological dimension, the best performance could be related to the interaction with the digital tool in their own language, while in the evaluative dimension, an improvement in the evaluative capacities of the experimental group was reflected.

Table 7: Averages of the scores obtained in the post-test GC and post-test GE evaluations

Dimensions	**Group**	**Mean**	**SD (Standard deviation)**	**SE (Standard error)**
Linguistic dimension	Post-test CG	5.00	1.31	0.338
	Post-test EG	7.93	0.961	0.248
Pedagogical dimension	Post-test CG	4.87	1.85	0.477
	Post-test EG	8.20	1.320	0.341
Technological dimension	Post-test CG	4.73	1.67	0.431
	Post-test EG	7.80	1.373	0.355
Evaluative	Post-test CG	4.87	1.60	0.413

Dimensions	Group	Mean	SD (Standard deviation)	SE (Standard error)
Linguistic	Post-test CG	5.00	1.31	0.338
dimension	Post-test EG	7.93	0.961	0.248
dimension	Post-test EG	8.20	1.146	0.296
Learning	Post-test CG	19.47	3.34	0.861
variable	Post-test EG	32.13	2.100	0.542

Table 8 presents the results of the T-test for the average scores obtained in the post-test of the CG and the EG in each dimension of mathematics learning in Quechua-speaking children. The alternative hypothesis (H_a) states that the average scores in the post-test of the CG and the EG are different (µPost-test CG ≠ µPost-test EG), since in all dimensions a significance level of $p < 0.05$ was obtained, which indicates that there is a statistically significant difference between the CG and the EG. Finally, in the global learning variable, the Student T-test showed a statistic of -12.45, 28 df and $p < 0.05$, which reflected a significant difference in total learning between the CG and the EG. This result supports the hypothesis that the digital educational tool in the Quechua language impacts mathematical learning in Quechua-speaking children in the EG positively.

Table 8: T-Test for the averages of the scores achieved in the post-test CG and post-test EG evaluations

Dimension /variable	Test	statistical	df	p
Linguistic dimension	Mann-Whitney U	11.5		0.000
Pedagogical dimension	Student T	-5.69	28.0	0.000
Technological dimension	Student T	-5.50	28.0	0.000
Evaluative dimension	Student T	-6.57	28.0	0.000
Learning variable	Student T	-12.45	28.0	0.000

Note. H_a µPost-test CG ≠ µPost-test EG

7. Discussion

The findings of this study align with prior research conducted by Bouhlila and Hentati (2022), Ferrari (2003) and Prediger et al. (2018), which suggested that the use of a native language facilitates a deeper understanding of mathematical concepts. This approach not only enhances information retention but also improves the ability to solve complex mathematical problems (Han & Ginsburg, 2001; Peng et al., 2020). The significant differences observed in post-test scores between the EG and CG in the linguistic dimension support the notion that students benefit from instruction in their native language. This practice reduces the cognitive load associated with mental translation between languages

(Saalbach et al., 2013), enhances comprehension of mathematical concepts, and contributes to academic success (Cummins, 2008; Bouhlila & Hentati, 2022).

The digital educational tool employed in this study appears to have created a conducive environment for active and contextualized learning. The results indicate improvements across all evaluated dimensions, particularly in the linguistic and pedagogical areas. This suggests that technology can serve as an effective mediator in facilitating learning in contexts where linguistic barriers are prominent (Huaman, 2021; Tranca, 2023).

Despite the positive outcomes, it is crucial to acknowledge the ongoing challenges in effectively implementing bilingual education programs. Insufficient teacher training and a lack of appropriate materials remain significant obstacles (Cama Alanoca, 2023; Ministry of Culture, 2023). Therefore, future research should not only focus on developing and implementing educational tools but also on comprehensive strategies to train educators and enhance educational infrastructures.

The results of this study have profound implications for educational policies in Peru and other regions with native-speaking populations. It is imperative that educational policies recognize and address existing linguistic and cultural disparities. Promoting IBE programs will not only improve the academic performance of Quechua-speaking students but also foster a sense of cultural identity and belonging (Hynsjö & Damon, 2016), in alignment with state policies (President of Peru, 2021).

8. Conclusion

Digital solutions designed in native languages are specifically crafted to promote cultural preservation, enhance learning outcomes, and foster educational equity. Teaching mathematics in a student's native language respects their cultural identity and strengthens their cognitive abilities by enabling them to grasp complex concepts without encountering linguistic barriers. Conversely, teaching in a second language at an early age can lead to frustration, academic delays, and demotivation, as children have not yet fully developed the linguistic skills required in the secondary language.

For these reasons, a digital educational tool developed in the Quechua language demonstrated a significant and positive impact on mathematics learning among second-grade primary school children in a Peruvian province. In the EG, post-test scores were consistently higher than pre-test scores across all evaluated dimensions (linguistic, pedagogical, technological, and evaluative, $p < 0.05$ for all dimensions). This improvement highlights that using Quechua-language educational software strengthened specific competencies related to mathematical learning, such as understanding mathematical language, technological interaction, and evaluative skills. This contrasts with the CG, which showed limited and expected progress, underscoring the tool's effectiveness in fostering comprehensive mathematical competencies.

Consequently, this study provides empirical evidence of the positive impact that tailored bilingual education can have on mathematical learning. By integrating digital tools in the Quechua language into the educational curriculum, a pathway is opened toward more inclusive and equitable education for all students. This approach enhances academic performance and supports linguistic and cultural revitalization, aligning with the principles of IBE, a commitment recognized by the Peruvian State.

Finally, it is worth noting that a solid foundation in mathematics contributes to the development of key skills necessary to address future challenges, strengthening human capital in vulnerable communities and fostering their socioeconomic development.

7. References

Adelaar, W. (2004). *The languages of the Andes*. Cambridge University Press.

Álvarez, W., Rojas Enriquez, H., Arbieto Mamani, O., & Renteria Ayquipa, R. A. (2019). Educación intercultural bilingüe y calidad del servicio educativo en Apurímac, 2018 [Bilingual intercultural education and quality of educational services in Apurímac, 2018]. *CICIC 2019 - Novena Conferencia Iberoamericana de Complejidad, Informatica y Cibernetica, Memorias*, 135–140. https://www.iiis.org/CDs2019/CD2019Spring/papers/CB637SY.pdf

Añaños, K., & Herreras, G. (2023). La protección de la cultura y el derecho a la educación intercultural bilingüe en Pichari (VRAEM) de Perú [The protection of culture and the right to bilingual intercultural education in Pichari (VRAEM) of Peru]. *Revista Electrónica Iberoamericana*, *17*(1), 120–154. https://doi.org/10.20318/reib.2023.7804

Berríos, M. (2023). Última prueba PISA expone las marcadas desigualdades de la educación en el Perú [Latest PISA test exposes marked inequalities in education in Peru]. *Ojo Público*. https://ojo-publico.com/derechos-humanos/la-nueva-evidencia-la-desigualdad-la-educacion-peru

Betts, J., & Roemer, J. (2005). *Equalizing opportunity for racial and socioeconomic groups in the United States through educational-finance reform*. MIT Press. https://doi.org/10.7551/mitpress/6051.003.0014

Bialystok, E., Craik, F. I. M., & Ryan, J. (2006). Executive control in a modified antisaccade task: Effects of aging and bilingualism. *Journal of Experimental Psychology: Learning Memory and Cognition*, *32*(6), 1341–1354. https://doi.org/10.1037/0278-7393.32.6.1341

Bouhlila, D. S., & Hentati, I. (2022). The effect of the language of instruction on primary students' performance: Evidence from Gulf States. *Journal of Education in Muslim Societies*, *4*(2), 53–80. https://doi.org/10.2979/jems.2022.a896974

Cabrera, L., Marrero, G., Rodriguez, J. G., & Salas-Rojo, P. (2020). *Inequality of opportunity in Spain: New insights from new data.* Hacienda Pública Española. https://hpe-rpe.org/wpfd_file/inequality-of-opportunity-in-spain-new-insights-from-new-data/

Cama Alanoca, Y. L. (2023). *Estado del arte: Lenguas originarias del Perú en educación inicial [State of the art: Native languages of Peru in early childhood education]*. Escuela de Educación Superior Pedagógica Pública "La Inmaculada."

Chávez-Epiquén, A., Moscoso-Paucarchuco, K. M., & Cadillo-León, J. R. (2021). Método activo en el desarrollo de competencias matemáticas en niños de la cultura Awajún, Perú [Active method in the development of mathematical skills in children of the Awajún culture, Peru]. *Uniciencia*, *35*(1), 55–70. https://doi.org/10.15359/ru.35-1.4

Checchi, D., & Peragine, P. (2010). Inequality of opportunity in Italy. *The Journal of Economic Inequality*, *8*(4), 429–450. https://doi.org/10.1007/s10888-009-9118-3

Cummins, J. (2008). Teaching for transfer: Challenging the two solitudes assumption in bilingual education. In *Encyclopedia of language and education* (pp. 1528–1538). Springer. https://doi.org/10.1007/978-0-387-30424-3_116

Espada, J. P. (2012). The native language in teaching kindergarten mathematics. *Journal of International Education Research (JIER)*, *8*(4), 359–366. https://doi.org/10.19030/jier.v8i4.7282

Fernández, P., Vallejo, G., Livacic-Rojas, P., & Tuero, E. (2014). Validez estructurada para una investigación cuasi-experimental de calidad. Se cumplen 50 años de la presentación en sociedad de los diseños cuasi-experimentales [Structured validity for quality quasi-experimental research. 50 years since the introduction]. *Anales de Psicología*, *30*(2). https://doi.org/10.6018/analesps.30.2.166911

Ferrari, P. L. (2003). Abstraction in mathematics. Philosophical transactions of the Royal Society of London. *Series B: Biological Sciences*, *358*(1435), 1225–1230. https://doi.org/10.1098/rstb.2003.1316

Garcés, J. V., & Hidalgo, S. F. (2019). El pensamiento multiplicativo de niños del pueblo indígena shipibo-konibo de Ucayali: una perspectiva piagetiana [The multiplicative thinking of children of the Shipibo-Konibo indigenous people of Ucayali: a Piagetian perspective]. *Educação e Pesquisa*, *45*. https://doi.org/10.1590/s1678-4634201945200589

González-Martín, A. M., Berd-Gómez, R., Saura-Montesinos, V., Biel-Maeso, M., & Abrahamse, E. (2024). On the relationship between bilingualism and mathematical performance: A systematic review. *Education Sciences*, *14*(11), 1172. https://doi.org/10.3390/educsci14111172

Gutiérrez Gómez, E., Ocampo Yahuarcani, I., Jeri Lagos, K. D., & Saravia Llaja, L. A. (2019). Warma: Aplicativo móvil para el aprendizaje de matemáticas y lenguaje en instituciones educativas de las comunidades quechua hablantes en Ayacucho [Warma: Mobile application for learning mathematics and language in educational institutions of Quechua-peaking communities in Ayacucho]. *Puriq*, *1*(01), 68–82. https://doi.org/10.37073/puriq.1.01.57

Han, Y., & Ginsburg, H. P. (2001). Chinese and English mathematics language: The relation between linguistic clarity and mathematics performance. *Mathematical Thinking and Learning*, *3*(2–3), 201–220. https://doi.org/10.1080/10986065.2001.9679973

Hanushek, E., & Kimko, D. (2000). Schooling, labor force quality, and the growth of nations. *An Economic Review*, *90*(5), 1184–1208. https://doi.org/10.1257/aer.90.5.1184

Holguin-Alvarez, J. A., Villa-Morocho, C., Montalvo-Callirgos, M., Villena-Guerreo, M., Carrasco-Nuñez, Y., & Espinola-Ayala, L. (2019). Meaning of learning mathematic in linguistic contexts of Quechua and city dwellers. *Investigación Valdizana*, *13*(3), 143–155. https://doi.org/10.33554/riv.13.3.343

Hu, X., Gong, Y., Lai, C., & Leung, F. K. S. (2018). The relationship between ICT and student literacy in mathematics, reading, and science across 44 countries: A multilevel analysis. *Computers and Education*, *125*(June), 1–13. https://doi.org/10.1016/j.compedu.2018.05.021

Huaman, Y. (2021). *El uso de materiales didácticos producidos por el docente y su influencia en el desarrollo cognitivo en el área de matemáticas de los niños y niñas de cuatro años, distrito de Huayllati, Provincia de Grau, Apurímac, 2019 [The use of teaching materials* *produced by the teacher and their influence on cognitive development in the area of mathematics of four-year-old boys and girls, Huayllati district, Grau Province, Apurímac, 2019]* [Unpublished master's thesis]. Universidad Antonio Ruiz de Montoya. https://repositorio.uarm.edu.pe/server/api/core/bitstreams/56ffc0fd-57d4-4fd5-b01f-7f0474e2197a/content

Huayta, G. (2022). *Estrategias didácticas en el fortalecimiento del idioma quechua en estudiantes de una institución educativa, Ayacucho, 2022 [Teaching strategies to strengthen the Quechua language in students of an educational institution, Ayacucho, 2022]* [Unpublished Phd thesis]. Universidad César Vallejo. https://repositorio.ucv.edu.pe/bitstream/handle/20.500.12692/109898/Huayta_EG-SD.pdf;jsessionid=C125C6033A1850670D311D8B930A1103?sequence=1

Hynsjö, D., & Damon, A. (2016). Bilingual education in Peru: Evidence on how Quechua-medium education affects indigenous children's academic achievement. *Economics of Education Review*, *53*, 116–132. https://doi.org/10.1016/j.econedurev.2016.05.006

Internation Organization for Migration. (2015). *Migraciones internas en el Perú [Internal migrations in Peru]*. https://peru.iom.int/sites/g/files/tmzbdl951/files/Documentos/Migraciones_Internas.pdf

Kempert, S., Saalbach, H., & Hardy, I. (2011). Cognitive benefits and costs of bilingualism in elementary school students: The case of mathematical word problems. *Journal of Educational Psychology*, *103*(3), 547–561. https://doi.org/10.1037/a0023619

Klieme, E. (2001). *PISA 2000. Basiskompetenzen von Schülerinnen und Schülern im internationalen Vergleich [PISA 2000. Basic skills of students in international comparison].* (Springer). https://www.springer.com/gp/book/9783322834133

Kung, M., Schmitt, S. A., Zhang, C., Whiteman, S. D., Yang, F., & Purpura, D. J. (2019). The role of mathematical language in mathematics development in China and the US. *International Journal of Educational Research*, *95*, 131–142. https://doi.org/10.1016/j.ijer.2019.02.008

Martínez, J. M., & Dominguez, H. (2018). Navigating mathematics and language tensions in language immersion classrooms. *Teaching and Teacher Education*, *75*, 1–9. https://doi.org/10.1016/j.tate.2018.05.013

McArdle, J. J., Ferrer-Caja, E., Hamagami, F., & Woodcock, R. W. (2002). Comparative longitudinal structural analyses of the growth and decline of multiple intellectual abilities over the life span. *Developmental Psychology*, *38*, 115–142. https://doi.org/10.1037/0012-1649.38.1.115

Ministry of Culture. (2023). *Informe de Evaluación de la Política Nacional de Lenguas Originarias, Tradición Oral e Interculturalidad (PNLOTI) al 2040 [Evaluation Report of the National Policy on Native Languages, Oral Tradition and Interculturality (NPNLOTI) to 2040]*. https://transparencia.cultura.gob.pe/sites/default/files/transparencia/2024/06/informes-de-monitoreo-y-evaluacion-de-los-planes-y-politicas/informe-de-analisis-estrategico/20240613informedeevaluaciondelapnlotial2040f.pdf

Ministry of Culture. (2024). *Reporte de cumplimiento de la política nacional de lenguas originarias, tradición oral e interculturalidad al 2040 [Report on compliance with the national policy on indigenous languages, oral tradition and interculturality by 2040]*. https://transparencia.cultura.gob.pe/sites/default/files/transparencia/2024/06/informes-de-monitoreo-y-evaluacion-de-los-planes-y-politicas/informe-de-analisis-estrategico/20240613reportedecumplimientodelapnlotial2040f.pdf

Ministry of Development and Social Inclusion. (2021). *Reporte regional de indicadores* *sociales del departamento de Apurímac [Regional report on social indicators for the department of Apurímac].* https://sdv.midis.gob.pe/redinforma/Upload/regional/Apurimac.pdf

Ministry of Education. (2004). *Diccionario de matemática Yupa awa simi taqi [Dictionary of Mathematics Number of mathematics]*. https://repositorio.minedu.gob.pe/bitstream/handle/20.500.12799/9087/Diccionario de matemática castellano - quechua propuesta inicial Yupa awa simi taqi castellanomanta runasimiman qallariyllanraq.pdf?sequence=1

Ministry of Education. (2015). *Matemáticas en Educación Intercultural Bilingüe. Orientaciones pedagógica [Mathematics in Bilingual Intercultural Education. Pedagogical guidelines]*. https://www.ugelcasma.gob.pe/files/Data_EIB/Diversos_materiales_EIB/Matemática EIB.pdf

Ministry of Education. (2018). R*esultados evaluación internacional PISA [PISA international assessment results]*. http://umc.minedu.gob.pe/resultadospisa2018/

Ministry of Education. (2019). *Evaluaciones de logros de aprendizaje [Learning achievement assessments]*.

Ministry of Education. (2021). *Yupana. Kuskalla yachasunchik [Yupana. Let's learn together]*. https://repositorio.minedu.gob.pe/handle/20.500.12799/8197

Ministry of Education. (2023). *Resultados de la Evaluación Censal Estudiantes [Results of the Student Census Evaluation]*. http://umc.minedu.gob.pe/resultadosece2016/

Ministry of Education. (2024). *Recursos educativos de Educación Intercultural Bilingüe [Educational resources for Bilingual Intercultural Education]*. https://repositorio.minedu.gob.pe/handle/20.500.12799/7939

National Institute of Statistics and Information. (2017). *Evolución de la pobreza monetaria 2007-2016 [Evolution of monetary poverty 2007-2016]*. https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1533/libro.pdf

Opfer, J. E., Kim, D., & Qin, J. (2018). How does the "learning gap" open? A cognitive theory of nation effects on mathematics proficiency. In *Language and culture in mathematical cognition. Mathematical cognition and learning* (Vol. 4, pp. 99–130). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-812574-8.00005-5

Organisation of Economic Development. (2019). *Resultados de PISA 2018 Volumen I, ¿Qué saben y qué pueden hacer los estudiantes? [PISA 2018 Volume I Results, What do students know and what can they do?]*.

Outhwaite, L. A., Gulliford, A., & Pitchford, N. J. (2020). Language counts when learning mathematics with interactive apps. *British Journal of Educational Technology*, *51*(6), 2326–2339. https://doi.org/10.1111/bjet.12912

Park, S., Dotan, P. L., & Esposito, A. G. (2023). Do executive functions gained through two-way dual-language education translate into math achievement? *International Journal of Bilingual Education and Bilingualism*, *26*(4), 457–471. https://doi.org/10.1080/13670050.2022.2116973

Peng, P., Lin, X., Ünal, Z. E., Lee, K., Namkung, J., Chow, J., & Sales, A. (2020). Examining the mutual relations between language and mathematics: A meta-analysis. *Psychological Bulletin*, *146*(7), 595–634. https://doi.org/10.1037/bul0000231

Pérez, I. C. (2015). Indigenous languages , identity and legal framework in Latin America: an ecolinguistic approach. *Procedia - Social and Behavioral Sciences*, *212*, 111–116. https://doi.org/10.1016/j.sbspro.2015.11.307

Poonpon, K., Chansanam, W., Nilubol, K., Sameephet, B., Jannok, A., Satthamnuwong, B., Rakhshandehroo, M., & Srisawat, C. (2024). TIGA-based English learning platform for language learner competency development in a digital environment. *International Journal of Learning, Teaching and Educational Research*, *23*(6), 73–95. https://doi.org/10.26803/ijlter.23.6.4

Prediger, S., Wilhelm, N., Büchter, A., Gürsoy, E., & Benholz, C. (2018). Language proficiency and mathematics achievement. *Journal Für Mathematik-Didaktik*, *39*(S1), 1–26. https://doi.org/10.1007/s13138-018-0126-3

President of Peru. (2021). *Decreto Supremo 012-2021-MC [Supreme Decree 012-2021-MC]*. https://cdn.www.gob.pe/uploads/document/file/2022679/DECRETO SUPREMO O12-2021-MC.pdf.pdf?v=1626712803

Regional Press. (2023). Tacna se ubica en el primer lugar en educación por octavo año consecutivo [Tacna ranks first in education for the eighth consecutive year]. *Consejo de La Prensa Peruana*. https://prensaregional.pe/tacna-se-ubica-en-el-primer-lugar-en-educacion-por-octavo-ano-consecutivo/

Republic of Perú. (2024). *Registro Nacional de Instituciones Educativas que brindan el Servicio de Educación Intercultural Bilingüe [National Registry of Educational Institutions that provide the Bilingual Intercultural Education Service]*. https://cdn.www.gob.pe/uploads/document/file/7207198/6169968-rvm_n-_130-2024-minedu-copy.pdf?v=1731420261

Rojas, H., Renteria, R., Pilares, M., Alvarez, W., Arias, K. A., & Ibanez, V. (2020). Construction of a virtual museum as an educational tool for cultural learning. *Proceedings of the 15th Latin American Conference on Learning Technologies, LACLO 2020*. https://doi.org/10.1109/LACLO50806.2020.9381153

Saalbach, H., Eckstein, D., Andri, N., Hobi, R., & Grabner, R. H. (2013). When language of instruction and language of application differ: Cognitive costs of bilingual mathematics learning. *Learning and Instruction*, *26*, 36–44. https://doi.org/10.1016/j.learninstruc.2013.01.002

Saldivar, L., Rojas, H., & Catacora, N. (2021). Pedagogical digital tool for the area of mathematics in Quechua language. *ACM International Conference Proceeding Series*, 117–122. https://doi.org/10.1145/3483794.3483813

Schroeder, J. (2005). Más allá de los platos típicos: el proyecto matemática intercultural en el Perú [Beyond the typical dishes: the intercultural mathematics project in Peru]. *Cuadernos Interculturales*, *3*(4). https://www.researchgate.net/publication/26446711_Mas_alla_de_los_platos_tipicos_el_proyecto_matematica_intercultural_en_el_Peru

Sicat, L. V., & David, M. E. D. (2016). Performance in basic mathematics of indigenous students. *Universal Journal of Educational Research*, *4*(2), 320–325. https://doi.org/10.13189/ujer.2016.040202

Spiridonova, N., & Savvinova, A. (2015). Distinctive features of mathematical language formation in the context of bilingual education. *Procedia - Social and Behavioral Sciences*, *214*(June), 714–721. https://doi.org/10.1016/j.sbspro.2015.11.693

Suppiah Shanmugam, S., Veloo, A., & Md-Ali, R. (2021). The mathematics performance of aboriginal pupils for computation and word problem items in using academic and community languages. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(8), em1989. https://doi.org/10.29333/ejmste/11017

Tranca, J. (2023). *¿Por qué están desapareciendo nuestras lenguas originarias? ¿Qué podemos hacer al respecto? [Why are our native languages disappearing? What can we do about it?].* Actualidad Ambiental. https://www.actualidadambiental.pe/por-que-estan-desapareciendo-nuestras-lenguas-originarias-que-podemos-hacer/

United Nations. (2007). *Declaracion de las Naciones Unidas sobre los derechos de los pueblos indígenas [United Nations Declaration on the rights of indigenous peoples]*.

Vukovic, R. K., & Lesaux, N. K. (2013). The language of mathematics: Investigating the ways language counts for children's mathematical development. *Journal of*

Experimental Child Psychology, *115*(2), 227–244. https://doi.org/10.1016/j.jecp.2013.02.002

Wanjiru, R. D., Kitainge, K., & Dinah, S. (2021). Effects of students' language interpretation on performance in mathematics in selected secondary schools in Nakuru North Sub-County Kenya. *African Journal of Education, Science and Technology*, *6*(3), 348–393. https://doi.org/10.2022/ajest.v6i3.565

Appendix 1

Table 9 shows the instrument used to evaluate students' performance in mathematics. The linguistic, pedagogical, and technological dimensions were assessed on a five-point scale through direct observation by the classroom instructor. In contrast, the evaluative dimension was classified based on the scores obtained by the students in the software.

Table 9: Observation checklist

Level of Satisfaction	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
Linguistic dimension					
The student utilizes Quechua to communicate with the tool.					
The student demonstrates comprehension of mathematical concepts explained in Quechua.					
PEDAGOGICAL DIMENSION					
The student actively participates in interactive activities and games.					
The student relates mathematical content to their cultural context and prior experiences.					
TECHNOLOGICAL DIMENSION					
The student navigates the tool with ease and understands its functionality.					
The student enjoys and shows motivation when using the digital tool.					
EVALUATIVE DIMENSION	**Never**	**Rarely**	**Sometimes**	**Often**	**Always**
	0 a 3.9	4 a 7.9	8 a 11.9	12 a 15.9	16 a 20
The student demonstrates progress in learning mathematical concepts through the tool.					
The student accesses and solves statements in the tool					