



Bridging Science and Humanity:

Research for Societal Change

Editor: Delfina Goya Cornejo Poma

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Bridging Science and Humanity: Research for Societal Change

UNIVERSIDAD NACIONAL DEL ALTIPLANO - ESCUELA DE POSGRADO

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PRESENTATION

This book containing 26 research articles from different fields such as education, engineering, and social sciences, reflects an interdisciplinary approach aimed at addressing contemporary challenges with social impact, demonstrating that academic research can integrate scientific rigor with a genuine commitment to social well-being and transformation.

This publication is evidence of a three-month postgraduate training process in acquiring English language due the use of this language enables the dissemination of knowledge at an international level, access to specialized sources, and the strengthening of academic collaboration. Thus, this book represents not only a research achievement but also a commitment to continuous academic development and the global projection of scientific work.

Mg. Delfina Goya Cornejo Poma

EDUCATIONAL SUPPORT AND TEACHING PERFORMANCE AT THE MARÍA ASUNCIÓN GALINDO SECONDARY SCHOOL

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ABSTRACT

This study analyzed the relationship between pedagogical support and teacher performance at the María Asunción Galindo Secondary School in Juli. The research was conducted within the framework of improving educational quality and strengthening teaching practice through advisory, monitoring, and formative feedback processes. A quantitative correlational approach and a non-experimental cross-sectional design were used. The population consisted of secondary school teachers, who were given instruments to measure the study variables. Spearman's correlation coefficient was used for data analysis to determine the degree of relationship between the variables and their dimensions. The results showed a high and statistically significant positive correlation between pedagogical support and teacher performance, with a correlation coefficient of 0.788. Likewise, high positive correlations were identified between the dimensions of pedagogical support and teacher performance, highlighting progressive autonomy with a coefficient of 0.811, the habit of continuous reflection with 0.724, and the improvement of pedagogical practice with 0.779. It was concluded that pedagogical support is a fundamental strategy for strengthening teacher performance, as it promotes processes of professional reflection, pedagogical autonomy, and continuous improvement of educational practice, contributing significantly to strengthening the quality of the teaching and learning process in the school context.

Keywords: Pedagogical support; teacher performance; pedagogical practice; teacher professional development; secondary education.

INTRODUCTION

In the contemporary educational context, improving the quality of teaching has been a priority challenge for education systems, particularly in Latin America, where inequalities in access, retention, and learning achievement have persisted. Recent reports by UNESCO (2022) and ECLAC (2021) highlight significant gaps in educational quality, teacher training, and learning outcomes, which has called for policies aimed at strengthening the professional development of teachers. In this context, pedagogical support is positioned as a key strategy for strengthening teacher performance through systematic processes of mentoring, monitoring, and formative feedback (Ascencio, 2019; Vásquez, 2019; Zeballos, 2020). Likewise, the Peruvian Ministry of Education (2018, 2020) maintains that pedagogical support constitutes a situated training action aimed at improving learning by strengthening teaching practice.

Teaching performance is understood as the integrated set of pedagogical, didactic, and socio-emotional competencies that teachers deploy to generate meaningful learning, considering

the institutional and sociocultural context in which they work (Ministry of Education, 2019; Zambrano, 2020). This performance involves not only disciplinary mastery, but also critical reflection, professional autonomy, and the ability to adapt to changing educational scenarios.

Several studies have analyzed the relationship between pedagogical support and teacher performance. Agreda and Pérez (2020) point out that support strengthens reflective teaching practice; Yana and Adco (2018) show improvements in curriculum planning and student learning. Likewise, Chávez and Oseda (2021) highlight its positive influence on institutional teaching performance. In addition to these contributions, recent research highlights support as a strategy for professional teaching development, especially in diverse educational contexts. Caballero (2022) identifies it as a key factor for continuous improvement; Vásquez (2019) highlights its impact in rural contexts; Pedroso (2019) links it to critical teacher reflection; and Calderón and Loja (2018) emphasize its role in redefining the teaching role in the 21st century. However, there is still a gap in studies that integrate these dimensions with teacher performance in specific contexts of Peruvian secondary education.

In response to this problem, the present study aims to determine the relationship between pedagogical support and teacher performance in a secondary educational institution in the Puno region, providing empirical evidence to strengthen continuing teacher training strategies and contribute to improving educational quality.

Within this framework, pedagogical support has been conceived as a systematic process of formative advice aimed at improving teaching practice through observation, feedback, and pedagogical reflection (Ascencio, 2019; Ministry of Education, 2018). According to Ruiz (2017) and Zeballos (2020), this process must be continuous, contextualized, and focused on the professional improvement of teachers, promoting pedagogical innovation and institutional learning.

One of the dimensions of pedagogical support is progressive teacher autonomy, understood as the development of professional skills that enable informed and contextualized pedagogical decisions to be made. Álvarez (2015) argues that professional autonomy is built through social interaction and pedagogical experience, while Maldonado (2017) points out that it promotes responsible pedagogical freedom. Likewise, Martínez (2018) indicates that this autonomy is strengthened throughout the professional career through reflective training processes.

Another relevant dimension is the habit of continuous reflection, considered an essential component of professional teaching development. Sevilla et al. (2021) affirm that reflective practice allows for the analysis and improvement of pedagogical performance; Anijovich and Cappelletti (2018) highlight its contribution to improving professional performance; and Verástegui and González (2019) emphasize its role in educational innovation.

Pedagogical support seeks to optimize teaching practice through counseling, continuing education, and formative feedback. Luque (2018) argues that pedagogical feedback promotes teaching performance, while Navareño (2020) highlights the need for ongoing institutional counseling for educational innovation. Prada et al. (2021) emphasize that pedagogical planning is a key element in strengthening teachers' professional skills.

Likewise, teaching performance has been defined as the mastery of professional skills that enable meaningful learning and appropriate educational environments (Ministry of Education,

2019; Valdés, 2009). Anchundia (2019) points out that this performance is influenced by sociocultural and institutional factors, while Zambrano (2020) highlights the role of teachers as agents promoting effective learning.

According to the classroom observation rubrics of the Ministry of Education (2017), teacher performance has been evaluated considering five fundamental components:

1. Actively engages students in learning. This involves generating interest, motivation, and active participation through meaningful pedagogical strategies.
2. Promotes reasoning, creativity, and critical thinking. This is aimed at stimulating higher cognitive processes through reflective activities and problem solving.
3. Evaluates progress for feedback. This includes constant monitoring of learning and formative feedback tailored to student needs.
4. Fosters an environment of respect and closeness. This considers the socio-emotional climate of the classroom, teacher empathy, and respectful interaction.
5. It positively regulates student behavior. This refers to the formative management of coexistence and the use of pedagogical strategies to promote self-regulation.

These components show that teaching performance is a comprehensive process that combines pedagogical, socio-emotional, and didactic skills aimed at educational quality.

MATERIALS AND METHODS

The study was conducted using a quantitative approach with a non-experimental correlational design, aimed at analyzing the relationship between pedagogical support and teacher performance without manipulating variables. The research was conducted at the María Asunción Galindo Secondary School, located in the district of Juli, province of Chucuito, Puno region, in 2021 in a virtual education context. The population consisted of 50 teachers from various specialties, so a census sampling was used, including all participants.

A 23-item Likert-type questionnaire was used to collect data for the pedagogical support variable, which had a Cronbach's alpha coefficient of 0.943, demonstrating high reliability. The teacher performance evaluation rubric validated by the Peruvian Ministry of Education was also used. Statistical processing was performed using SPSS version 24 software. After applying the Kolmogorov-Smirnov normality test, it was determined that the data did not follow a normal distribution, so Spearman's Rho coefficient was used to establish the relationship between the variables.

RESULTS AND DISCUSSION

Table 1

Degree of correlation between pedagogical support and teacher performance

		Teaching performance
Spearman's rho	Pedagogical support	Correlation coefficient
		,788**
		Sig. (two-tailed)
	Teaching performance	,000
		N
		50
Spearman's rho	Pedagogical support	Correlation coefficient
		1,000
		Sig. (two-tailed)
	Teaching performance	.
		N
		50

** . The correlation is significant at the 0.01 level (two tails).

According to Table 1, Spearman's correlation coefficient was $\rho = .788$ ($p < .001$), which showed a high and statistically significant positive correlation between pedagogical support and teaching performance.

Table 2

Degree of correlation between progressive autonomy and teaching performance

		Teaching performance
Spearman's rho	Progressive autonomy	Correlation coefficient
		,811**
		Sig. (two-tailed)
	Teaching performance	,000
		N
		50
Spearman's rho	Progressive autonomy	Correlation coefficient
		1,000
		Sig. (two-tailed)
	Teaching performance	.
		N
		50

** . The correlation is significant at the 0.01 level (two tails).

According to Table 2, the correlation coefficient was $\rho = .811$ ($p < .001$), showing a high positive correlation between the progressive autonomy dimension and teaching performance.

Table 3

Degree of correlation between the habit of continuous reflection and teaching performance

		Teaching performance
Spearman's rho	Habit of continuous reflection	Correlation coefficient
		,724**
		Sig. (two-tailed)
	Teaching performance	,000
		N
		50
Spearman's rho	Habit of continuous reflection	Correlation coefficient
		1,000
		Sig. (two-tailed)
	Teaching performance	.
		N
		50

** . The correlation is significant at the 0.01 level (two tails).

Table 3 showed a coefficient of $\rho = .724$ ($p < .001$), indicating a high positive correlation between the habit of continuous reflection and teaching performance.

Table 4

Degree of correlation between improvement in teaching practice and teaching performance

		Teaching performance
Spearman's rho	Improvement of teaching practice	Correlation coefficient
		Sig. (two-tailed)
		N
	Teaching performance	Correlation coefficient
		Sig. (two-tailed)
		N

.779**

.000

50

1,000

.

50

** . The correlation is significant at the 0.01 level (two tails).

According to Table 4, the correlation coefficient was $\rho = .779$ ($p < .001$), showing a high and significant positive correlation between improvement in teaching practice and teacher performance.

DISCUSSION

The results showed a high positive relationship between pedagogical support and teacher performance ($\rho = .788$), confirming that training support was significantly associated with strengthening professional teaching practice. This finding was consistent with Agreda and Pérez (2020), who pointed out that pedagogical support has an impact on the reflective improvement of teaching practice. Similarly, it coincided with Yana and Adco (2018), who showed improvements in curriculum planning and evaluation as a result of support.

The results were also consistent with Chávez and Oseda (2021), who reported significant relationships between pedagogical support and teaching performance in Peruvian educational contexts. In this sense, the findings supported the approach of the Peruvian Ministry of Education (2018), which conceives of support as a training strategy aimed at continuous improvement.

The highest correlation was observed in the progressive autonomy dimension ($\rho = .811$). This result indicated that strengthening curriculum planning and pedagogical decision-making was closely linked to teacher performance. Mucha (2019) argued that teacher preparation for teaching, especially in curriculum planning, is a central component of professional performance. This finding was also consistent with recent studies on teacher professional development that highlight autonomy as a key to educational improvement (Caballero, 2022).

The significant relationship between the habit of continuous reflection and teacher performance ($\rho = .724$) showed that reflective practice was associated with improvements in pedagogical performance. Agreda and Pérez (2020) stated that programs with a critical-reflective approach strengthen teacher professional development. Likewise, García (2016) pointed out that reflective processes significantly influence continuous performance improvement. These results reinforced the idea that pedagogical support, when it promotes systematic spaces for analysis and feedback, contributes to consolidating a professional culture oriented toward improvement.

The improvement in teaching practice showed a high correlation ($\rho = .779$), which showed that the guidance, monitoring, and feedback provided by the teaching coordinator were associated with better levels of teaching performance. Choque (2019) indicated that limited monitoring frequency can affect educational quality, highlighting the importance of constant support. Similarly, González (2022) argued that continuous teacher training increases the likelihood of success in achieving meaningful learning, which supports the results obtained in the study.

CONCLUSIONS

A high and statistically significant positive relationship was found between pedagogical support and teaching performance at the María Asunción Galindo Secondary School during 2021 ($\rho = .788$). Likewise, the dimensions of progressive autonomy ($\rho = .811$), habit of continuous reflection ($\rho = .724$), and improvement of pedagogical practice ($\rho = .779$) showed high positive associations with teacher performance.

The findings confirmed that pedagogical support, conceived as a systematic process of advising, monitoring, and formative feedback, was significantly linked to the strengthening of professional teaching performance. The contribution of the study was to provide contextualized empirical evidence in high Andean secondary education, supporting pedagogical support as a key strategy for improving educational quality.

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THE IMPACT OF PROFESSIONAL ETHICS ON MODERNIZING PUBLIC ADMINISTRATION AMONG CIVIL SERVANTS

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ABSTRACT

This study analyzes the relationship between professional ethics and the modernization of public administration among public servants. A quantitative, descriptive, non-experimental design was employed. The sample comprised 50 public servants from municipal, regional, and national institutions, selected through non-probabilistic convenience sampling. Data were collected using a validated questionnaire that assessed dimensions such as the internalization of ethical values, efficiency, transparency, innovation, regulatory compliance, inter-institutional cooperation, and resistance to change. The findings indicate that most respondents (76%) perceived high levels of professional ethics and regulatory compliance, reinforcing institutional legitimacy, citizen trust, and efficiency in public management. Furthermore, 60% positively valued institutional innovation and modernization, although limitations were identified, particularly resistance to change and the need for enhanced ethical and administrative training. In conclusion, professional ethics emerges as a strategic factor in advancing administrative modernization, fostering responsible conduct, inter-institutional collaboration, and the sustainability of public services.

Keywords: professional ethics, administrative modernization, public servants, transparency, innovation.

INTRODUCTION

Professional ethics are an essential element in the training and performance of public servants, and a determining factor in ensuring transparency, fairness, and efficiency in public administration. Today, government institutions face increasingly complex challenges, such as citizen demand for faster and more effective services, the digitization of processes, and the need to strengthen society's trust in public officials. In this context, professional ethics is presented not only as a regulatory framework, but also as a set of values and principles that guide the conduct of public servants and have a direct impact on the modernization of the administration.

According to Velasco (2018), professional ethics in the civil service is not limited to compliance with legal norms, but implies an active commitment to integrity, accountability, and transparency. These values are fundamental to reducing corrupt practices, optimizing resource management, and ensuring that services are provided efficiently and equitably.

For his part, Garcia (2020) emphasizes that the modernization of public administration cannot be understood solely as the adoption of new technologies or administrative procedures; its success depends largely on the internalization of ethical principles by public servants, who are the agents responsible for implementing institutional changes.

Several authors have also pointed out the importance of professional ethics in building a strong organizational culture. Fernandez and Lopez (2017) explain that citizens' perceptions of the honesty and responsibility of public servants directly influence institutional legitimacy and social acceptance of public policies. Similarly, Martinez (2019) argues that the internalization of ethical values enables inter-institutional cooperation, continuous improvement of processes, and the ability to adapt to contemporary challenges, thus consolidating administrative modernization. Pérez (2015) adds that professional ethics also contribute to preventing corrupt practices and foster an environment of trust and respect within public institutions, which is essential for any process of change or innovation.

Likewise, professional ethics becomes a strategic tool for addressing phenomena such as excessive bureaucratization, resistance to change, and lack of institutional commitment. Sánchez (2021) argues that ethical training and awareness programs within public institutions not only strengthen the skills of civil servants, but also create more collaborative work environments geared toward the common good. Thus, it is clear that professional ethics is not an abstract concept, but an active factor that drives the modernization of public administration and the improvement of services offered to citizens. In this same vein, Rojas (2018) emphasizes that professional ethics is an essential factor in the planning and execution of effective public policies, as it ensures that institutional actions are aligned with the principles of equity and transparency.

On the other hand, specialized literature also emphasizes that professional ethics directly impact citizens' perceptions of public administration. Hernández (2017) argues that ethical public servants foster social trust, improve the legitimacy of institutions, and promote citizen participation in governance processes. This approach shows that professional ethics is not an accessory concept, but a central element that enables effective and sustainable administrative modernization.

In summary, this research focuses on analyzing professional ethics as a determining factor in the modernization of public administration among civil servants. It seeks to identify how ethical values and principles influence efficiency, transparency, and institutional innovation, as well as the challenges faced by civil servants when attempting to align their performance with professional ethical standards. The study is based on the premise that administrative modernization cannot be effective without an ethical commitment that guides the decisions and actions of public servants, this being a key element in strengthening legitimacy, public trust, and the quality of public management.

The overall objective of this research is to analyze the influence of professional ethics on the modernization of public administration among public servants, considering its relationship with efficiency, transparency, institutional innovation, and regulatory compliance.

MATERIALS AND METHODS

The study was conducted using a quantitative-descriptive approach, following the line of Garcia (2020), who argues that administrative modernization does not depend solely on the implementation of technologies, but also on the internalization of ethical principles by public servants. This design allowed us to explore and describe the relationship between professional ethics and key dimensions of public administration, such as efficiency, transparency, and institutional innovation.

The study population consisted of 50 civil servants from municipal, regional, and national institutions, selected through non-probability convenience sampling based on availability and willingness to participate (Fernandez & Lopez, 2017). Participation was voluntary, and data were collected using a structured 24-item questionnaire on a five-point Likert scale, designed from specialized literature and validated by experts in ethics and public administration following Hernández (2017). The instrument, administered both in person and online, assessed dimensions such as ethical values internalization, efficiency, transparency, innovation, regulatory compliance, interinstitutional cooperation, and resistance to change. Data were organized into a database and analyzed descriptively using absolute frequencies, percentages, and valid percentages (García, 2020), allowing the identification of patterns in the relationship between professional ethics and administrative modernization.

RESULTS AND DISCUSSION

The results show that professional ethics is a significant factor influencing efficiency, transparency, and innovation in public management. The key indicators obtained from the sample (n = 50) are detailed below.

Table 1
Ethical Values and Principles in Public Administration

Item evaluated	Frequency	%	% valid	Interpretation
Very high	20	40	40	Excellent
High	18	36	36	Good
Moderate	8	16	16	Fair
Low	3	6	6	Weak
Very low	1	2	2	Very weak
Total	50	100	100	-

Note. Most public servants perceive a high or very high level of internalization of ethical values (76% overall), which shows that the principles of integrity, responsibility, and transparency are widely recognized within institutions. Only 8% perceive these values as low or very low, suggesting areas for improvement in ethical awareness. These results reinforce the idea that professional ethics are a central factor in strengthening institutional legitimacy and public trust.

Table 2
Civil Servants' Perceptions of Efficiency and Transparency in Public Administration

Item evaluated	Frequency	%	% valid	Interpretation
Very high	15	30	30	Excellent
High	20	40	40	Good
Moderate	10	20	20	Fair
Low	4	8	8	Weak
Very low	1	2	2	Very weak
Total	50	100	100	-

Note. 70% of public servants rated efficiency and transparency as high or very high, indicating a positive perception of institutional management. However, 10% report low levels, pointing to possible gaps in administrative processes or in the communication of results, a finding that suggests that administrative modernization is partially associated with the internalization of ethical values, where a positive perception of efficiency and transparency is linked to consistent ethical behavior.

Table 3
Experiences in Innovation and Institutional Modernization

Item evaluatel	Frequency	%	% valid	Interpretation
Very high	12	24	24	Excellent
High	18	36	36	Good
Moderate	12	24	24	Fair
Low	6	12	12	Weak
Very low	2	4	4	Very weak
Total	50	100	100	-

Note. Sixty percent of participants perceive high levels of innovation and modernization, compared to 16% who consider them low. These results reflect significant institutional progress, although limited by factors such as resistance to change and insufficient ethical and administrative training. In this sense, professional ethics emerges as a key component in promoting the adoption of innovative practices in the public sphere.

Table 4
Regulatory Compliance and Professional Ethics

Item evaluatel	Frequency	%	% valid	Interpretation
Very high	18	36	36	Excellent
High	20	40	40	Good
Moderate	7	14	14	Fair
Low	4	8	8	Weak
Very low	1	2	2	Very weak
Total	50	100	100	-

Note. 76% of public servants perceive that they comply with rules and regulations to a high or very high degree, indicating that professional ethics influence respect for the institutional legal framework.

Table 5
Resistance to Change

Item evaluatd	Frequency	%	% valid	Interpretation
Very high	5	10	10	Excellent
High	12	24	24	Good
Moderate	15	30	30	Fair
Low	13	26	26	Weak
Very low	5	10	10	Very weak
Total	50	100	100	-

Note. There is a moderate perception of resistance to change, indicating that administrative modernization requires strategies that integrate ethics and training for civil servants.

Table 6
Interinstitutional Cooperation

Item evaluatd	Frequency	%	% valid	Interpretation
Very high	10	20	20	Excellent
High	22	44	44	Good
Moderate	12	24	24	Fair
Low	5	10	10	Weak
Very low	1	2	2	Very weak
Total	50	100	100	-

Note. The majority (64%) perceive a high level of cooperation between institutions, reflecting that ethical values promote collaboration and teamwork in the public sphere.

DISCUSSION

The results obtained confirm that professional ethics is a determining factor in the modernization of public administration, supporting the theoretical approaches developed in the specialized literature. First, the high level of internalization of ethical values (76%) coincides with the findings of Velasco (2018), who argues that ethics in public service transcends mere regulatory compliance and is linked to an active commitment to integrity, accountability, and transparency. The correspondence between ethical internalization and high regulatory compliance observed in the study demonstrates consistency between principles and institutional practice.

Likewise, the results related to efficiency and transparency (70% high rating) support the findings of Fernandez and Lopez (2017), who assert that the perception of honesty and responsibility in public servants strengthens institutional legitimacy. In this sense, professional ethics not only guide individual behavior, but also directly impact the quality of management and public trust, as argued by Hernández (2017).

In terms of institutional innovation and modernization, although 60% perceive significant progress, the presence of resistance to change reflects the findings of Sánchez (2021), who warns that modernization processes require not only structural reforms, but also ethical training and skills strengthening programs. The moderate resistance identified in the results suggests that professional ethics should be consolidated as a cross-cutting theme in training and organizational transformation processes.

On the other hand, the 64% favorable perception of inter-institutional cooperation confirms the findings of Martínez (2019), who highlights that the internalization of ethical values facilitates collaborative work and coordination between public entities. This reinforces the idea that professional ethics is not an isolated element, but rather a structural component that affects the systemic efficiency of public administration.

In general, the results coincide with those presented by García (2020), who argues that administrative modernization is not limited to the incorporation of technologies, but depends on the ethical commitment of public servants. Similarly, Pérez (2015) and Rojas (2018) emphasize that professional ethics prevent inappropriate practices and ensure that public policies are implemented under principles of equity and transparency, aspects that are reflected in the high perception of regulatory compliance observed in the research.

However, it is important to recognize that, although the results are mostly positive, there are still areas for improvement related to resistance to change and the need to strengthen ethical and administrative training. This suggests that the modernization of public administration requires comprehensive strategies that combine continuous training, ethical leadership, and an organizational culture oriented toward the common good.

In summary, the discussion allows us to affirm that professional ethics is a strategic axis for administrative modernization, as it directly influences efficiency, transparency, innovation, and inter-institutional cooperation, contributing to the strengthening of institutional legitimacy and citizen trust.

CONCLUSIONS

This study shows that professional ethics is a determining factor in the modernization of public administration, as it directly affects efficiency, transparency, innovation, and inter-institutional cooperation. The results of the study allow us to affirm that the internalization of ethical values by public servants not only strengthens institutional legitimacy and citizen trust, but also constitutes an active mechanism for improving administrative processes and preventing corrupt practices.

The findings show that most civil servants perceive high levels of ethics, efficiency, and transparency, confirming that professional conduct has a tangible influence on the quality of services offered to citizens. Despite the progress observed, challenges remain, such as resistance to change and the need for ongoing ethics training, aspects that underscore the importance of integrating ethics as a cross-cutting theme in administrative modernization strategies.

The original contribution of this research lies in demonstrating, empirically and quantitatively, the direct relationship between professional ethics and institutional modernization in local and national public contexts. This reinforces the idea that modernization does not depend solely on technology or procedures, but on the internalization of ethical values and principles that guide

the performance of public servants. Consequently, the study provides solid evidence supporting the need for public policies aimed at strengthening professional ethics as a strategic tool for institutional development and improving services to citizens.

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TECHNOLOGICAL MODERNIZATION AND E-GOVERNMENT AS DETERMINANTS OF PUBLIC SERVICE QUALITY

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ABSTRACT

The objective of this study was to analyze the influence of state technological modernization and e-government on the quality of services provided to citizens. A quantitative, non-experimental, cross-sectional, and correlational design was employed. The sample consisted of 357 citizens who use digital public services, selected through simple random probability sampling. Data were collected using a structured questionnaire with a five-point Likert scale, validated by expert judgment and demonstrating reliability above 0.80 according to Cronbach's alpha. The findings revealed favorable perceptions of both technological modernization and service quality. Moreover, a positive and statistically significant correlation was identified between the two variables ($r = 0.72$; $p < 0.001$). Linear regression analysis indicated that technological modernization accounted for 51% of the variance in citizens perceived service quality. In conclusion, strengthening e-government initiatives and digitizing administrative processes significantly contribute to enhancing the efficiency, accessibility, and user satisfaction of public services.

Keywords: electronic government; technological modernization; public service quality; citizen satisfaction; digital government.

INTRODUCTION

The technological modernization of the state has become established as a key strategy for optimizing administrative processes, improving transparency, and strengthening the relationship between the state and its citizens. International organizations have highlighted that digital governments can increase the operational efficiency of public services by up to 20–30% (Organization for Economic Cooperation and Development [OECD], 2023).

The area of study is digital public management, which is scientifically relevant for its contribution to e-governance and socially relevant for its direct impact on citizen satisfaction. According to the United Nations (2022), countries with the most developed e-governance have higher levels of institutional trust and reduced administrative processing times.

In Latin America, progress has been uneven. While some countries have consolidated integrated digital service platforms, others face infrastructure limitations and a digital divide (Economic Commission for Latin America and the Caribbean [ECLAC], 2023). This inequality raises questions about the real impact of technological modernization on service quality.

Analyzing the impact of technological modernization of the state and e-government on the quality of services provided to citizens, objectives such as the following are established: Evaluate the relationship between the digitization of procedures and citizen satisfaction, analyze the influence of institutional interoperability on the perception of efficiency, and determine the impact of technological training for public personnel on service quality. The Organization for Economic Cooperation and Development (2023) noted that integrated digital governments improve administrative efficiency and reduce operating costs, highlighting interoperability as a key factor. The United Nations (2022) reported that the e-government development index showed overall improvement, although structural digital divides between regions persisted.

According to Mergel, Ganapati, and Whitford (2021), government digital transformation requires profound organizational changes and institutional leadership to ensure sustainable impact. Luna-Reyes and Gil-García (2020) identified that the perceived quality of digital services depends on the accessibility, security, and ease of use of electronic platforms. ECLAC (2023) showed that digital inclusion and technological literacy are key factors in reducing inequalities in access to digital public services.

Another relevant aspect is the digital divide, understood as inequality in access to and use of ICTs. Norris (2001) warns that digital exclusion can deepen social inequalities if inclusive policies are not implemented. In the area of e-government, this problem can limit equitable access to public services, affecting the quality perceived by certain sectors of the population. Technological modernization, therefore, requires complementary strategies for digital literacy and adequate infrastructure.

In local and regional contexts, the adoption of e-government also faces challenges arising from inequalities in many cases of poor access to technology, digital literacy gaps, and structural limitations that condition the effectiveness of digital services (Zafra et al., 2025; Sharma, Kar & Gupta, 2025; Gupta et al., 2025; Mahmoud, Hamed & Dwidar, 2025).

This article therefore presents a review of the scientific literature to assess how technological modernization and e-government influence these aspects, highlighting the main contributions and limitations.

MATERIALS AND METHODS

This study was conducted using a quantitative approach, with a non-experimental, cross-sectional, and correlational design, aimed at analyzing the relationship between the technological modernization of the State and the quality of services provided to citizens. This design was chosen because the variables were studied in their natural context, without deliberate manipulation.

The population consisted of citizens who used digital public services at the regional level, with an estimated universe of approximately 5,000 active users during the study period. The sample size was determined using the formula for finite populations, with a confidence level of 95% and a margin of error of 5%, resulting in a sample of 357 participants. The sampling type was simple random probability, ensuring equal selection opportunities for users registered on institutional digital platforms.

A structured five-point Likert scale questionnaire was used as a data collection tool (1 = strongly disagree; 5 = strongly agree), composed of items grouped into two main dimensions:

(a) technological modernization (digitization of procedures, institutional interoperability, and technological training of staff) and (b) service quality (efficiency, accessibility, reliability, and citizen satisfaction). The instrument was validated by experts in public management and digital government, and its reliability was determined using Cronbach's alpha coefficient, obtaining a value greater than 0.80, which is considered adequate.

SPSS version 26 statistical software was used for data processing and analysis. Descriptive statistics (frequencies, percentages, means, and standard deviation) were applied to characterize the variables, and inferential statistics were used through Pearson's correlation test to determine the relationship between the study variables. Simple linear regression was also used to evaluate the level of influence of technological modernization on the quality of citizen service, considering a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

The findings are presented according to the dimensions of the independent variable (technological modernization of the state) and its relationship with the dependent variable (quality of service to citizens). Descriptive statistics and inferential results are shown.

1. Level of technological modernization of the State

The descriptive results show that 68% of respondents perceive a high level of digitization of procedures, while 21% consider it medium and 11% low. In terms of institutional interoperability, 62% report a high perception, 25% medium, and 13% low. Regarding the technological training of public personnel, 59% rate it as high, 27% as medium, and 14% as low.

The overall average for the technological modernization variable was 3.87 (SD = 0.64) on a scale of 1 to 5, indicating a favorable trend in citizen perception.

Table 1

Level of Perceived Technological Modernization

Dimension	Mean	Standard Deviation
Digitalization of procedures	3.94	0.71
Institutional interoperability	3.81	0.68
Technological training	3.76	0.73
Overall mean	3.87	0.64

2. Level of Quality of Citizen Service

Regarding the service quality variable, 71% of the participants reported a high level of satisfaction, 19% a medium level, and 10% a low level. The dimensions with the highest scores were efficiency (M = 4.02; SD = 0.66) and accessibility (M = 3.95; SD = 0.70), followed by reliability (M = 3.88; SD = 0.69) and overall satisfaction (M = 3.93; SD = 0.65). The overall mean of the variable was 3.95 (SD = 0.61), indicating a predominantly positive assessment.

Table 2*Level of Perceived Service Quality*

Dimension	Mean	Standard Deviation
Efficiency	4.02	0.66
Accessibility	3.95	0.70
Reliability	3.88	0.69
Satisfaction	3.93	0.65
Overall mean	3.95	0.61

3. Relationship Between Technological Modernization and Service Quality

The inferential analysis using the Pearson correlation coefficient showed a positive and statistically significant relationship between technological modernization and service quality ($r = 0.72$; $p < 0.001$).

Likewise, the simple linear regression analysis showed that technological modernization explains 51% of the variance in service quality ($R^2 = 0.518$; $F = 382.41$; $p < 0.001$). The standardized beta coefficient was $\beta = 0.72$, indicating a direct relationship between both variables.

Table 3*Correlation and Regression Between Variables*

Statistic	Value
Pearson's r	0.72
Significance level (p)	0.000
R^2	0.518
F	382.41
β	0.72

The results show significant associations between the analyzed variables, consistent with the objectives proposed in the research.

DISCUSSION

The results show a positive and statistically significant relationship between the technological modernization of the State and the quality of citizen services ($r = 0.72$; $p < 0.001$), confirming that higher levels of digitalization, interoperability, and technological training are associated with a better perception of efficiency, accessibility, and satisfaction. These findings support the general objective of the study and are consistent with what the Organisation for Economic Co-operation and Development (OECD, 2023) states, namely that digital integration in public administration improves operational efficiency and optimizes service delivery.

In the same line, the United Nations (2022) report on e-government highlights that countries with greater digital development show better indicators of institutional performance and citizen trust. The results obtained empirically confirm this relationship in the analyzed context, particularly regarding digitalization of procedures and institutional interoperability as dimensions explaining 51% of the variance in service quality ($R^2 = 0.518$).

Furthermore, the findings are consistent with recent studies emphasizing that digital transformation not only involves technological adoption but also organizational changes and the strengthening of human capacities. Recent research (Zafra et al., 2025; Sharma, Kar & Gupta, 2025; Gupta et al., 2025; Mahmoud, Hamed & Dwidar, 2025) shows that staff training and technological governance directly influence citizens' perceptions of efficiency and reliability. In this study, the technological training dimension showed a favorable mean ($M = 3.76$), suggesting that human capital is a determining factor in the quality of digital services.

On the other hand, the results also align with contemporary perspectives on perceived quality in digital services, where accessibility and ease of use are key variables for citizen satisfaction (Luna-Reyes & Gil-García, 2020). Indeed, the efficiency dimension obtained the highest mean ($M = 4.02$), reinforcing the idea that the simplification of administrative processes through digital platforms directly impacts user experience.

CONCLUSIONS

This study confirms that technological modernization of the State and the development of e-government are key factors in improving the quality of citizen-oriented public services. Based on the analysis conducted, a positive and statistically significant relationship was identified between both variables ($r = 0.72$; $p < 0.001$), demonstrating that strengthening administrative digitalization directly influences citizens' perceptions of efficiency, accessibility, and satisfaction with digital public services.

In accordance with the proposed objectives, it was determined that digitalization of procedures, institutional interoperability, and technological training of public personnel represent key components in the process of State modernization. These elements contribute to optimizing administrative processes, reducing service time, and improving interaction between citizens and public institutions. In particular, digitalization of procedures has become an effective mechanism to simplify processes and facilitate access to services, while institutional interoperability enables more integrated and efficient management of public information.

Likewise, the results show that technological training of public personnel constitutes a strategic factor to ensure the proper functioning of digital platforms and improve service quality. In this sense, the digital transformation of the State should not be understood solely as the incorporation of technologies, but as a comprehensive process involving organizational change, strengthening institutional capacities, and developing digital competencies among public servants.

From the researcher's perspective, the main contribution of this study lies in empirically demonstrating that technological modernization not only optimizes administrative management but also significantly influences citizens' perceptions of the quality of public services. In this way, the research contributes to strengthening the scientific evidence on the impact of e-government on public management, highlighting the importance of promoting inclusive digitalization policies that reduce technological gaps and foster equitable access to government services.

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INTELLIGENT VIRTUAL ASSISTANT FOR ENHANCING STUDENT PRODUCTIVITY AT SAN JOSÉ SCHOOL, JULIACA

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ABSTRACT

This applied quantitative research, conducted at an explanatory level with a quasi-experimental design, developed an Intelligent Virtual Assistant to predict academic performance at San José School in Juliaca. The primary objective was to design, develop, and implement a deep learning-based system aimed at optimizing student productivity through the analysis of behavioral patterns and the enhancement of educational management decision-making. Methodologically, a modular software architecture was designed using microservices and a RESTful API. Academic and sociodemographic data were collected and preprocessed (including data cleaning, normalization, and encoding) to train and fine-tune Deep Neural Network (DNN) models. Validation procedures included five-fold cross-validation ($k = 5$), as well as functional and stress testing, with results visualized through an interactive interface developed using Dash and Plotly. The findings indicated that the predictive models achieved 92% accuracy, 89% recall, and an F1-score of 90% in identifying at-risk students. Furthermore, architectural optimization increased operational efficiency by 18.21%, while the implementation of parallel processing reduced the average query response time by 30% (from 5 to 3 seconds). The system demonstrated robustness in managing high concurrency and large-scale data processing, enabling the timely generation of alerts. It is concluded that the virtual assistant achieves a high level of predictive performance, representing a modern tool for the personalization of educational intervention strategies that can be replicated in other contexts.

Keywords: Academic Performance Prediction, Data Analysis, Deep Learning, Educational Management, Virtual assistant

INTRODUCTION

Machine learning has reached increasingly advanced levels within academic research, thereby enabling the development of Virtual Learning Assistants (VLAs) which employ advanced natural language processing techniques. These systems have demonstrated positive outcomes, as they allow students to interact dynamically with the platform in order to achieve their academic objectives (Mitchell, 2021; Russell & Norvig, 2020). This evolution has been driven by the incorporation of deep learning models capable of analyzing multimodal data such as text, audio, and video, together with the adoption of multifaceted teaching and learning methodologies. The automation of these systems enables the identification of large-scale academic data patterns, taking into account adaptive learning variables among students and providing personalized solutions for the entire educational community. Overall, learning processes are becoming increasingly active and interactive (Chollet, 2021; Goodfellow et al., 2016).

Application of supervised and unsupervised machine learning techniques, including classification and regression methods, has significantly contributed to the prediction of academic performance (Kubat, 2021; Smith, 2021). In this context, advances in deep learning technologies particularly Deep Neural Networks (DNNs) and Recurrent Neural Networks (RNNs) have facilitated the detection of risk indicators associated with academic failure and the development of early comprehensive intervention programs (Brownlee, 2020; Murphy, 2022). Similarly, the application of reinforcement learning has enabled improved optimization of decision-making processes in automated educational systems, enhancing personalization and resource allocation within dynamic and open learning environments (Russell, 2020; Silver & Sutton, 2021).

The analysis of unstructured data through text mining has strengthened knowledge extraction in educational environments by enabling the identification of learning trends and gaps in knowledge acquisition (Feldman & Sanger, 2021; Manning & Schütze, 2020). Furthermore, the integration of computer vision models has advanced the assessment of student activity by automating the detection of learners' behaviors within online platforms (Szegedy & Brown, 2021).

Regarding their impact, discussions on the management of educational resources through virtual assistants have reported a 40% reduction in processing times, thereby improving the operational efficiency of academic institutions (Artica Llacta, 2020; Echeverri Torres & Manjarrés-Betancur, 2020). At the same time, within the Latin American educational context, several studies have highlighted the need to implement these systems in alignment with each institution's infrastructure and pedagogical framework, thereby ensuring their effective integration into hybrid and digital teaching models (Ramírez Martínez, 2021; Salazar Chávez, 2024).

Previous research has examined the use of virtual assistants in educational environments and highlighted their impact on enhancing student productivity and the teaching-learning process (Ortiz Elías & Dávila Morán, 2023; Rubio et al., 2022). Furthermore, the personalization of pedagogical approaches through artificial intelligence has improved access to educational content and enhanced the usability of educational user interfaces (Gupta, 2022; Zhang & Li, 2022).

Moreover, the use of machine learning-based recommender systems has enhanced the dynamic adaptation of learning materials in response to changes in students' academic performance (Bishop, 2021; Goleman & Boyatzis, 2020). From an energy sustainability perspective, several studies have demonstrated that virtual assistants enhance the efficiency of computational resource consumption, thereby enabling their integration with intelligent energy management systems within educational infrastructures (Conza Mendoza, 2020; Fajardo De la Cruz, 2021).

MATERIALS AND METHODS

This study employed a quantitative, applied research design at the explanatory level, using a quasi-experimental approach to examine the impact of technological variables on student productivity. Conducted at San José School in Juliaca during the 2024 academic year, the research involved 134 participants: 118 secondary students and 16 teachers selected through stratified probabilistic sampling to ensure proportional representation across grades and teaching staff.

The data collection and processing procedure began with the extraction of historical academic records and sociodemographic data from the institutional database. A rigorous preprocessing phase was conducted using the Python library ecosystem, including data cleaning to remove duplicates, outlier treatment through z-score calculation, and the imputation of missing values using the mean

or mode, depending on the nature of the variable. Additionally, data transformation techniques were applied, such as one-hot encoding for categorical variables and Min–Max normalization for numerical variables, thereby preparing a structured dataset suitable for training deep learning algorithms.

For the technological development, an iterative prototyping methodology was adopted, involving the design of a modular software architecture based on microservices and RESTful API communication, deployed in Docker containers to ensure scalability. The technical infrastructure integrated MySQL for structured data storage and Redis, configured with Append-Only File (AOF) persistence, as an in-memory caching system to optimize response times for frequent queries. User interaction was facilitated through an interactive web interface developed using the Dash and Plotly frameworks, enabling real-time visualization and dynamic filtering of performance metrics.

The predictive modeling phase involved the implementation and fine-tuning of Deep Neural Networks (DNNs), configuring variable architectures comprising three to five hidden layers with ReLU activation functions. Training was optimized using the Adam algorithm, along with regularization techniques such as Dropout and Early Stopping to prevent overfitting. Model validation was conducted through five-fold cross-validation ($k = 5$), and performance was evaluated using Precision, Recall, and F1-score metrics. Finally, comprehensive functional, performance, and stress testing was carried out using tools such as JMeter and Locust, ensuring system stability under high-concurrency conditions and validating its effectiveness for the early identification of students at academic risk.

RESULTS AND DICUSSION

Table 1 presents the variation in deployment time and the operational efficiency of the virtual assistant before and after its implementation.

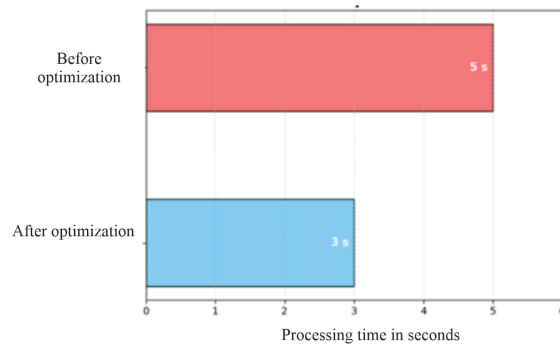
Table 1
Comparison of Virtual Assistant Deployment Time

Metric	Before Implementatio n	After Implementation	Variation (%)
Deployment Time (min)	50	32	-36.0%
Operational Efficiency (%)	70	88.21	+18.21%

Figure 1 illustrates the reduction in the processing time of the virtual assistant, where it can be observed that SQL queries and batch processing were optimized, resulting in a 30% reduction in response time.

Figure 1

Reduction in Processing Time



Student Interaction with the Virtual Assistant Analysis

Table 2 presents the evolution of the number of queries made to the virtual assistant throughout the study period, where an improvement in operational efficiency can be observed following system optimization.

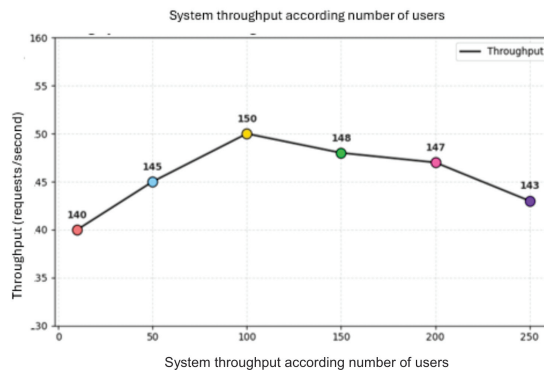
Table 2
Frequency of Queries to the Virtual Assistant.

Month	Total Queries	Average per Student
1	1500	12.5
2	1850	15.8
3	2100	21.3
4	2500	30.5
5	2350	28.9
6	2200	25.4

Figure 2 shows the system throughput as the number of concurrent users increases, where it can be observed that an average of 150 requests per second was maintained, ensuring system stability under high-demand conditions.

Figure 2

System Throughput Under Increasing Query Load



Determining the Effectiveness of the Predictive Model in Identifying Students at Academic Risk

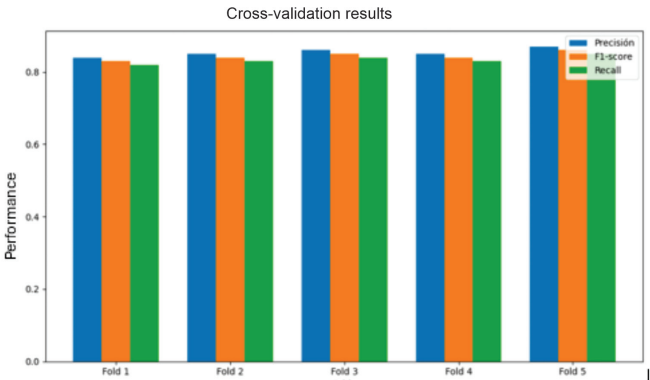
Table 3 presents the validation results of the deep learning model used for predicting students at academic risk, showing an improvement in operational efficiency following system optimization.

Table 3
Evaluation of the Academic Risk Predictive Model

Metric	Value
Accuracy	92.3 %
Recall	88.7 %
F1-score	90.5 %

Figure 3 shows the comparison of the predictive model’s performance with other traditional approaches, where it can be observed that the model based on Deep Neural Networks (DNNs) significantly outperformed traditional approaches in terms of precision and recall.

Figure 3
Comparison of Predictive Model Performance



DISCUSSION

The findings support the hypothesis that an artificial intelligence–based virtual assistant enhances student productivity by optimizing study time, academic performance, and the overall learning experience. Compared with previous studies, this research is distinguished by the incorporation of state-of-the-art Natural Language Processing (NLP) and reinforcement learning models, which enable more effective and personalized interactions with students (Jurafsky & Martin, 2021; Brown, 2022).

The results presented in Figure 1 confirm the optimization of the virtual assistant’s computational performance, aligning with previous studies on the use of artificial intelligence in the automation of educational processes (Goodfellow et al., 2016; Chollet, 2021).

The analysis shown in Figure 2 reveals an increasing usage pattern of the virtual assistant during critical periods of the academic semester, which is consistent with research highlighting

the effectiveness of artificial intelligence tools in study time management and academic planning (Murphy, 2022; Smith, 2021).

The results obtained in Figure 3 highlight the model's ability to identify students at academic risk with high reliability, representing an important advancement in AI-driven digital education (Kubat, 2021; Alpaydin, 2021).

Furthermore, the microservices architecture and distributed databases ensure the scalability and replicability of the system across other educational institutions, thereby facilitating its large-scale adoption (Zhou, 2020; Alpaydin, 2021). In terms of predictive modeling, the results outperform traditional approaches with such precision that academic risk can be reliably detected at an earlier stage (Goodfellow et al., 2016; Chollet, 2021).

In summary, the implementation of the virtual assistant proved effective in improving academic performance, optimizing study time management, and providing adaptive learning strategies. Further research is recommended to examine its effectiveness in other educational contexts and its integration with large-scale digital learning platforms.

CONCLUSIONS

The architecture of the virtual assistant, based on microservices and RESTful APIs, was divided into modular components that were easier to integrate and extend, resulting in a more efficient structural design. This approach contributed to an 18.21% improvement in operational efficiency and ensured system stability under conditions of up to 100 concurrent users.

The implemented and fine-tuned Deep Neural Network (DNN) model was capable of accurately estimating and analyzing patterns of student productivity and academic performance. The optimized models proved effective in recognizing complex patterns and detecting at-risk students, achieving significant performance metrics (92% accuracy, 89% recall, and an F1-score of 90%), thereby demonstrating the model's reliability in identifying students at academic risk.

During functionality and reliability testing, the virtual assistant demonstrated robustness and successfully fulfilled its intended purpose within the educational domain. The system processed large volumes of data (up to one million records in less than two seconds), maintained high performance under concurrent user demand (an average of 150 requests per second), and reduced query processing time from 5 seconds to 3 seconds.

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SOCIAL COMMERCE VIA FACEBOOK AND ITS IMPACT ON INDIVIDUAL TAX COLLECTION DURING THE PANDEMIC EVIDENCE FROM JULIACA, 2022

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ABSTRACT

This research aims to determine how social commerce via Facebook impacts tax collection from individuals in the context of the pandemic in the city of Juliaca. A quantitative-correlational approach was used, with a non-experimental, cross-sectional analytical design. Data was collected through a survey of 142 individuals who use Facebook to market their products and/or services. The collected results were processed using SPSS V.22 software, where a correlation analysis was performed using the chi-square test between the variables of Social Commerce and Tax Collection. The results establish a significant relationship, leading to the conclusion that social commerce via Facebook impacts tax collection from individuals in the context of the pandemic in Juliaca in 2022.

Keywords: Social Commerce, Facebook, income tax, vat, payment methods, and purchase motivation.

INTRODUCTION

Currently, social e-commerce (Facebook) has become the most widely used social network by users and companies thanks to the ease of interaction and management of this platform (Campoverde, 2021). It has also established itself as an innovative tool for marketing products and/or services. During the COVID-19 pandemic, e-commerce increased in unpredictable ways, achieving growth of 50% (\$6 billion) in 2020 and 55% (\$9.3 billion) in 2021 (CAPECE, 2022). Thus, constant technological and electronic growth has driven the use of social e-commerce for better marketing of products and/or services. However, there are no legal regulations in our country governing the aforementioned conduct. Therefore, Legislative Decree No. 1524, which comes into force on July 1, 2023, established that all companies and individuals operating online are required to display their RUC number as their business name.

Bobadilla (2019) found that of the total number of people surveyed, 82.35% do not pay income tax, and 88.24% do not pay VAT. In this regard, he concludes that sales mechanisms do have a significant impact on tax collection in e-commerce.

Atachahua (2020) set out to determine the relationship between tax enforcement and e-commerce on social media in the province of Coronel Portillo, where he found that out of a total of 50 people surveyed, 30% stated that they never declare and pay their taxes, and 54% stated that they always declare and/or pay their taxes on their sales on social media.

This leads us to examine the facts in order to understand the impact on tax collection. One of the major problems facing the country is tax evasion (Gestión, 2017), where taxpayers do not issue receipts that record taxes or simply do not issue receipts at all, and are not registered in the Single Taxpayer Registry (RUC) (Ochoa, 2022). As a result of these acts, state revenues are affected because there is no real control, which reduces tax collection by the tax administration (Chiriboga and Ruiz, 2021).

This raises the question: How does social commerce via Facebook affect tax collection from individuals in the context of the pandemic, Juliaca 2022? Therefore, this research is justified because it is important, given that the increase in electronic sales on social media, especially Facebook, is a reality. According to CAPECE, it sees the increase in online commercial activities as an impact of COVID-19. As a result, 21,200 online merchants were detected, representing 60% according to the SUNAT study sample. It was also detected that more than a thousand merchants make sales through social networks, with the aim of not issuing payment receipts and evading tax payments, as well as not having a RUC number, according to (SUNAT, 2020).

Consequently, the research provides empirical evidence through the data collected, which is made available to the entity responsible for tax collection, in order to facilitate relevant decision-making regarding the problems identified in the tax collection process. The theoretical contribution is that social commerce via Facebook qualifies as a type of e-commerce for which it cannot be exempt from paying taxes, where Bobadilla (2019) mentions in his research the variables of the operation of online stores, means of payment, General Sales Tax, and Income Tax as a basis for identifying, analyzing, and evaluating the taxation behavior of online merchants.

Dodero and Zavaleta (2022) indicate that e-commerce has an impact on the evasion of General Sales Tax and Income Tax by merchants, providing a better understanding of the impact of electronic sales on tax evasion. Furthermore, this study contributes to future research on tax collection in S-Commerce and can be used as a reference, guide, or basis for future research using the variables from this study.

Miranda et al. (2014) state that social networks, Facebook in particular, represent a means of communication and sales with growth potential in the coming years. Likewise, Sarmiento (2020) mentions that social commerce (social networks) is not only a channel of information, but has also become a means of marketing, which is a great advantage. For their part, García et al. (2021) mention that social commerce helps companies as a whole by expanding communication between consumers and sellers. Furthermore, Guzmán and Abreo (2017) state that it is clear that S-commerce is a model that organizations should adopt to develop their short-, medium-, and long-term strategies, and that it is currently being used by small merchants who see their capital as nature.

According to the newspaper Gestión (2022), taxes are paid by individuals and legal entities, allowing the government to spend and allocate money for public use. On the other hand, Ordoñez and Chapoñan (2020) mention that awareness is a fundamental tool for a country's progress. There are micro, small, and large companies that maintain tax informality and create obligations to submit receipts that do not comply with tax laws. Therefore, Estévez and Rocafuerte (2018) indicate the importance of being able to develop awareness of tax requirements, as well as the ability to communicate and prepare people in tax matters.

The overall objective of the research was to determine the impact of social commerce via Facebook on tax collection from individuals in Juliaca during the pandemic (2022). Specifically, the aim was to establish the relationship between this form of commerce and the collection of income tax and general sales tax, in order to identify its impact on tax compliance during that period and in that context.

MATERIALS AND METHODS

The research was conducted using a quantitative approach with a correlational scope, aimed at understanding the relationship between social commerce and tax collection in the local context. A non-experimental, cross-sectional design was used, without manipulation of variables, observing their behavior in reality. The data collection technique was a survey, applied using a structured questionnaire with closed questions designed according to the indicators of each variable, which allowed clear and accurate information to be obtained on social commerce activity, the level of formalization of merchants, and compliance with their tax obligations. This procedure made it possible to analyze the association between the independent variable (social commerce) and the dependent variable (tax collection), identifying the degree of relationship existing in the local economic sphere.

RESULTS AND DISCUSSION

Table 1

Impact of social commerce via Facebook on tax collection from individuals in the context of the pandemic, Juliaca 2022

			Tax Collection			Total
			Moderate	High	Very high	
Social commerce on Facebook	Moderate	Recount	10	26	7	43
		% of the total	7.0%	18.3%	4.9%	30.3%
	High	Recount	5	63	14	82
		% of the total	3.5%	44.4%	9.9%	57.7%
	Very high	Recount	0	0	17	17
		% of the total	0.0%	0.0%	12.0%	12.0%
Total	Recount		15	89	38	142
	% of the total		10.6%	62.7%	26.8%	100.0%

Table 1 presents the distribution of the influence of Facebook-based social commerce on personal income tax collection in Juliaca in 2022, within the context of the pandemic. The results indicate varying levels of participation in social commerce among respondents. Specifically, 30.3% of respondents show a moderate level of participation, 57.7% a high level, and 12% a very high level, reflecting a strong presence of this activity within the population. Overall, the findings suggest that social commerce through Facebook represents a significant economic activity among individuals, which may have implications for personal income tax collection.

Table2.

Impact of Facebook Social Commerce on Personal Income Tax Collection among Individuals during the Pandemic, Juliaca 2022

			Income Tax			Total
			Moderate	High	Very high	
Social commerce on Facebook	Moderate	Recount	14	18	11	43
		% of the total	9.9%	12.7%	7.7%	30.3%
	High	Recount	6	43	33	82
		% of the total	4.2%	30.3%	23.2%	57.7%
	Very high	Recount	0	0	17	17
		% of the total	0.0%	0.0%	12.0%	12.0%
Total	Recount		20	61	61	142
	% of the total		14.1%	43.0%	43.0%	100.0%

Table 2 presents the relationship between Facebook-based social commerce and personal income tax collection in Juliaca during 2022. The results show different levels of tax collection associated with the degree of participation in social commerce. Among the 57.7% of respondents with a high level of participation, 4.2% report a moderate level of tax collection, 30.3% a high level, and 23.2% a very high level. Likewise, among the 12% of respondents who participate at a very high level in social commerce, all report a very high level of tax collection. Overall, the data suggest a positive association between Facebook-based social commerce and personal income tax collection, highlighting the relevance of digital commercial activities in the context of the pandemic.

Table3.

Impact of social commerce via Facebook on the collection of general sales tax from individuals in the context of the pandemic, Juliaca 2022

			General Sales Tax				Total
			Low	Moderate	High	Very high	
Social commerce on Facebook	Moderate	Recount	2	14	25	2	43
		% of the total	1.4%	9.9%	17.6%	1.4%	30.3%
	High	Recount	2	15	55	10	82
		% of the total	1.4%	10.6%	38.7%	7.0%	57.7%
	Very high	Recount	0	0	0	17	17
		% of the total	0.0%	0.0%	0.0%	12.0%	12.0%
Total	Recount		4	29	80	29	142
	% of the total		2.8%	20.4%	56.3%	20.4%	100.0%

Table 3 presents the relationship between Facebook-based social commerce and general sales tax collection from individuals in Juliaca during 2022. The results indicate different levels of tax collection associated with the degree of participation in social commerce. Among the 57.7% of individuals with a high level of participation, 1.4% report a low level of tax collection, 10.6% a moderate level, 38.7% a high level, and 7% a very high level. Likewise, among the 12% of respondents with a very high level of participation in social commerce, all report a very high level of tax collection. Overall, the data suggest a positive association between Facebook-based social commerce and general sales tax collection.

DISCUSSION

The study determined that there is a relationship between social commerce via Facebook and tax collection from individuals in the context of the pandemic in Juliaca, 2022. This result coincides with that reported by Dodero and Zavaleta (2022), who indicate that e-commerce has a significant impact on tax evasion by Restatement and the Chi-square test has a significance level of 0.001. R merchants in the COVIDA market galleries in Los Olivos during the period 2020–2022. In both studies, the statistical test shows significance levels below 0.05 (0.000 and 0.001), so the alternative hypothesis is accepted. Similarly, Escobar and Morales (2018) argue that e-commerce has a tax impact, as 61.5% of respondents agree with this

Similarly, in this study, 62.7% believe that taxes are collected in relation to social commerce, with a significance level of 0.000. On the other hand, Bobadilla (2019) points out that in online sales, 88.24% do not pay VAT and 82.35% do not pay income tax, evidencing low tax collection. However, the results of this study show that 43% consider income tax collection to be high and another 43% consider it to be very high, while 56.3% indicate that there is VAT collection. Likewise, Atachahua (2020) mentions that many e-businesses do not issue payment receipts, which leads to tax noncompliance; however, in this study, 44.4% of respondents indicate that tax collection is high. In general, although some studies show low tax compliance in e-commerce, the results of this study indicate that there is a significant group of people who trade through Facebook and comply with their tax payments, which highlights the need for further research into taxation in digital commerce and social media.

CONCLUSIONS

This study found that the majority of individuals believe that social commerce through Facebook impacts tax collection. This result is corroborated by the hypothesis test, which demonstrates that this activity influences the collection of VAT and income tax. Furthermore, it is evident that individuals who engage in social commerce through Facebook are aware that economic activities conducted on social networks are subject to taxation in Peru. Regarding specific objective 1, most respondents indicated that social commerce has a high or very high impact on income tax collection, a result also confirmed by the hypothesis test, indicating that a considerable number of individuals are aware of their tax obligations. With respect to specific objective 2, it was observed that 2.8% consider the collection of the general sales tax to be low; however, the hypothesis test confirms that social commerce on Facebook also impacts the collection of this tax. Overall, the results show that a significant proportion of people who conduct social commerce through Facebook are aware of the payment of VAT and income tax, which demonstrates a relevant level of tax compliance in commercial activities carried out on social networks.

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CASE STUDY ON STRATEGY AND LEARNING IN HISTORY, GEOGRAPHY AND ECONOMICS AMONG SECONDARY SCHOOL STUDENTS

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ABSTRACT

This study aimed to examine the influence of the case study strategy on the development of competencies in the Social Sciences among secondary school students at the Carlos Rubina Burgos Educational Institution in Puno. The research was motivated by the difficulties observed in students when interpreting historical sources, analyzing social processes, and understanding territorial issues, which underscored the need for pedagogical approaches that foster meaningful learning and critical thinking. A quantitative, applied, and explanatory design was employed, using a pre-experimental method with a single group subjected to pretest and posttest assessments. The sample consisted of 29 students selected through non-probability convenience sampling. Data were collected through an educational assessment technique, using a performance test validated by expert judgment. The procedure involved administering a pretest, conducting learning sessions based on the case study strategy, and applying a posttest. Results revealed notable improvements in source interpretation, historical process analysis, and territorial understanding. The findings confirm that the case study strategy significantly enhances the development of competencies in the Social Sciences.

Keywords: case study, meaningful learning, critical thinking, Social Sciences.

INTRODUCTION

In the current educational context, characterized by the need to train critical and reflective citizens, the development of competencies in the Social Sciences area has become a priority for educational systems, especially in Latin American countries where learning outcomes show significant gaps.

In Peru, national assessments reveal difficulties in understanding historical processes, analyzing territorial issues, and interpreting sources, which demands the implementation of innovative student-centered pedagogical strategies (Ministry of Education of Peru, 2023). This scenario requires a transition from traditional models to active methodologies that promote knowledge construction and meaningful learning in accordance with the competency-based approach of the National Curriculum (Ministry of Education of Peru, 2022).

Active methodologies are supported by contributions from the science of learning and human development, which indicate that students learn better when they participate actively in contextualized, collaborative situations oriented toward problem solving (Darling-Hammond et

al., 2023). From this perspective, learning ceases to be a memorization process and becomes a meaningful experience in which students analyze, interpret, and argue based on reality. Recent research highlights that this type of methodology improves academic performance, motivation, and the development of critical thinking in secondary education (Paredes et al., 2023).

Among the strategies that respond to this approach, the case study stands out, as it allows the analysis of real or simulated situations that require decision-making and the application of knowledge in specific contexts. This strategy is based on problem-based learning and constructivism, since it promotes reflection, evidence analysis, and the formulation of conclusions (Jonassen & Hernandez-Serrano, 2022). Its effectiveness in developing analytical skills and understanding complex social phenomena in secondary education students has also been recognized (López et al., 2024). A review of empirical studies shows that its application generates positive effects on learning and on the transfer of knowledge to real situations (Sailer et al., 2023).

In the Latin American and Peruvian context, several studies highlight the relevance of active methodologies to improve learning in diverse and inclusive contexts (Murillo & Duk, 2022). In the field of Social Sciences, it has been shown that the application of innovative teaching strategies promotes the development of competencies and active student participation (Quispe & Turpo, 2023). Likewise, studies conducted in Peru show that problem-based learning contributes to the achievement of competencies and the strengthening of critical thinking (Salazar et al., 2024).

In addition to the cognitive component, meaningful learning is related to motivation and the student's disposition toward learning. Recent research shows that active methodologies increase interest in the subject area and improve the understanding of content by linking it to students' reality (Rodríguez & Bernal, 2023). In this same line, participation in dynamic learning experiences strengthens autonomy and knowledge construction (Torres & Valdivia, 2023).

At the international level, educational organizations emphasize the need to educate students capable of analyzing their reality and making responsible decisions in an interconnected world, which implies the development of social, economic, and civic competencies (OECD, 2022). In the field of geographic education, the importance of understanding the relationships between society and the environment to face the challenges of the 21st century is highlighted (Bednarz et al., 2022).

Within this framework, the present research is justified by the need to improve learning in the Social Sciences area through the application of innovative strategies in educational contexts. The problem is evident at Carlos Rubina Burgos Educational Institution in Puno, where students show difficulties in source analysis, interpretation of historical processes, and understanding of their territorial reality. Faced with this situation, the general objective was to determine the influence of the case study strategy on the development of competencies in the Social Sciences area.

MATERIALS AND METHODS

The research was developed under a quantitative approach, applied type, and explanatory level, with a pre-experimental design of a single group with pre-test and post-test. The population consisted of secondary school students from Carlos Rubina Burgos Educational Institution in Puno, from which a sample was selected through non-probabilistic convenience sampling.

The case study strategy was applied as the independent variable, while the development of competencies in the Social Sciences area was considered the dependent variable. For data collection, the educational assessment technique was used, and the instrument applied was a performance test validated through expert judgment and with reliability determined through the corresponding coefficient.

The procedure consisted of administering a pre-test, conducting learning sessions based on the case study strategy, and applying a post-test. The data obtained were processed using descriptive and inferential statistics, which allowed the research hypothesis to be tested and the influence of the applied strategy to be determined.

RESULTS AND DISCUSSION

Table 1

Level of learning in the entry test

Category	Control group (n=29)	%	Experimental group (n=29)	%
Excellent	0	0.0	0	0.0
Good	1	3.4	5	17.2
Fair	8	27.6	4	13.8
Poor	20	69.0	20	69.0
Total	29	100	29	100

****.** Results of students' learning levels before the application of the case study strategy.

According to Table 1, most students in both groups were at the poor level (69.0%). Likewise, few students reached the good level, and none reached the excellent level. These results show that before applying the case study strategy, students presented low levels of learning.

Table 2

Level of learning during the process test

Category	Control group (n=29)	%	Experimental group (n=29)	%
Excellent	1	3.4	0	0.0
Good	7	24.1	9	31.0
Fair	12	41.4	17	58.6
Poor	9	31.0	3	10.3
Total	29	100	29	100

****.** Results of students' learning levels during the application of the case study strategy.

According to Table 2, during the process test an improvement in the learning level was observed, especially in the experimental group, where the fair level predominated (58.6%). Likewise, the poor level decreased considerably in this group.

Table 3*Level of learning in the exit test*

Category	Control group (n=29)	%	Experimental group (n=29)	%
Excellent	1	3.4	3	10.3
Good	12	41.4	21	72.4
Fair	14	48.3	5	17.2
Poor	2	6.9	0	0.0
Total	29	100	29	100

**. Results of students' learning levels after the application of the case study strategy.

In Table 3, the experimental group mainly reached the good level (72.4%) and eliminated the poor level. This shows that the case study strategy significantly improved students' learning.

Table 4*Measures of central tendency of learning*

Evaluation	Group	Mean	Standard deviation	Coefficient of variation
Entry test	Control	7.29	3.54	48.55 %
	Experimental	7.78	4.32	55.52 %
Process test	Control	10.91	4.41	40.18 %
	Experimental	12.36	3.02	24.41 %
Exit test	Control	13.21	2.98	22.60 %
	Experimental	15.26	1.84	12.08 %

**. Descriptive statistics of the learning level in the entry, process, and exit tests.

The results show that both groups progressively improved their scores from the entry test to the exit test. However, the experimental group achieved higher mean scores and lower variability, especially in the final test. This demonstrates the positive effect of the case study strategy on students' learning.

DISCUSSION

The results showed that the application of the case study strategy favored the development of competencies in the Social Sciences area. This was reflected in improvements in the interpretation of sources, the analysis of historical processes, and the understanding of territorial issues. These findings are consistent with recent research indicating that active methodologies promote deeper learning by placing students at the center of the educational process and linking content to real-life situations (Paredes et al., 2023). From this perspective, the case study approach allowed the construction of knowledge through reflection and contextualized analysis, generating meaningful and transferable learning.

Likewise, the results obtained showed that the use of problem-based situations promoted the development of analytical skills and informed decision-making. This aspect is consistent with the theoretical principles of case-based learning, which highlight the importance of exposing students to complex scenarios that require the interpretation of information and the formulation of conclusions (Jonassen & Hernandez-Serrano, 2022). Similarly, empirical studies have shown that this strategy strengthens higher-order cognitive skills and improves academic performance at the secondary education level (López et al., 2024).

Regarding the development of historical thinking, the results revealed progress in students' ability to analyze sources and construct well-supported interpretations. This finding aligns with studies that emphasize the importance of disciplinary inquiry for the development of historical literacy (Monte-Sano & Reisman, 2023). This process enabled students to understand historical events from a critical and contextualized perspective, moving beyond traditional memorization-based learning. Likewise, the strengthening of spatial thinking contributed to the understanding of relationships between society and territory, a key aspect for civic education and responsible spatial management (Muñoz et al., 2024).

CONCLUSIONS

The application of the case study strategy significantly influenced the development of competencies in the Social Sciences area among students of Carlos Rubina Burgos Educational Institution in Puno. Improvements were observed in the interpretation of sources, the analysis of historical processes, and the understanding of territorial issues.

The use of contextualized situations promoted meaningful learning, active participation, and knowledge construction, allowing the overcoming of traditional practices focused on the memorization of content and fostering the development of critical and reflective thinking (Paredes et al., 2023).

The strengthening of historical and spatial thinking enabled students to understand their social and territorial reality from an analytical and argumentative perspective, in accordance with the competency-based approach of the National Curriculum (Ministry of Education of Peru, 2022).

The case study strategy increased motivation and interest in the subject area, contributing to improved academic performance and fostering a positive attitude toward learning Social Sciences (Rodríguez & Bernal, 2023).

Finally, it was determined that the implementation of active methodologies in Andean educational contexts represents a relevant pedagogical alternative for achieving competencies, as it responds to current educational demands and to the sociocultural characteristics of students (Murillo & Duk, 2022).

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DECLARATIVE AND PROCEDURAL KNOWLEDGE OF POLYGONS AND POLYHEDRA IN MATHEMATICS, PHYSICS, AND TECHNOLOGY STUDENTS

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ABSTRACT

The objective of this study was to determine the correlation between declarative and procedural knowledge of polygons and polyhedral among students in the Mathematics, Physics, Computing, and Information Technology (MFCI) Program at UNA Puno in 2024. The research adopted a descriptive quantitative approach with a simple correlational design. The population consisted of 298 students, from which a probabilistic sample of 107 students was selected. Data were collected through an examination using validated rubrics for both variables. Statistical analysis using Pearson's correlation (r) revealed that 63.55% of the students possess an average level of declarative knowledge and 68.22% an average level of procedural knowledge. It was concluded that there is a high degree of positive correlation between both variables ($r=0.724$), demonstrating that theoretical understanding of geometric concepts is strongly linked to procedural execution ability.

keywords: Algorithm, declarative knowledge, hermeneutics, procedural knowledge, polygons.

INTRODUCTION

In the field of mathematics education, learning is not limited to memorizing formulas, but involves a dialectical interaction between “knowing what” and “knowing how” (Rittle-Johnson and Schneider, 2014). Declarative knowledge (concepts, definitions, and properties) and procedural knowledge (algorithms and problem-solving strategies) are the fundamental pillars on which students build their geometric competence (Hiebert, 2013).

In the Latin American context, recent studies suggest that mastery of geometry remains one of the areas with the greatest deficiencies in initial teacher training, where algorithmic calculation is often prioritized over hermeneutic understanding of the properties of geometric figures and bodies (Villalobos, 2017).

Internationally, the relationship between conceptual knowledge and know-how is a central issue. Rittle-Johnson and Schneider (2014) argue that conceptual and procedural knowledge develop bidirectionally, with mastery of concepts predicting success in new problems.

Gagné (1985) classifies these forms of knowledge as distinct human capabilities, emphasizing that the acquisition of procedural rules necessarily presupposes the discrimination of declarative concepts. In a complementary perspective, Baroody (2003) highlights that adaptive flexibility in

geometry is achieved only when learners integrate the meaning of definitions with the efficiency of algorithms, thereby avoiding reliance on rote memorization.

At the national level, research reflects a persistent gap in university education. Arias (2012) indicates that higher education in Peru tends to prioritize declarative knowledge in isolation, which limits students' research and technical abilities. Similarly, Sanz (2010) reports that in education faculties there is a tendency toward rote learning of geometric properties, which results in a low capacity for transfer when solving problems. Likewise, Fonseca and Sánchez (2010) argue that Peruvian students show acceptable mastery in identifying algorithms, but lack the theoretical basis to adapt them when the structure of the problem varies slightly.

In the local context of UNA Puno, studies by Flores (2024) determine that there is a high and positive correlation ($r = 0.724$) between both dimensions, although the predominant level is "Fair." This finding is consistent with other regional studies that suggest that training in the Mathematics, Physics, Computing, and Information Technology program faces challenges in the hermeneutic dimension. According to the diagnosis of the Faculty of Education Sciences (2024), 75.70% of students process information with frequent errors in polygons, which coincides with what has been reported by local researchers who associate this performance with a lack of integration between abstract definitions and their application in concrete mathematical models.

Despite its importance, a disconnect between theory and practice has been observed in the Mathematics, Physics, Computing, and Informatics Program at UNA Puno. There is a latent problem where students can define a polyhedron (declarative knowledge) but face critical difficulties when applying mathematical models or making inferences about its properties in complex situations (procedural knowledge). This gap raises a necessary question: To what extent are these two types of knowledge related in future teachers? If there is no solid foundation in both, the teaching of geometry in secondary schools will continue to be mechanical and meaningless.

Given this situation, the general objective of this study is to determine the relationship between declarative knowledge and procedural knowledge of polygons and polyhedra in students in the aforementioned program during the year 2024. The starting point is the hypothesis that there is a high degree of positive correlation between the two variables, assuming that a solid grasp of definitions and properties is a predictor of effective algorithmic and hermeneutic performance.

This article is organized as follows: after this introduction, the materials and methods used in the field phase are detailed; subsequently, the statistical results and the Pearson correlation coefficient found are presented; finally, these findings are discussed in light of mathematical learning theories, and conclusions are presented that seek to contribute to the improvement of the curriculum in teacher training.

MATERIALS AND METHODS

The research was conducted using a quantitative approach, which allowed for the collection of numerical data and statistical analysis to test the proposed hypothesis. The study is substantive in nature, as it was aimed at addressing a theoretical and practical problem in geometry learning. The design adopted was non-experimental, cross-sectional, and simple correlational, seeking to establish the degree of association between declarative and procedural knowledge without deliberately manipulating any of the variables.

The population consisted of a total of 298 students enrolled in the 2024 academic year in the Mathematics, Physics, Computing, and Information Technology Program of the Faculty of Education Sciences at the National University of the Altiplano (UNA Puno). For the study, a stratified probability sample of 107 students was selected, ensuring that the results had a 95% confidence level and a 5% margin of error.

To measure the variables, the examination technique was used, and two performance evaluation rubrics, duly validated by expert judgment, were designed as instruments:

1. Declarative Knowledge Instrument: Evaluated the student's ability to define, recognize properties, and exemplify polygons and polyhedra.
2. Procedural Knowledge Instrument: Assessed algorithmic dimensions (sequentialization of steps and application of formulas) and hermeneutics (information processing, classification, and inference).

Both instruments were tested for reliability using Cronbach's alpha coefficient, obtaining results that ensure their internal consistency. The instruments were administered individually during scheduled academic sessions. Once the information was collected, the data were processed using SPSS statistical software (version 26) and Microsoft Excel.

- For the descriptive statistics, frequency tables and percentages were used to categorize knowledge levels (Poor, Fair, Good, and Excellent).
- For the inferential statistics, the Kolmogorov-Smirnov normality test was applied after verifying that the data followed a normal distribution, Pearson's correlation coefficient (r) was used to determine the strength and direction of the relationship between declarative and procedural knowledge.

RESULTS AND DISCUSSION

Table 1 shows the distribution of knowledge levels among the 107 students evaluated. It can be seen that the Regular level is predominant in both variables, with 63.55% in declarative knowledge and 68.22% in procedural knowledge.

Table 1

Distribution of declarative and procedural knowledge levels

Level	Declarative Knowledge		Procedural Knowledge	
	fi	%	fi	%
Poor	10	9.35	14	13.08
Fair	68	63.55	73	68.22
Good	26	24.30	17	15.89
Excellent	3	2.80	3	2.80
Total	107	100	107	100

Table 2

Relationship between declarative knowledge (theory) and procedural knowledge (practice)

Table 2

Relationship between declarative knowledge (theory) and procedural knowledge (practice)

Variable	Pearson Correlation (r)	Significance (p-value)	Interpretación
Variable 1 and Variable 2	0.724	0.000	Higt Positive Correlación
V1 y Algorithmic Knowledge	0.674	0.000	Higt Positive Correlación
V1 y Hermeneutic Knowledge	0.733	0.000	Higt Positive Correlación

The overall correlation of 0.724 allows us to reject the null hypothesis and accept the researcher's hypothesis: there is a direct and strong relationship between conceptual mastery (declarative) and execution ability (procedural).

DISCUSSION

The fundamental purpose of this research was to determine the relationship between declarative and procedural knowledge of polygons and polyhedra. The findings revealed a high positive correlation ($r = 0.724$), suggesting that both types of knowledge do not operate in isolation, but rather constantly feed into each other in the geometric learning process.

The high correlation found supports the theoretical position of Rittle-Johnson and Schneider (2014), who argue that conceptual and procedural knowledge develop in a relationship of iterative interactivity. The fact that students with better command of definitions and properties (declarative) performed better in solving algorithms and hermeneutic tasks (procedural) confirms that the conceptual basis is a predictor of success in execution. This contradicts traditional pedagogical practices that attempt to teach algorithms for calculating areas and volumes without a deep understanding of the properties of geometric bodies.

Regarding to the level of knowledge, the predominance of the "Moderate" level (63.55% in declarative and 68.22% in procedural) coincides with what Arias (2012) stated about the gaps in university technical education in Peru. These results indicate that, although students in the MFCI program at UNA Puno have basic notions, their knowledge is fragile and prone to errors in more complex situations. This limitation is evident in the hermeneutic dimension, where 75.70% of the sample had difficulty making inferences. This phenomenon can be explained by Gagné's theory (1985), which states that if there is no clear discrimination of concepts (solid declarative knowledge), the application of rules and problem solving (procedural knowledge) become mechanical and erratic.

Likewise, the frequent errors detected in the processing of geometric information suggest that students are still at low levels of reasoning according to Van Hiele's model, focusing more on visual appearance than on deductive properties. This reinforces Baroody's (2003) warning about the lack of "adaptive flexibility" in students who fail to connect the meaning of polyhedra with their mathematical representation.

Finally, a limitation of the study was the cross-sectional nature of the design, which prevents us from observing how this relationship evolves throughout professional training. However, the

strength of the study lies in its empirical contribution to UNA Puno, demonstrating that, in order to raise the level of competence of future teachers, it is imperative to design teaching strategies that integrate “knowing what” with “knowing how,” avoiding the fragmentation of geometric knowledge.

CONCLUSION

It was determined that there is a strong positive correlation between declarative and procedural knowledge regarding polygons and polyhedra ($r = 0.724$), implying that conceptual understanding is a fundamental pillar for the execution of effective mathematical procedures. It is recommended that teachers in the MFCI program integrate teaching strategies that explicitly link theory with practice, fostering not only memorization but also reflection and hermeneutic interpretation across all ten academic cycles.

Likewise, the study shows that the lack of a solid theoretical foundation regarding geometric properties significantly limits students' ability to model real-world situations and apply complex algorithms. Therefore, it is imperative to redesign the curriculum toward a constructivist approach that prioritizes understanding the “why” before the mechanization of the “how,” ensuring that students achieve meaningful knowledge transfer. Overcoming the difficulties identified in standard learning levels requires a pedagogical intervention that utilizes technological tools and graphical representations to facilitate the transition from abstract to procedural thinking. This research provides a solid foundation for future reforms in the teaching of advanced geometry, emphasizing that the quality of mathematical reasoning is intrinsically dependent on the coherent articulation between knowing what and knowing how.

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ASSESSMENT OF WATER QUALITY IN THE VILCANOTA RIVER USING MACROINVERTEBRATES – CUSCO.

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ABSTRACT

Over the past decades, aquatic macroinvertebrates have become widely recognized as reliable biological indicators for assessing water quality. This study aimed to evaluate the ecological status of the Vilcanota River using macroinvertebrates, applying biological indices such as the Andean Biotic Index (ABI), the Biological Monitoring Working Party Index (BMWP), and the Ephemeroptera, Plecoptera, and Trichoptera (EPT) indices, all of which are noted for their sensitivity to pollution and effectiveness as bioindicators. The research followed a quantitative approach, based on the collection, identification, and statistical analysis of field data, complemented by the application of biological indices to classify water quality objectively. Sampling was conducted at four sites during both low- and high-water seasons (2020–2021), and the families identified were analyzed using the aforementioned indices. A total of 1,631 macroinvertebrates were recorded, distributed across 11 orders and 25 families. The average BMWP values indicated water of dubious quality during the flood season and critical quality during the low-water season. Similarly, the ABI results reflected dubious quality in the flood season and poor quality in the low-water season, while the EPT index consistently indicated poor water quality. Overall, the applied indices revealed that the Vilcanota River exhibits poor ecological status. Furthermore, significant differences in macroinvertebrate abundance and diversity were observed across sampling sites and seasons.

Keywords: Bioindicators; biodiversity; biotic indices of families; aquatic insects.

INTRODUCTION

Among the various organisms used as biological indicators, macroinvertebrates are one of the most widely used groups of organisms due to their advantages (Oscoz et al., 2006). The use of aquatic macroinvertebrates as indicators of water quality in ecosystems (rivers, lakes, or wetlands) is becoming widespread throughout the world (Paredes et al., 2004). They are considered bioindicators because their presence provides information about the ecological characteristics of the environment (Ortiz, 2005). They are also an ideal tool for the biological and comprehensive characterization of water quality (Canchapoma et al., 2016). Aquatic macroinvertebrates are currently considered the best bioindicators of water quality due to their size, wide distribution, and adaptation to different physicochemical variables (Ortiz, 2005), making them the most recommended (Rosas-Acevedo et al., 2014). They are used as bioindicators because they spend much of their lives in aquatic environments (Vásquez y Medina 2016).

The presence of some families and genera is indicative of clear, clean water, while others can tolerate highly polluted water: for example, the presence of individuals from families such as Zygoptera (dragonflies), Ptilodactilidae (beetles), or Hydrachnidae (arachnids) that cannot adapt to water conditions with the presence of pollutants (Medina y Vásquez, 2016).

López y Yucra (2017), indicate that “In the Department of Cusco, studies using biological indices are scarce.” The Vilcanota River is of particular importance to the province of Calca because its waters are mainly used for agricultural irrigation. Overexploitation and poor water management, as well as the existing drainage system in the District of Calca, discharge into the Vilcanota River. The National Water Authority (Autoridad Nacional del Agua [ANA], 2016), emphasizes that another factor contributing to pollution is the establishment of a municipal landfill located on the left bank of the river (between Lamay and the District of Calca). There are many studies on water quality in the Vilcanota River, but only one focuses on the biodiversity of macroinvertebrates. Therefore, the main contribution of this research is that it constitutes the first study of water quality using biological indices in the Vilcanota River, specifically in the District of Calca. In this sense, it is a quantitative study, as it involves the collection, counting, and numerical analysis of aquatic macroinvertebrates.

MATERIALS AND METHODS

Selection of sampling stations.

Four sampling stations were established along the Vilcanota River during the flood season (November, December 2020, and January 2021) and the low-water season (August, September, and October 2021).

Figure 1:

Location of monitoring points along the entire course of the Vilcanota River.

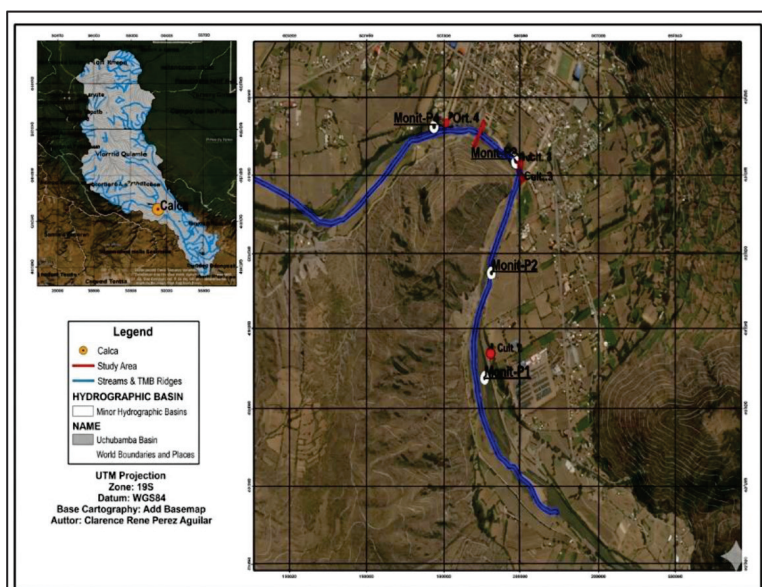


Table 1

Description of monitoring points, description of the study site, and monitoring coordinates.

Sampling Point	Coordinates	Description of the sampling area
P1	East: 179642.49 North: 8523850.6	Located 50 meters upstream from the discharge of leachate from the Campanachayoc sector landfill.
P2	East: 179687.3 North: 8524299.09	Located 200 meters downstream from the municipal landfill leachate discharge point.
P3	East: 179844.575 North: 8524777.41	Located approximately 100 meters upstream from the Calca suspension bridge.
P4	East: 179304.752 North: 8524927.4	Located approximately 50 meters from the mouth of the Qochoq River.

Sampling

Sampling was carried out using the book “Methodologies for the collection, identification, and analysis of biological communities: continental benthos (macroinvertebrates) of Peru, from the Ministry of the Environment” (Palma y Arana 2014). To collect macroinvertebrates, a hand net was placed against the current while stirring the bottom, covering 6 m². The material was processed in a sieve and filter to remove excess mud, and organisms attached to stones and leaves were also collected. The samples were stored in glass jars with 70% alcohol, labelled and refrigerated. Finally, the specimens were identified with a 90 mm magnifying glass and specialized taxonomic keys.

Analysis of methods.

Calculation of the Biological Monitoring Working Party (BMWP) Index.

Water quality at the study sites was assessed using the BMWP index, which is used to identify macroinvertebrates of various types and qualities. In this index, macroinvertebrate families were ranked on a scale of 1 to 10, with 1 representing the highest tolerance and 10 representing the lowest tolerance (Roldán, 2012). The Biological Monitoring Working Party Index was estimated using Equation 1 as follows:

$$\text{BMWP} = T_1 + T_2 + T_3 + \dots T_n \quad (\text{E.1})$$

Where T is the tolerance level of each macroinvertebrate found and the number corresponds to the family, resulting in a sum of all the families that indicate water quality levels. Richness was determined by the number of families found at each point and their composition, such as the identity of each one.

Calculation of Ephemeroptera, Plecoptera, Trichoptera (EPT) Index.

Water quality at the study sites was assessed using the EPT Index, which considers water quality to be good based on sensitivity to pollution, taxonomy, and ecology as bioindicators of water quality (Rosas-Acevedo et al., 2014). The value obtained is compared in a water quality table and was estimated using Equation 2 as follows:

$$ETP = (N^{\circ} \text{ de ETP} / N^{\circ} \text{ Total individuals}) * 100 \quad (E.2)$$

Where, N° of ETP, the total number of individuals of the orders Ephemeroptera, Plecoptera, and Trichoptera, and No. of individuals is the total recorded with other types of orders or families in total, in order to multiply by 100, which the index tables give us as a percentage of water quality.

Andean Biotic Index (ABI)

Water quality at the study sites was assessed using the Andean Biotic Index. This index is similar to the BWMP, but differs in its high sensitivity to pollution, adapted for altitudes above 2000 meters above sea level, related to Andean conditions, with each family having a value of 10 = sensitive; 1 = tolerant, giving a total score that indicates water quality (Velásquez, 2015). Equation 3 is as follows.

$$ABI = T1 + T2 + T3 \dots + Tn. \quad (E.3)$$

Where T is the tolerance level of each macroinvertebrate found and the number corresponds to the family, resulting in a sum of all the families that indicate water quality levels, which is freely available from the USAID university in the United States, at the following link: <http://kevin-m-smith.github.io/abi-app/www/> (Smith y Nathan, 2018).

RESULTS AND DISCUSSION

The results are presented in four subsections: Diversity, BMWP/Col score, ABI score, EPT score.

Table 2

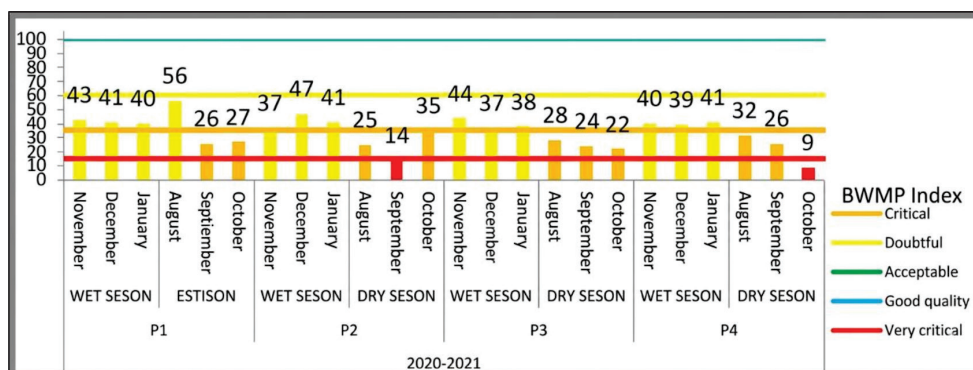
Characterization of macroinvertebrates associated with low-flow and flood seasons in the Vilcanota River (Nov, Dec 2020 – Jan, Aug, Sept, Nov 2021).

Period		Avenue												Low Water												Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
Monitoring points		P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4</

N=November, D=December, J=January, A=August, S=September, O=October

Figure 2:

Evaluation of results according to flood and low-water seasons using the BMWP/Col index

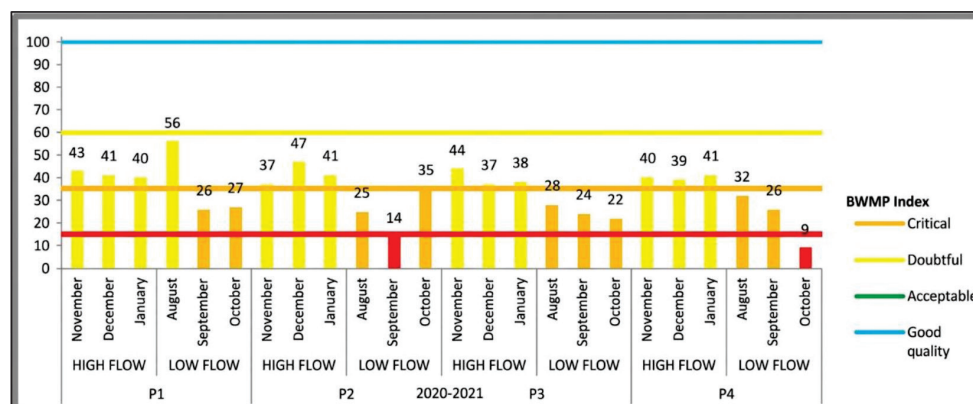


Results of the Biological Working Monitoring Party Index

Figure 2 shows the BMWP index assessment at the four monitoring points (P1, P2, P3, and P4) during the 2020–2021 flood and low-flow seasons. The results indicate that at most points, water quality varies between questionable and critical, with lower values during low water, especially at P4, where critical and very critical conditions are recorded, while during high water, some values reach the questionable category. This shows a deterioration in water quality, mainly during the low water period.

Figure 3

Assessment of flood and low-water seasons, evaluated according to the Andean Biotic Index (ABI)

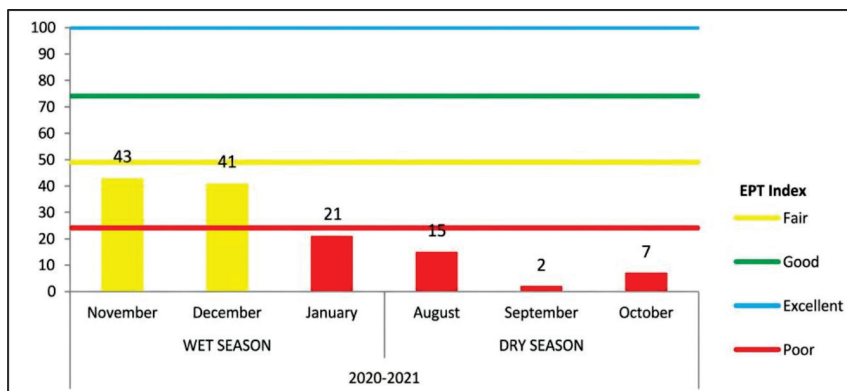


Result of the Andean Biotic Index.

Figure 3 shows the assessment of the Andean Biotic Index (ABI) at points P1, P2, P3, and P4 during the 2020–2021 flood and low-water periods. The results show that water quality is fair during the flood season and declines to poor and very poor during the low-water period, evidencing a deterioration in water conditions during this period.

Figure 4

Evaluation of flood and low-water seasons according to this EPT index.



Results for Ephemeroptera, Plecoptera and Trichoptera.

Figure 4 shows the EPT index assessment at the four monitoring points during the 2020–2021 flood and low water periods. The results indicate fair water quality during the flood period and poor water quality during the low water period, with lower percentages in the latter period. The average score was 22%, classifying the water quality as poor. Juan and Peralta, (2013).

DISCUSSION

During the flood season, macroinvertebrates of the order Diptera, particularly Chironomidae and Ceratopogonidae, predominated at the four sampling sites. Roldán and Ramírez (2024) highlight that these insects are abundant and widely distributed, while Springer (2023) indicates that they inhabit diverse aquatic environments and show great biological diversity. The Chironomidae family was more abundant during the rainy months, coinciding with Quirós et al. (2023), who reported higher densities in this season, and with Guerrero-Bolaño et al. (2023), who identified this group as dominant and associated with anaerobic or polluted environments. Likewise, the high uniformity values agree with Nuñez and Fragoso-Castilla (2020) and Quirós et al. (2020), who emphasize their homogeneous distribution and relationship with aquatic vegetation

The ABI index results indicate fair water quality, similar to Meneses-Campo et al. (2024) and Ríos-Touma et al. (2024), who relate this condition to substrate type, climatic factors, and anthropogenic activities. Velásquez (2025), Rodríguez Castillo et al. (2023), and García Rengifo and Endara González (2020) emphasize that the ABI index is suitable for high Andean rivers and reflects the influence of altitude and the families, native to the habitat.

The EPT index showed fair to poor quality, coinciding with Bullón (2016), Rosas-Acevedo et al. (2014), and Sánchez and Carvacho (2006), who indicate that these organisms are sensitive to pollution. Roldán-Pérez (2012) explains that their absence reflects disturbances, which coincides with Miranda and Palomino (2021) in the Vilcanota River. Likewise, the absence of Plecoptera confirms their high sensitivity as an indicator of good water quality (Baumann and Lee, 2014).

CONCLUSION

The BMWP index indicates that the waters of the Vilcanota River are generally classified as questionable during the flood season and show higher pollution levels in the low-water season, reaching critical and very critical quality levels (classes IV and V, below 35). Similarly, the ABI index classifies the water as fair during the flood season and poorer during the dry season, indicating poor to very poor quality. The EPT index also reflects poor water quality due to the low presence of EPT families, likely related to wastewater discharge and waste generated by the local community. Additionally, the abundance and diversity of macroinvertebrates showed significant differences according to the sector and sampling period.

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EFFECT OF *Pleurotus ostreatus*, FLOUR ON THE PHYSICOCHEMICAL, FUNCTIONAL, AND STRUCTURAL PROPERTIES OF EXTRUDED PLANT-BASED PROTEINS

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ABSTRACT

This experimental quantitative study assessed the effect of incorporating *Pleurotus ostreatus* flour at varying levels (0%, 7%, 15%, and 30%) on textured vegetable proteins (TVP) produced by thermoplastic extrusion. Oyster mushroom flour, with high protein (25%) and dietary fiber (12%) content, enhanced the nutritional profile of TVP. Increasing flour levels raised protein content and water-holding capacity, while reducing expansion ratio and increasing bulk density. Functionally, protein solubility and emulsifying capacity peaked at 15% addition, indicating improved protein–water interactions and interfacial stability. Texture profile analysis and microstructural evaluation revealed a more compact and cohesive fibrous network at intermediate inclusion levels. In conclusion, the incorporation of 15% *Pleurotus ostreatus* flour simultaneously improves physicochemical, functional, and structural properties of TVP, offering a sustainable technological alternative.

Keywords: *Pleurotus ostreatus*, textured vegetable proteins, extrusion, functional properties, sustainability.

INTRODUCTION

The sustained increase in global demand for protein, coupled with the environmental impacts associated with the production of animal-based foods, has intensified interest in developing more sustainable and healthier food alternatives. Within this context, plant-based foods have taken on a strategic role in the transition to resilient food systems, contributing to the reduction of the environmental footprint without compromising nutritional quality (Kyriakopoulou et al., 2021). Among these alternatives, textured vegetable proteins (TVPs) obtained through thermoplastic extrusion stand out for their ability to mimic the texture, appearance, and functionality of meat, which favors their acceptance by consumers.

Thermoplastic extrusion is a technology widely used in the food industry due to its efficiency, scalability, and versatility. During this process, the simultaneous application of heat, pressure, and shear forces induces denaturation, alignment, and reorganization of plant proteins, allowing the formation of anisotropic structures with characteristics similar to meat muscle fibers (Dekkers et al., 2018). As a result, it is possible to obtain products with textural and functional properties suitable for the development of meat analogues.

In this scenario, edible fungi have emerged as promising ingredients for food innovation due to their balanced nutritional composition, bioactive compound content, and low environmental impact. *Pleurotus ostreatus*, known as the oyster mushroom, contains between 20% and 30% protein on a dry basis, in addition to dietary fiber, β -glucans, vitamins, and essential minerals (Kalac, 2016; Heleno et al., 2015). These components give it relevant functional properties, such as a high capacity of water retention and an adequate structural stability, suggesting its potential to improve the technological performance of plant protein matrices subjected to extrusion.

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In Peru, *Pleurotus ostreatus* production has shown sustained growth, especially in regions such as Puno, driven by family farming and productive diversification initiatives. However, its use in high value-added processed products remains limited. In particular, there is a lack of research evaluating the interaction between oyster mushroom components and plant proteins during the extrusion process, as well as its overall impact on the physicochemical, functional, and structural properties of TPPs. This knowledge gap restricts the development of meat-analog foods with higher technological quality and nutritional value.

From a functional and structural point of view, Hong et al. (2023) demonstrated that the physicochemical properties of textured vegetable proteins directly influence the performance of final products such as vegetable burgers. In particular, they identified rehydration capacity as a key parameter associated with juiciness, hardness, and cooking losses, highlighting the importance of optimizing the functional properties of TVP.

Plant-based foods have taken on a strategic role in the transition towards sustainable food systems (Kyriakopoulou et al., 2021; McClements & Grossmann, 2021). Edible fungi are an important source of protein, fibre and bioactive compounds (Kalac, 2016; Valverde et al., 2015).

Extrusion is a key technology in structuring plant proteins for meat analogues (Dekkers et al., 2018; Asgar et al., 2010).

In recent years, the development of plant-based meat analogues has experienced significant growth driven by demand for more sustainable and healthier foods. These products seek to replicate the sensory characteristics of meat, such as fibrous texture, juiciness, and nutritional value, using plant-based raw materials processed using technologies such as high-moisture extrusion. This process allows protein structures to be reorganized and fibrous matrices similar

to muscle tissue to be generated, which is essential for improving consumer acceptance of plant-based foods (Joshi & Kumar, 2015; McClements & Grossmann, 2021).

Recent reviews indicate that extrusion, especially under controlled humidity conditions, allows for favorable modification of the structure and functionality of plant proteins (Boukid et al., 2021; Zhang et al., 2023). Likewise, McClements et al. (2021) emphasize the need to comprehensively evaluate physicochemical, functional, and microstructural properties to ensure the quality of meat analogues, identifying a gap in studies that integrate local fungal ingredients.

This research sought to assess the influence of *Pleurotus ostreatus* flour, incorporated at different inclusion levels (0%, 7%, 15%, and 30%), on the physicochemical, functional, and structural attributes of textured vegetable proteins obtained via thermoplastic extrusion. The results are intended to contribute to the advancement of sustainable meat alternatives with superior technological functionality and greater nutritional quality, while simultaneously encouraging the valorisation of local fungal resources and driving innovation in the plant-based food sector.

MATERIALS AND METHODS

A quantitative experimental design was applied using extruded plant protein formulations as experimental units. Four treatments were prepared with varying levels of *Pleurotus ostreatus* flour (0%, 7%, 15%, and 30%), selected through purposive sampling. Fresh oyster mushrooms were obtained from local producers in the Puno region (Peru), while food-grade, non-GMO soy protein isolate, wheat gluten, and corn starch were commercially sourced. The mushroom flour was processed (washing, blanching, drying, grinding, sieving) and characterized by proximate analysis following AOAC (2019) methods, alongside microbiological evaluation according to Peruvian health regulations.

The formulated mixtures were processed in a twin-screw extruder under controlled operating conditions. The resulting extrudates were assessed for physicochemical properties (protein content, expansion ratio, bulk density, water retention capacity, pH, and water activity), functional properties (protein solubility, emulsifying capacity, and water absorption), and structural properties, including texturization index and microstructural features analysed by scanning electron microscopy. All experiments were performed in triplicate. Statistical analyses were conducted using SPSS version 28.0. Results are reported as mean $\pm$ standard deviation, and differences among treatments were determined by one-way analysis of variance (ANOVA), applying Duncan's multiple range test at a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

The table 1 shows the proximate composition of *Pleurotus ostreatus* flour from dehydrated mushrooms, detailing the contents of protein, fat, dietary fiber and minerals.

Table 1

Proximate composition of oyster mushroom flour (Pleurotus ostreatus)

Component	Content (%)
Protein	28.6
Fat	3.4
Dietary fiber	19.2
Ashes (minerals)	7.1

The results of the physicochemical properties of the PVTs, including: protein content, expansion ratio (ER), bulk density (PAPP), water holding capacity (WHC), pH, and water activity (AW), are shown in Table 2.

Table 2

Physicochemical properties of textured vegetable proteins with different levels of Pleurotus ostreatus flour

Treatment (% oyster mushroom meal)	Protein (%) ± SD	Expansion ratio (ER) ± DE	Apparent density (g/cm ³) ± DE	CRA (g H ₂ O/g) ± DE	pH ± DE	aw ± DE
0%	53.18 ± 0.5 ^d	1.21 ± 0.03 ^a	0.42 ± 0.01 ^d	2.6 ± 0.1 ^d	6.42 ± 0.02 ^a	0.41 ± 0.01 ^b
7%	55.76 ± 0.4 ^c	1.12 ± 0.02 ^b	0.45 ± 0.02 ^c	3.1 ± 0.1 ^c	6.48 ± 0.03 ^a	0.43 ± 0.01 ^{ab}
15%	57.55 ± 0.3 ^b	1.03 ± 0.02 ^c	0.47 ± 0.01 ^b	3.5 ± 0.1 ^b	6.55 ± 0.02 ^a	0.45 ± 0.01 ^a
30%	59.75 ± 0.5 ^a	0.94 ± 0.03 ^d	0.49 ± 0.01 ^a	3.9 ± 0.2 ^a	6.65 ± 0.02 ^a	0.46 ± 0.01 ^a

Note: Different letters in the same column indicate significant differences (p < 0.05).

Functional properties

The results for protein solubility, emulsifying capacity, water retention capacity (WRC) and oil retention capacity (WRCe) are shown in Table 3:

Table 3

Functional properties

Level of replacement	Protein solubility (%)	Emulsifying capacity – EAI (%)	CRA (g H ₂ O/g)	CRAe (g oil/g)
Control (0%)	62.14	38.26	2.61	1.58
7% mushroom flour*	65.9	44.8	3.22	1.83
15% mushroom flour	70.25	52.18	3.91	2.12
30% mushroom flour	66.42	49.37	—	—

Note: CRA = water retention capacity; CRAe = oil retention capacity. *Oyster mushroom meal (*Pleurotus ostreatus*).

Instrumental Texture Analysis (TPA)

The results of the TPA analysis with the addition of mushroom flour are shown in Table 4:

Table 4

Functional properties

Level of replacement	Hardness (N)
0% (Control)	36.25
15% mushroom flour	48.63
30% mushroom flour	44.82

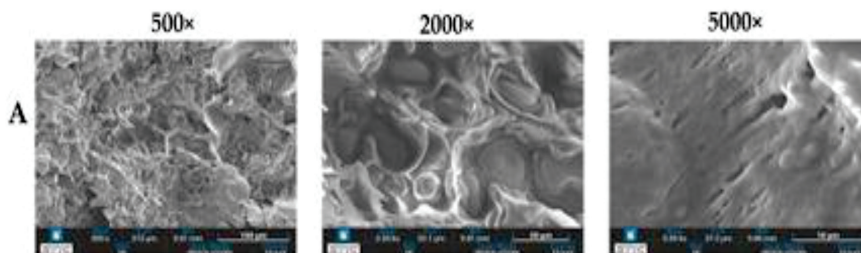
Note: Hardness measured in Newtons (N). Oyster mushroom flour (*Pleurotus ostreatus*).

Microstructural analysis (Scanning Electron Microscopy, SEM)

SEM micrographs showed that the morphology of the textured proteins varied according to the level of *Pleurotus ostreatus* meal. The control group exhibited a porous and irregular structure, while the meal group generated a dense, oriented fibrous network with continuous longitudinal fibers that mimicked meat. At 30%, fissures and collapsed areas appeared, indicating excessive rigidity and reduced expansion.

Figure 1

Microstructure of PVTs observed by scanning electron microscopy (SEM)



Note: Micrographs obtained at magnifications of 500 $\times$, 2000 $\times$ and 5000 $\times$.

DISCUSSION

The results of this study demonstrate that the incorporation of *Pleurotus ostreatus* flour significantly modifies the composition, functionality, and microstructure of textured vegetable proteins, highlighting its potential as a technological ingredient in the development of meat analogues. The protein content of the fungus, within the 20–35% range described in the literature, supports its use as an alternative protein source, while its contribution of dietary fiber and β -glucans helps improve the hydration and stability of the food matrix (Kalac, 2016; Shukri et al., 2020).

The increase in the protein content of the extrudate (from 53.18% to 59.75%) is attributed both to the intrinsic contribution of the fungus and to greater nitrogen retention during extrusion, a phenomenon previously observed in plant-based systems enriched with fungal ingredients (Zhang et al., 2021). Simultaneously, the decrease in the expansion ratio and the increase in bulk density indicate the formation of a more compact structure due to the presence of polysaccharides and insoluble fiber, which increase the viscosity of the melt and limit bubble formation during the process (Dekkers et al., 2018). This behavior results in less porous products with greater firmness, desirable characteristics in matrices that aim to mimic the texture of meat (Park et al., 2019).

From a functional standpoint, water retention capacity increased considerably with the addition of mushroom meal, which is associated with the hydrophilic nature of β -glucans and other structural polysaccharides that act as natural hydrocolloids, promoting water immobilization within the protein network (Lin et al., 2002). This property is key in meat analogues, as it improves juiciness, texture, and yield after rehydration. pH and water activity showed no significant changes, indicating that the addition of this ingredient does not compromise the product's physicochemical stability.

Protein solubility increased significantly up to an incorporation level of 15%, suggesting greater exposure of polar groups and structural flexibility that favors protein-water interaction (Morr et al., 1985). However, at higher concentrations, a slight decrease was observed, attributed to the formation of insoluble aggregates and the diluting effect of the fiber, a behavior also reported in mixtures of plant protein with fungi (Shukri et al., 2020). Similarly, emulsifying capacity improved at moderate addition levels due to the presence of amphiphilic macromolecules capable of stabilizing the oil-water interface, although high amounts can lead to supersaturation of the system (Pearce & Kinsella, 1978).

The textural properties reflected these structural changes. The increase in hardness and cohesiveness up to 15% indicates a strengthening of the three-dimensional network through protein-polysaccharide interactions, while higher levels cause a slight loss of structural integrity, probably due to discontinuities in the matrix (Dekkers et al., 2018). Microstructural observations confirmed that intermediate levels favor the formation of an oriented fibrous network, similar to muscle structure, while high concentrations generate fissures and structural collapse.

Pleurotus ostreatus meal acts as a functional ingredient capable of simultaneously modulating the nutritional value, hydration, emulsification, and texture of textured vegetable proteins. An incorporation level close to 15% represents the optimum point for achieving a balance between technological functionality and structural stability, providing a scientific basis for the design of more sustainable meat analogues. However, future research should include sensory evaluation, digestibility studies, and industrial scale-up studies to validate its commercial application.

CONCLUSION

The research demonstrated that the addition of *Pleurotus ostreatus* flour significantly modifies the physicochemical, functional, and structural properties of extruded textured vegetable proteins, fulfilling the stated objective. Its incorporation increased protein content and improved water and oil retention capacity, promoting protein-polysaccharide interaction and the formation of more stable matrices. Furthermore, the reduction in expansion and the increase in bulk density resulted in more compact and firm structures, with desirable technological characteristics for meat-analogous products.

At moderate levels of substitution, improvements in protein solubility, emulsifying capacity, and textural properties were observed, resulting in a more organized and cohesive fibrous network. In contrast, high proportions produced slight functional losses associated with excess fiber, confirming the need for a balance between nutritional enrichment and technological performance. A level close to 15% was identified as the most suitable for achieving this balance, providing improvements in texture, hydration, and stability without compromising the product's structure.

Taken together, the results support the use of mushroom flour as a functional and sustainable ingredient in the development of plant-based foods with greater nutritional value and technological quality, while also promoting the use of local resources and innovation in meat analogues. It is recommended that these findings be complemented with sensory and industrial-scale studies to strengthen their commercial application.

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EVALUATION OF THE ZOOPLANKTON COMMUNITY IN THE LAGOON OF THE INCAS BAY OF THE CITY OF PUNO

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ABSTRACT

This study is a descriptive, non-experimental investigation with a quantitative approach supported by qualitative data. It was conducted in the field and laboratory, with samples collected from the lagoon known as Bahía de los Inca, located in the city of Puno, to evaluate the existing zooplankton community. The study is of ecological relevance as it considers the biotic and abiotic factors that regulate the dynamics and structure of natural communities. Understanding the interactions among these factors and quantifying their importance is one of the challenges facing ecology. The characteristics and composition of the zooplankton community were evaluated, and seven species were recorded in this body of water: *Boeckella titicacae*, *Metacyclops leptopus*, *Daphnia pulex*, *Ceriodaphnia quadrangular*, *Bosmina hagmani*, *Keratella quadratam*, and *Polyarthra* sp. Recorded environmental parameters included temperature ranges from 9 to 16 °C, oxygen concentration from 0.2 to 3.1 mg/L, and the lagoon depth of 1.5 meters; which influence thermal variability within the system. The findings indicate that the limnological characteristics of the Bahía de los Inca lagoon do not correspond to those typically observed in high-Andean ecosystems.

Keywords: zooplankton, limnology, high-Andean ecosystems, ecological dynamics, biodiversity, abiotic factors, Puno, Peru

INTRODUCTION

Research on Lake Titicaca explains that it is an endorheic basin, the highest navigable body of water in the world, located at 3,810 meters above sea level, between 15° 10' 42" and 16° 25' 08" south latitude and 68° 34' 46" and 70° 00' 29" west longitude (Camacho 2004).

The study conducted is of ecological interest. Considering the biotic and abiotic factors that regulate the dynamics and structure of natural communities, understanding the interactions between these factors and quantifying their importance is one of the challenges facing ecology (Odum, 2005).

Planktonic communities are composed of short-lived organisms whose population dynamics respond rapidly to environmental variations. In this context, it is essential to analyze the specific composition and the factors that regulate changes in the relative abundance of each species. Among these factors, the nature and availability of trophic resources stand out, constituting a key determinant in the structuring and dynamics of these communities (Wetzel, 2001). These, in turn, are influenced by the physical and chemical characteristics of the environment in which they live (Reynolds, 2006).

The development of zooplankton populations will depend not only on the quantity of food available, but also on its quality (Sterner, 2002).

The different nutritional quality of the various algal taxa suggests that zooplankton will be limited by the nutritional quality of phytoplankton communities (Lampert, 2007).

Zooplankton acts as a primary consumer, feeding on phytoplankton and transferring energy to higher trophic levels such as fish, insect larvae, and other invertebrates. Without zooplankton, the energy produced by algae would not efficiently reach larger organisms. (CLARKE, G. 1976).

Zooplankton assessment involves studying the composition, abundance, diversity, and structure of these aquatic communities to understand their ecological role and their relationship with the environment. (American-APHA 2017).

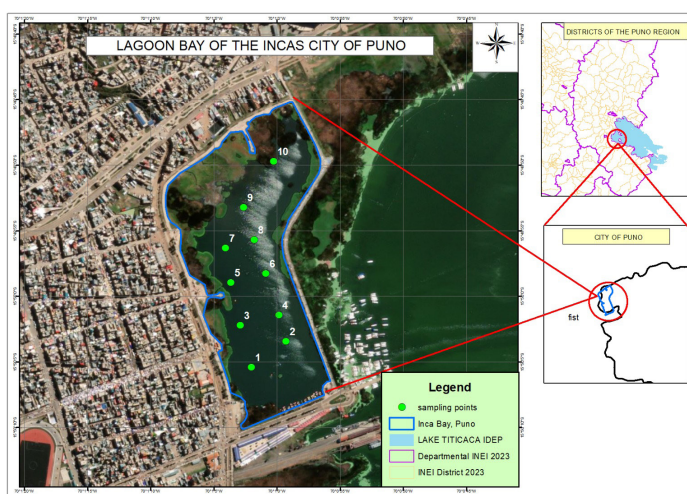
The question posed was: Are there a large number of zooplankton species in this body of water? The objective of this study was to understand the zooplankton community and determine the main limnological characteristics related to its presence in the Inca Bay of the City of Puno.

MATERIALS AND METHODS

This quantitative, non-experimental study, conducted in the field and laboratory, focused on the numerical measurement of variables such as density, biomass, relative abundance, diversity, and species composition. Standardized sampling and counting procedures were applied, and results were expressed in metric units (organisms/m³). A qualitative approach was used to identify species through qualitative analysis and to characterize the zooplankton community of the lagoon known as Bahía de los Incas, describing its composition, abundance, and diversity without manipulating variables.

Figure 1

Sampling points: Bahía de los Incas lagoon, Puno city



Determination of limnological characteristics

To determine the limnological characteristics, temperature, oxygen, incident light, and transparency were measured. These tests were performed in situ with different equipment and simultaneously during zooplankton sampling, as well as at different times of day, to help us determine the zooplankton community present in this lagoon, Bahía de los Incas, in the city of Puno.

Zooplankton collection method.

Zooplankton samples were collected from the deck of a vessel by vertical towing from the bottom to the surface using a Wisconsin plankton net with a 25 cm diameter opening (90 µm mesh) at a depth of 1 meter. This method is very common for collecting plankton samples; in practice, a significant proportion of the sample is retained on the inner edges of the net, so repeated and careful washing was essential to ensure the plankton settled to the bottom before removing the tray. The sample was then transferred to 120 ml plastic bottles, properly labeled (date and depth). To fix the sample, 5 ml of 40% concentrated formalin was added at each sampling point. One tow was performed per hour of sampling, for a total of three tows.

Laboratory analysis

Zooplankton samples were first evaluated for species identification, which was carried out with the aid of a stereomicroscope. Identification keys such as PENNAK (1991), MARGALEF (1983), ILTIS (1991), MORENO (1983), and CASTILLO (1982) were also used, and zooplankton illustrations were used as supporting material.

Quantitative analysis

Zooplankton samples, fixed with 40% formalin and transferred to the laboratory, were separated from the water and placed in Petri dishes divided into cm² to facilitate counting under a 30X stereoscope; each organism, regardless of size or stage, was considered a unit and numbered, recording date and results, expressing abundance in org/m³ by dividing the counts by the sampled volume equivalent to 0.198 m³.

RESULTS AND DISCUSSION

Zooplankton Composition and Abundance

Table 1

Zooplankton species recorded in the Inca Bay lagoon of the City of Puno.

Item	Scientific name	Common name
1	<i>Boeckella titicacae</i>	Titicaca copepod
2	<i>Metacyclops leptopus</i>	Cyclopoid copepod
3	<i>Daphnia pulex</i>	Water flea
4	<i>Ceriodaphnia quadrangula</i>	Small water flea
5	<i>Bosmina hagmani</i>	Water flea (Bosmina)
6	<i>Keratella quadrata</i>	Spiny rotifer
7	<i>Polyarthra Sp</i>	Mobile rotifer

Zooplankton density in the Bahía de los Incas lagoon.

Among the species recorded, Ceriodaphnia quadrangula presented the highest abundance, with an average density of 1,587 org/m³. However, particular attention should be given to the nauplius group, which represents the early developmental stage of copepod species, specifically Boeckella titicacae and Metacyclops leptopus. The average density of nauplii reached 2,118 org/m³, constituting the most abundant category, since this stage was used as the counting unit. In contrast, the least abundant species was Polyarthra sp., with an average of only 21 org/m³.

Figure 2

Abundance of zooplankton organisms in the Bahía de los Inca Lagoon

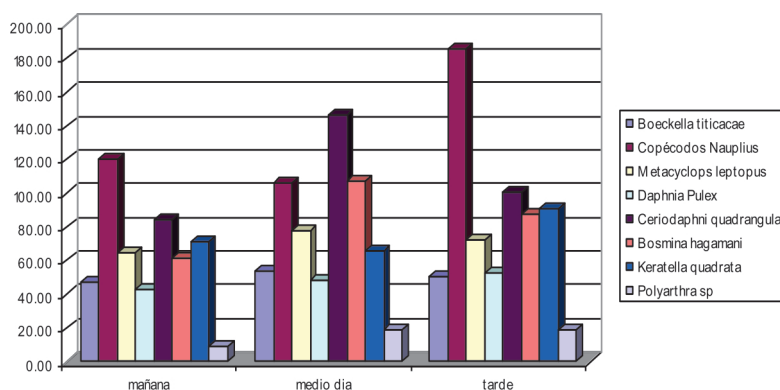


Table 2

ANOVA Results for Zooplankton Abundance by Sampling Hours in Bahía de los Incas Lagoon (September 18, 20, and 23)

FV	SC	GL	CM	F	SIG
VARZ	10101.118	7	1442.017	11.361	0.000**
HMUES	568.601	2	284.301	2.238	1.118 ns
VAR*HMUES	1854.911	14	132.494	1.043	0.430 ns
ERROR	6096.533	48	127.011		
Total	62,772.908	72			

The statistical analysis applied to the abundance data (ANOVA) indicates that, regarding variance, since $p = 0.00 < \alpha = 0.01$, there are significant differences with respect to the zooplankton species community at a significance level of 1%. For sampling hours, since $(p = 0.1 > \alpha = 0.05)$, there are no significant differences with a significance level of 1%. Regarding sampling hours and zooplankton species, since $(p = 0.4 > \alpha = 0.01)$, there are no significant differences with respect to the interaction of treatments at a significance level of 1%.

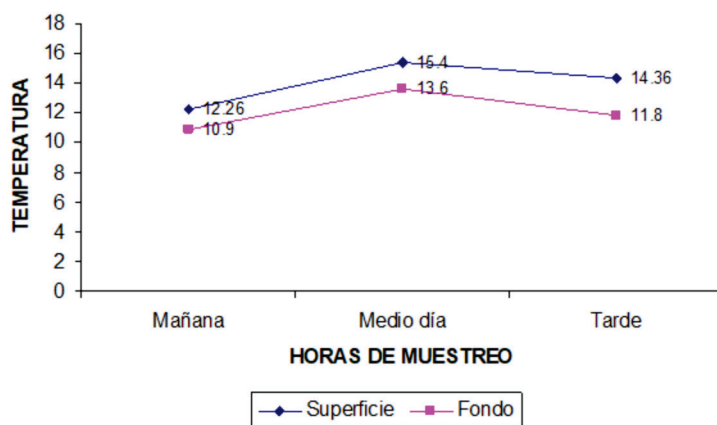
Limnological characteristics of the Bahía de los Incas Lagoon.

The results show that the Bahía de los Incas Lagoon has maximum surface temperatures of 16.8°C and minimum temperatures of 11.2°C, while at a depth of 1 m they reach 13.5°C in the afternoon and 9.6°C in the morning. These values exceed the typical ranges of a high-Andean aquatic ecosystem, which is explained by the abundant presence of heat-retaining macrophytes

and by the closed environment with little water mixing due to its shallow depth (1 m), factors that significantly contribute to the observed temperature increase.

Figure 3

Temperature found at different times of the day in the Bahía de los Incas lagoon.

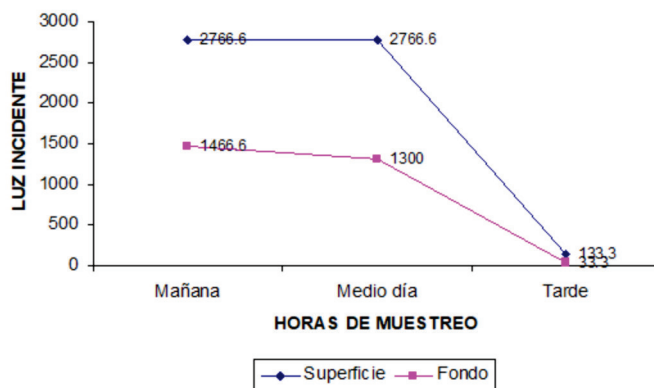


Light incidence on the water.

The maximum value of sunlight incidence on the water surface was 3000 candelas/ft², while the minimum was 100 candelas/ft². Regarding sunlight at the bottom of the lagoon, the maximum value was 1600 candelas/ft² in the afternoon. Conversely, zero candelas/ft² were recorded at the bottom in the afternoon. Transparency exceeds 1.20 m; the Inca Bay lagoon is not very deep, as it was constructed for recreational purposes for visitors. The bottom is covered in silt and there is an abundance of macrophytes, with only about 1 m of very clear water. Therefore, it was not necessary to use a Secchi disk to measure water transparency.

Figure 4

Light incidence recorded at different times of the day in the Bahía de los Incas lagoon.



DISCUSSION

Regarding the richness of zooplankton species that characterize aquatic ecosystems in the high Andean systems, these are mentioned by CASTILLO (1982), CHINÈS (1986), and MORENO (1983). *Boeckella titicacae*, *Boeckella occidentalis*, *Keratella quadrata*, *Daphnia pulex*, *Ceriodaphnia quadrangula*, *Metacyclops* sp., *Bosmina* sp., and *Polyarthra* sp. In some cases, other species were found, such as *Filina* sp., *Alona* sp., *Asplanchna* sp., and *Brachionus* sp., and SUAÑA (1993) recorded *Eristalia tenax*.

The dissolved oxygen results in the Bahía de los Incas Lagoon show very low concentrations, with maximum values of 3.1 mg/L at the surface and 4.0 mg/L at the bottom at midday, and minimum values of 0.6 mg/L and 0.2 mg/L, respectively, in the morning. These conditions are not typical of aquatic ecosystems, as most organisms cannot tolerate such low oxygen levels, although the zooplankton community does adapt to changing environments with low oxygenation. Consequently, the lagoon cannot be considered a dead ecosystem, but it does present a potential risk that requires attention to ensure its ecological balance and functionality.

CONCLUSIONS

The species richness of the zooplankton community in the Bahía Incas Lagoon is as follows:

Copepods: (*Boeckella titicacae* (Harding), *Metacyclops leptopus*). A copepod stage (nauplius) was also found and considered as a single unit. Cladocerans: (*Daphnia pulex* (Leydig), *Ceriodaphnia quadrangula* (O.F. Muller), *Bosmina hagmani*). Rotifers: (*Keratella quadrata* (O.F. Muller), *Polyarthra* sp.).

The most abundant species in the zooplankton community was *Ceriodaphnia quadrangula*, with an average of 1587 org/m³. The least abundant species was *Polyarthra* sp., with an average of 21 org/m³. Nauplii, a copepod stage, had a total average of 2118 org/m³.

The limnological characteristics of the Baía dos Incas lagoon do not correspond to those of a normal high-Andean ecosystem, since the surface temperature was 16.8 °C and a minimum of 11.2 °C, and in the deeper part, 13.5 °C and a minimum of 9.6 °C. Oxygen levels were low in the surface part, with a maximum of 3.1 mg/l and a minimum of 0.6 mg/l, and in the deeper part, with a maximum of 4.0 mg/l and a minimum of 0.2 mg/l.

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PROSOCIAL BEHAVIOR AND MENTAL HEALTH IN UNIVERSITY STUDENTS OF PUERTO MALDONADO: CORRELATIONAL AND PREDICTIVE INSIGHTS

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ABSTRACT

The purpose of this study was to examine the associations between prosocial behavior (empathy, respect, sociability, and leadership) and mental health factors (depression, anxiety, and stress) among university students in Puerto Maldonado. A cross-sectional design was employed with a sample of 820 students (57% female; average age = 21.32 years). The CC-P (58 items, four dimensions) and the DASS-21 (21 items, three dimensions) were administered. Spearman's correlations (ρ) and multiple linear regressions were conducted (three models; predictors: empathy, respect, sociability, leadership; covariates: age, gender). Results indicated strong interrelationships among prosocial dimensions ($\rho \approx 0.61\text{--}0.75$). At the bivariate level, anxiety was strongly associated with empathy ($\rho = 0.792$), sociability ($\rho = 0.750$), leadership ($\rho = 0.675$), and respect ($\rho = 0.574$). Conversely, depression and stress decreased as leadership ($\rho = -0.259$) and respect ($\rho = -0.146$) increased, while empathy showed no association with stress. In adjusted models, anxiety increased with empathy ($\beta = 0.490$), sociability ($\beta = 0.318$), and leadership ($\beta = 0.222$), whereas respect acted as a protective factor ($\beta = -0.121$). Stress was lower with leadership ($\beta = -0.195$) and age ($\beta = -0.091$), but higher with empathy ($\beta = 0.109$) and gender ($\beta = 0.106$). Depression decreased with leadership ($\beta = -0.327$) and age ($\beta = -0.127$), and increased with empathy ($\beta = 0.163$). In conclusion, prosocial leadership emerges as the primary protective factor against depression and stress, while empathy—along with sociability—appears linked to higher anxiety. These findings suggest that emotional regulation and purpose-driven leadership training should be prioritized in higher education contexts.

Keywords: prosocial behavior; empathy; leadership; DASS-21; anxiety; depression; stress; college students.

INTRODUCTION

Mental health in higher education has emerged as a critical priority, as evidenced by high levels of depression, anxiety, and stress among students and institutional responses that remain inadequate. The World Health Organization (2022) emphasizes the need to transform support systems based on evidence. A UNICEF study (2020) in Latin America, which included 8,444 young people aged 13 to 29, revealed that 27% experienced symptoms of anxiety and 15% showed signs of depression; furthermore, 6% reported reduced motivation for enjoyable activities, and 36% felt less motivated to perform daily activities.

Prosocial behavior evolves progressively from childhood (tangible rewards) to adolescence and adulthood (internal rules, strengthened bonds, less aggression), with possible changes in

adults due to contextual and neuropsychological factors (Ramirez-Sanchez et al., 2025). Multifactorial (biology, culture, family, school), it is enhanced in school environments with low victimization (Garaigordobil, 2014), it fosters collaborative societies via multiple perspectives in children (Moñibas, 1996), it is essential in social psychology (Marín, 2010) and it promotes group integration and valuation (Paredes-Ayora, 2022).

International research on prosocial behavior and mental health (anxiety, depression, stress) indicates that empathy, cooperation, sociability, and positive leadership strengthen interpersonal bonds and emotional balance (Llorca et al., 2014). In contrast, social anxiety and trait elevate worry, avoidance, and negative self-perception, inhibiting prosocial actions (Zhang et al., 2023). Prosocial participation generates positive emotions, purpose, and self-efficacy, protecting against emotional disorders (Llorca et al., 2014). In addition, an inverse relationship with depression is evidenced: greater empathy and cooperation correlate with less depressive symptomatology (Eli et al., 2021), while social recognition of prosociality enhances subjective well-being and mitigates long-term depressive symptoms (Nagaoka et al., 2023).

Evidence positions prosocial behavior as a regulatory mechanism of mental health, particularly in educational contexts with academic and emotional pressures in young university students and professionals, elucidating psychological and social processes of emotional well-being. During the COVID-19 pandemic, these behaviors played a protective role in the mental health of young people and adults (Miles et al., 2022).

In Peru, the Ministry of Health defines mental health as a dynamic process of well-being that integrates personal capacities and environment, linked to empathy, trust, and self-care (Ministry of Health, 2024). A high incidence of depression and anxiety is recorded (Alarcón, 2019), with high prevalences in Peruvian universities via DASS-21, differentiated by academic and sociodemographic variables, justifying screening and promotion of well-being (Gastelu & Hurtado, 2022). During COVID-19, university students showed moderate rates of depression (24.3%), anxiety (28.5%), and stress (13.0%), associated with younger age, initial years of study, and chronic diseases (Sandoval et al., 2023). Young people and university students with high prosociality exhibit less anxiety and depression, with empathy and altruism as psychological buffers (Samochuallpa-Solis & Luna-Solis, 2024); however, greater emotional sensitivity from others correlates with high stress, indicating that prosociality does not always protect against academic burdens (Guzmán & Valencia, 2024).

In Madre de Dios, institutional estimates during the pandemic reveal that, of 746 university students, 45.2% showed low depression, 38.7% moderate depression and 16.1% high; 48% moderate stress and 30.4% moderate anxiety, urging prevention strategies and psychological support for emotional and academic well-being (Farfan-Latorre et al., 2023). In 670 undergraduate students in Puerto Maldonado, 62.2% presented high stress, 34.9% medium and 2.8% low, demanding interventions to mitigate academic stress (Zegarra, 2022). Another study found low anxiety, but moderate depression and stress in university students, with significant associations between them and life satisfaction (Estrada-Araoz et al., 2024).

The research is justified in analyzing how prosocial factors (empathy, respect, sociability, leadership) are related to mental health dimensions (depression, anxiety, stress), moving from global approaches to differential maps for precise interventions, guiding intentional leadership, emotional/compassionate regulation and social hygiene programs (temporal management, interpersonal limits) in university curricula and services (Furlong et al., 2014). These results

show a significant burden of psychological distress in traditional academic contexts, motivating us to explore whether prosocial behavior is associated with fewer symptoms in university students in Puerto Maldonado.

MATERIALS AND METHODS

The research was developed under a quantitative approach, with a correlational and explanatory scope, with a non-experimental and cross-sectional design, aimed at analyzing the influence of prosocial behavior (empathy, respect, sociability and leadership) on mental health factors (depression, anxiety and stress) in university students in Puerto Maldonado in 2025. The sample included 820 participants with an average age of 21.32 years, from three local universities, with a predominance of students in the first years of training. Two instruments were applied: the Prosocial Behavior Questionnaire (CC-P), with high internal consistency ($\alpha = 0.946$), and the DASS-21 scale to assess depression, anxiety, and stress ($\alpha = 0.957$). The questionnaires were administered through Google Forms in classrooms, guaranteeing anonymity and informed consent. The statistical analysis was performed with SPSS v.26, using descriptive tests and Spearman's correlation coefficient (ρ), since the distribution did not meet the assumptions of normality.

RESULTS AND DISCUSSION

Table 1
Correlation between the variables of DASS-21 and Prosocial Behavior

	1	2	3	4	5	6	7
Spearman's Rho	Empathy (1)	-	,697**	,752**	,661**	-,085*	,792**
	Respect (2)		-	,644**	,605**	-,146**	,574**
	Sociability (3)			-	,619**	-,099**	,750**
	Leadership (4)				-	-,259**	,675**
	Depression (5)					-	-,099**
	Anxiety (6)						-
	Stress (7)						

** . The correlation is significant at the 0.01 level (bilateral).

* . The correlation is significant at the 0.05 level (bilateral).

relationship with the dimensions of prosocial behavior, highlighting empathy as the factor with the greatest associative strength ($\rho=0.792$; $p<0.01$), followed by sociability ($\rho=0.750$; $p<0.01$), leadership ($\rho=0.675$; $p<0.01$) and, to a lesser extent, respect ($\rho=0.574$; $p<0.01$).

It is observed that depression is inversely related to all prosocial dimensions, being more marked with leadership ($\rho=-0.259$; $p<0.01$), followed by respect ($\rho=-0.146$; $p<0.01$), sociability ($\rho=-0.099$; $p<0.01$) and empathy ($\rho=-0.085$; $p<0.05$). This implies that those who have higher levels of prosocial behavior tend to experience fewer depressive symptoms, which coincides with the evidence that points to prosocial behavior as a protective factor of emotional well-being.

Finally, with respect to stress, negative correlations were observed with leadership ($\rho=-0.172$; $p<0.01$), respect ($\rho=-0.128$; $p<0.01$) and sociability ($\rho=-0.071$; $p<0.05$), while the relationship with empathy did not reach statistical significance ($\rho=-0.041$; $p>0.05$). These results show that prosocial competencies oriented towards interaction and recognition of others can attenuate the

perception of tension or emotional charge.

Table 2

Multiple linear regression model of the prediction of the dimensions of Prosocial Behavior with the dimensions of mental health, age and gender

	Stress			Anxiety			Depression		
	b	Say .	B* IC 95%	b	Say.	B* IC 95%	b	Say.	B* IC 95%
Empathy	,109	,00	,079	,490	,000	,165	,163	,008	,092
		2	[,014 ; ,144]			[,143 ; ,187]			[,024 ; ,159]
Respect	-,051	,33 8	-,118 ; 041	-,121	,000	[-,086 ; - ,031]	,008	,879	[-,076 ; ,089]
			-,014			,161			,008
Sociability	-,018	,75 6	[-,105 ; ,076]	,318	,000	[,130 ; ,193]	,009	,875	[-,086 ; ,101]
			-,181			,131			-,322
Leadership	-,195	,00 0	[-,273 ; - ,089]	,222	,000	[,099 ; ,163]	-,327	,000	[-,418 ; - ,227]
			-,096			,004			-,142
Age	-,091	,00 9	[-,168 ; - ,023]	,005	,775	[-,021 ; ,029]	-,127	,000	[-,216 ; - ,067]
			1,004			,209			,642
Gender	,106	,00 2	[,358 ; 1,650]	,035	,066	[-,014 ; ,432]	,064	,060	[-,027 ; 1,311]

empathy, respect, sociability, and leadership; anxiety, stress and depression, finding that some factors act as predictors of others.

In the case of the analysis of stress predictor variables, it was identified that empathy predicted greater stress ($\beta=0.109$; $p<0.01$); the leadership factor was associated with lower stress ($\beta=-0.195$; $p<0.01$); as did the age factor ($\beta=-0.091$; $p<0.01$); finally, the gender factor showed a positive association with stress ($\beta=0.106$; $p<0.01$).

Regarding the analysis of the predictors of anxiety, it was identified that the empathy factor predicted greater anxiety with a strong effect ($\beta=0.490$; $p<0.01$); the respect factor was associated with lower anxiety ($\beta=-0.121$; $p<0.01$); the sociability factor was associated with greater anxiety ($\beta=0.318$; $p<0.01$); the leadership factor was associated with greater anxiety ($\beta=0.222$; $p<0.01$). We can then point out that empathy is the predictor with the greatest positive weight on anxiety, followed by sociability and leadership. In contrast, the respect factor has a protective (negative) effect. Age and gender factors are not predictors of anxiety.

Finally, in the analysis of the predictors of depression, it was identified that the empathy factor predicted greater depression ($\beta=0.163$; $p<0.01$), leadership showed a strong protective effect ($\beta=-0.327$; $p<0.01$), age was associated with less depression ($\beta=-0.127$; $p<0.01$).

DISCUSSION

The literature shows an inverse relationship between prosocial behavior and anxiety, modulated by contextual and personal variables. Zhang et al. (2023) and Llorca et al. (2014) confirm that prosociality reduces anxious symptoms in adolescents, with empathy as a key mediator. However, Samochualpa-Solis and Luna-Solis (2024) report a significant correlation, but of low magnitude in post-pandemic contexts, while Yang et al. (2024) indicate that social anxiety inhibits prosocial motivation. This dynamic positions prosociality as a protective factor, by enhancing social connections and purpose, although its impact varies with depressive symptoms and situational conditions. Longitudinal designs and mediation analyses are recommended to elucidate mechanisms and optimize psychoeducational interventions in adolescents and university students.

The review of studies reveals a significant negative association between prosocial behavior and depression, mediated by cultural context, age and resilience. Eli et al. (2021) show that adolescents with high prosociality exhibit a lower risk of depression, enhanced by resilience; Nagaoka et al. (2023) confirm that prosocial recognition attenuates symptoms in early adolescence. Zhang et al. (2023) show that depression negatively moderates prosociality-anxiety, limiting altruistic disposition. Thus, prosociality not only promotes social well-being, but also acts as an antidepressant protector. There is an urgent need for longitudinal evidence in Latin American university students; Educational interventions in empathy and leadership would optimize academic mental health.

Studies show that prosocial behavior can influence stress, sometimes being a negative predictor of stress. Forbes et al. (2023) found that acute stress reduces motivation to collaborate, but individuals with high empathy continue to help under pressure. Harris et al. (2022) observed that, in situations of prolonged stress, such as the COVID-19 pandemic, prosocial behavior decreases. Guzmán and Valencia (2024) suggest that empathy, without emotional regulation, can increase stress reactivity, while leadership helps by fostering a socially supportive environment. In addition, it is proposed that promoting prosocial behavior among university students through workshops and community programs could improve their mental health, adapting these initiatives to local cultural characteristics.

CONCLUSIONS

The study indicates that anxiety is positively related to prosocial behavior, with empathy being the most significant predictor, followed by sociability and leadership; respect acts as a protective factor. Greater sensitivity to the needs of others and social involvement can increase anxiety in college students, while norms of respect help decrease this response. It is suggested that fostering prosocial skills should include emotional management to mitigate the risk of anxiety associated with high levels of empathy and sociability.

Regarding depression, the data indicate that there is an inverse relationship between depression and prosocial behaviors, highlighting leadership as the main protective factor, followed by respect and sociability. Age also protects. However, empathy was found to be positively associated with depressive symptoms, suggesting that not all prosocial behaviors affect emotional well-being in the same way. Therefore, interventions to reduce depression should focus on fostering leadership and social connections, while managing the emotional burden of intense empathy.

Stress is related to leadership competencies and maturity, where higher levels of these are associated with lower perceived tension. In contrast, empathy and gender are linked to increased

stress. This suggests that prosocial elements and experience enhance emotional stability, while unregulated empathy can increase stressor. It is recommended that university programs integrate leadership and emotional regulation strategies to maximize prosocial benefits and minimize vulnerability to stress.

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PREDICTIVE MODEL OF SECURITY INCIDENTS IN PENITENTIARY INSTITUTIONS BASED ON RECURRENT NEURAL NETWORKS (RNN).

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ABSTRACT

The present study aimed to develop a predictive model of security incidents in penitentiary institutions in Peru, with the purpose of anticipating critical events such as riots, escapes, inmate confrontations, and assaults on staff, within a context characterized by overcrowding and limited institutional response capacity. The research adopted a quantitative, applied approach, with a non-experimental, longitudinal, and explanatory design, and was conducted at the Puerto Maldonado Penitentiary Establishment during the period from January 2023 to March 2024. The population consisted of approximately 2,400 incident records, from which a non-probabilistic sample of 1,850 complete records was selected. Documentary and observational techniques were employed, using institutional records and video surveillance systems as data collection instruments. Data processing was carried out using Python 3.10 (Pandas, NumPy, and Scikit-learn) and TensorFlow with Keras for training the Recurrent Neural Network (RNN) model. The results demonstrated an accuracy of 92.3%, a sensitivity of 90.1%, and an AUC of 0.95, as well as a 46% reduction in the frequency of incidents and a decrease in response time from more than 90 minutes to less than 50 minutes. It is concluded that the RNN model constitutes an effective and scalable tool for incident prediction and the optimization of evidence-based penitentiary management.

Keywords: Artificial intelligence, incident prevention, penitentiary security, predictive model, recurrent neural networks.

INTRODUCTION

The Peruvian penitentiary system faces persistent structural problems, such as overcrowding, violence, and the limited incorporation of management technologies (Defensoría del Pueblo, 2019). Zúñiga and Reyes (2021) argue that these factors increase the incidence of riots and escapes, thereby evidencing the need to implement innovative technological solutions.

Gaona-Jiménez (2024) highlights the potential of artificial intelligence to prevent critical events through the analysis of data patterns. At the national level, Hernández et al. (2025) report that the implementation of artificial intelligence-based surveillance systems in Lima enabled a 30% reduction in property crimes. Likewise, Lujano (2024) employed recurrent neural networks (RNN) to forecast the levels of Lake Titicaca, demonstrating their capacity to model complex temporal dynamics.

In the Latin American context, Fernández et al. (2025) emphasize applications of artificial intelligence in penitentiary video surveillance aimed at anticipating high-risk behaviours,

while Sarabia (2023) documents improvements in the early detection of incidents. However, Bustamante and Bustamante (2023) warn about the presence of ethical biases in security algorithms, underscoring the need to establish robust regulatory frameworks.

Ramos et al. (2020) and Silva et al. (2021) point out the scarcity of research on the use of RNN in Latin American correctional facilities, revealing an opportunity to develop studies contextualized within the region.

Hochreiter and Schmidhuber (1997) introduced recurrent neural networks as effective models for capturing long-term dependencies in temporal sequences. Goodfellow et al. (2016) and Graves (2013) demonstrate their effectiveness in complex prediction tasks.

In the field of cybersecurity, Alom et al. (2019) and Hassan et al. (2019) show that RNNs enable more accurate anomaly detection in network traffic compared to traditional methods. Similarly, Shen et al. (2019) developed Tiresias, an RNN-based model that achieved an accuracy of 0.93 in predicting security events in information systems. Complementarily, Zhang et al. (2021) and Chak et al. (2020) identify security trends through RNN aimed at preventing cyberattacks.

The use of RNN-GRU architectures with attention mechanisms has optimized the extraction of spatiotemporal features, as reported by Wang et al. (2020) and by the CNN-GRU with attention model applied to network security (MDPI, 2022).

Fumarola and Lanotte (2018) demonstrated their usefulness in predicting police traffic, while Al-Mhiqani (2022) applied RNN to insider threat detection. In the field of predictive criminology, although decision tree-based models have been employed, as in the case of Ukraine (MDPI, 2022), a systematic application of RNN in this context has not yet been documented.

The available evidence suggests that the integration of RNN with large volumes of penitentiary data can facilitate the generation of early warning alerts and optimize operational management (Peña et al., 2023).

Consequently, the present study proposes the design and implementation of a predictive model of security incidents in Peruvian correctional facilities, using recurrent neural networks to capture temporal patterns in variables such as visitation, surveillance, and the behaviour of persons deprived of liberty. In doing so, this research seeks to contribute to strengthening a more efficient, preventive, and evidence-based management approach within the Peruvian penitentiary system (Gonzales and Rivas, 2022; UNODC, 2022; Ramos et al., 2020).

MATERIALS AND METHODS

The research was conducted at the Puerto Maldonado Penitentiary Establishment, located in Madre de Dios, Peru, an environment characterized by overcrowding conditions, technological limitations, and high inmate turnover associated with organized crime and illegal mining. A quantitative, applied approach was adopted under a non-experimental, longitudinal, and explanatory research design to develop a predictive model based on recurrent neural networks (RNN) to anticipate security incidents. The study was grounded in the observation of historical records over fifteen months, enabling the identification of temporal patterns and correlations between penitentiary risk factors and the occurrence of critical events, while projecting preventive management scenarios replicable in other correctional facilities across the country.

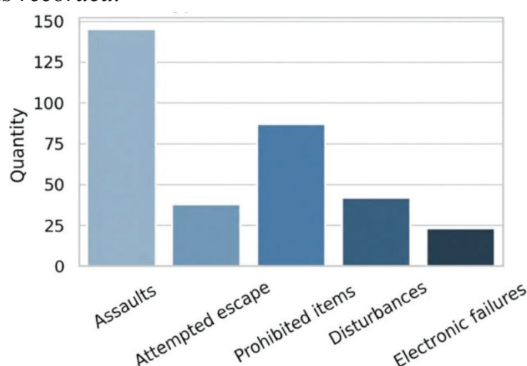
The population consisted of approximately 2,400 documented records of security incidents, from which 1,850 complete and verifiable records were selected through intentional non-probabilistic sampling. Data were collected using documentary, observational, and technological techniques, including official reports, video surveillance recordings, and structured databases in CSV format. The analysis was conducted in sequential phases of preprocessing, modelling, and validation, employing Python and TensorFlow for RNN construction, complemented by statistical testing in SPSS. The model architecture enabled the identification of sequential patterns and the generation of predictions with robust performance metrics, represented through confusion matrices, trend graphs, and heat maps, thereby providing empirical evidence to support strategic decision-making in penitentiary management.

RESULTS AND DISCUSSION

The predictive model developed through a Recurrent Neural Network (RNN) identified patterns in the occurrence of security incidents recorded over fifteen months (January 2023–March 2024). A total of 1,850 classified records were processed, enabling predictions for events such as physical assaults, escape attempts, possession of prohibited objects, disturbances, and failures in electronic security systems. The model achieved an accuracy of 92.3% on the test dataset, with a sensitivity of 90.1%, a specificity of 93.6%, an F1-score of 0.91, and an Area Under the ROC Curve (AUC) of 0.95. Spatial analysis revealed that incidents were concentrated in high-risk cellblocks and areas with limited direct supervision, while temporal analysis identified critical time slots between 03:00–05:00 a.m. and 20:00–22:00 p.m. A statistically significant correlation ($p < 0.05$) was observed between the number of inmates per cell and incident frequency. Furthermore, heat maps generated by the model highlighted zones with the highest incidence, and temporal recurrence graphs revealed cyclical patterns, with increases particularly on Mondays and Fridays.

Figure 1.

Types of incidents recorded.



Evaluation of the Indicator: Incident Resolution Time

Incident response time was measured in two periods: before (August–December 2023) and after (January–May 2024) the implementation of the RNN-based predictive model.

Before implementation, the average response time for incidents such as physical assaults, possession of prohibited objects, and escapes exceeded 90 minutes (95.3, 88.6, and 102.1 minutes, respectively).

After the implementation of the model, the average response times decreased significantly, with values ranging between 38 and 48 minutes for the different types of incidents.

Table 1.

Comparison of the types of incidents recorded before and after the implementation of the RNN model.

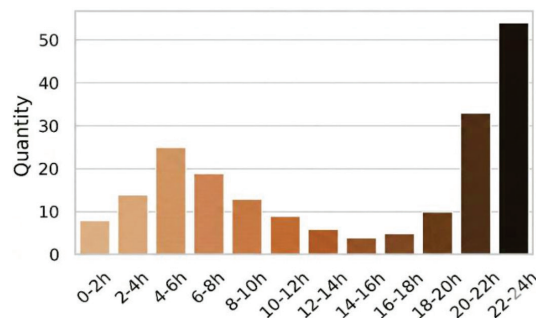
Incidents	Number Before Model	Number After Model	Average Time Before (minutes)	Average Time After (minutes)
Physical assaults	22	12	95.3	47.2
Possession of weapons	17	10	88.6	43.5
Escapes or escape attempts	3	2	102.1	48.0
Incidents involving staff	12	6	91.7	46.4
Incidents between inmates	19	10	89.9	44.1
Emergencies	7	5	76.8	39.3
Self-harm	5	3	83.2	42.8
Others	6	1	80.5	38.0

Evaluation of the Indicator: Frequency of Incidents by Time Slot

The analysis of incident frequency by time slot allowed the identification of periods with the highest occurrence within the penitentiary establishment. Prior to the implementation of the RNN model (August–December 2023), incidents were most concentrated between 09:00–13:00 and 17:00–20:00 hours. Following the application of the model, however, a notable decrease in incident frequency was observed during these critical time slots, evidencing the effectiveness of the RNN approach in reducing behavioral disruptions within the institution.

Figure 2.

Frequency of incidents by time slot.



DISCUSSION

The results obtained indicate that the predictive model based on recurrent neural networks exhibits a high capacity to identify risk patterns within the penitentiary context. The accuracy of 92.3% and the AUC value of 0.95 indicate robust system performance for the prediction of security incidents. These findings are consistent with previous research on the use of artificial intelligence in institutional security. For instance, Berk (2017) notes that predictive models based on machine learning can achieve accuracy levels exceeding 85% in forecasting risk events within criminal justice systems. Similarly, Ridgeway (2018) reports that predictive models applied to security and criminology demonstrate high discriminative capacity when deep learning algorithms and neural networks are employed. In comparison with these studies, the performance achieved in the present research falls within the upper range reported in the literature.

The significant correlation between the number of inmates per cell and the frequency of incidents confirms that overcrowding constitutes one of the main risk factors in penitentiary security, which is consistent with various studies on penitentiary management and institutional criminology. Research conducted by Gaes (1994) and later by Steiner and Wooldredge (2009) demonstrated that correctional facilities with higher levels of overcrowding present a greater likelihood of inmate violence and disturbances. Likewise, Useem and Piehl (2008) found that prison overpopulation increases social tension within correctional facilities, thereby elevating the risk of conflicts and disciplinary incidents. In this regard, the results obtained in the present study reinforce existing empirical evidence on the negative impact of overcrowding on penitentiary security.

Furthermore, the reduction of more than 50% in incident response times following the implementation of the model suggests that predictive analytics tools can significantly enhance institutional response capacity. This shift reflects a transition from a reactive approach to a preventive approach in security management. Similar results have been reported in studies on predictive policing and criminal analysis, where the incorporation of artificial intelligence systems has enabled the optimization of operational decision-making. For example, Perry et al. (2013) indicate that the use of predictive analytics in public security can improve resource allocation and reduce response times to incidents. Likewise, Mohler et al. (2015) found that predictive models applied to security management contribute to anticipating risk events and improving institutional operational efficiency.

On the other hand, the reduction of incidents during previously critical time slots demonstrates that the information generated by the model can be used to optimize the distribution of surveillance personnel and improve operational planning. This finding is consistent with studies on strategic security management, which argue that the analysis of temporal patterns allows for the identification of high-risk periods and the adjustment of resource allocation. In this sense, Ratcliffe (2016) highlights that the analysis of spatial and temporal patterns in applied criminology enables improvements in the planning of security operations and reduces the occurrence of incidents. Similarly, Braga, Papachristos, and Hureau (2014) emphasize that the strategic targeting of resources based on data analysis significantly contributes to the prevention of criminal events.

Overall, these results suggest that the implementation of predictive systems based on artificial intelligence can constitute an effective tool for strengthening penitentiary security. Moreover, the model demonstrates scalability potential to other penitentiary establishments in Peru, provided

that digitized and structured records are available. This conclusion is consistent with Kitchin (2017), who argues that data analytics and machine learning technologies are transforming the management of public institutions by enabling evidence-based decision-making. Likewise, Berk et al. (2021) highlight that predictive models can be integrated into institutional management systems to enhance risk prevention and optimize resource utilization in security environments.

CONCLUSIONS

The implementation of a predictive model based on Recurrent Neural Networks (RNN) at the Puerto Maldonado Penitentiary Establishment demonstrated high effectiveness in anticipating and significantly reducing the occurrence of critical incidents, consolidating itself as a strategic artificial intelligence tool for contemporary penitentiary management.

The comparative analysis between the periods prior to and following the implementation of the model revealed a 46% reduction in the total frequency of recorded incidents. This result confirms the system's capacity to operate preventively against historically recurrent risk patterns, thereby strengthening evidence-based decision-making.

Likewise, the incident response time indicator showed substantial improvement. The average response time decreased from more than 90 minutes to less than 50 minutes, contributing to a reduction in event severity, exposure to risk among penitentiary staff, and levels of internal destabilization. This finding reflects an effective transition from a reactive approach to an anticipatory management model grounded in predictive analytics.

The analysis of incident distribution by time slot enabled the identification of critical periods such as the 11:00 to 13:00 time window during which a reduction of up to 52% in the frequency of events was achieved. This evidence facilitated the optimization of human resource allocation and the strengthening of supervision mechanisms during periods of greater operational vulnerability.

The results obtained validate that the RNN model is not only functional in complex contexts such as Madre de Dios, but also demonstrates strong scalability potential to other penitentiary establishments in the country, provided that digitized records and appropriate data management processes are available.

Overall, this research provides solid empirical evidence on the use of artificial intelligence as an instrument for governance, prevention, and the strengthening of penitentiary security. These findings are aligned with public policies aimed at the digital transformation of the justice system and the modernization of social reintegration processes in Peru, promoting a more efficient, strategic, and scientifically evidence-based penitentiary management.

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CARBON MONOXIDE AND ITS PROBLEMS IN THE USE OF TRADITIONAL STOVES IN CAMATA (A CONCENTRATION ASSESSMENT)

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ABSTRACT

The environmental problem of high carbon monoxide (CO) concentrations in rural homes poses a serious risk to human health, particularly in the Camata sector of the Platería district, Puno province, where the traditional use of firewood, dung, and dry wood in kitchens without adequate ventilation generates emissions that affect residents in adobe houses. This research aims to identify and analyze these concentrations in 12 randomly selected homes over a 24-hour period, using a quantitative, exploratory, descriptive, non-experimental approach. This study was conducted in homes with traditional stoves, using a portable CO recorder that captured data every minute. The data was tabulated as averages over 15 minutes, 1 hour, and 8 hours, as well as maximum minute readings, considering exposure limits according to international organizations. Data analysis, using averages and percentages, reveals higher concentrations in the mornings (67% and 83% of homes exceeded limits over 15 minutes and 1 hour, respectively; 33% and 25% over 8 hours), with peaks reaching 716 ppm, accompanied by symptoms such as headaches and dizziness. In conclusion, the high CO Traditional kitchens pose a silent danger to public health in Camata, justifying urgent interventions in ventilation.

Keywords: Housing, Carbon Monoxide Concentration, Health, Diseases, Limit Values.

INTRODUCTION

The problem addressed in this study focuses on the high emission of carbon monoxide (CO) in homes in the Camata area, Platería district (Peru), where the use of biomass in rustic stoves, coupled with poor ventilation and precarious construction conditions, generates dangerous concentrations that contribute to hypoxia and respiratory illnesses, especially in high Andean contexts (MINAM, 2023). Within this framework, the study seeks to analyze the CO concentrations recorded in 2013, providing local evidence on the exposure of the residents and linking the environmental problem to its health effects, in order to demonstrate the relevance of this risk in rural communities of Puno.

Indoor concentrations of pollutants such as carbon monoxide often exceed those of the outdoor environment due to internal sources and inadequate ventilation (Guardino X., 2003). This situation is exacerbated in high Andean communities that depend on biomass for cooking and heating, intensifying indoor CO exposure (Ramirez M., 2023). In the Camata area, the traditional kitchen structure is based on adobe materials, using firewood, dung, dried plants, and dry wood for fuel.

Updated data estimate that 2.1 billion people (25-27% of the world's population) rely on solid fuels for cooking/heating, generating CO₂ through incomplete combustion (WHO, 2025 ;IEA, 2024), with public health impacts such as brain and heart damage (CDC Health Alert Network, 2021; Ministerio de Salud de la Nación, 2025). Statistics confirm 9 mg/m³ as the 8-hour limit, but in rural Peru, thresholds are exceeded, justifying scientific and social urgency (OMS, 2006).

(WHO, 2025) and (Smith K., 2005) analyze the strict WHO limits and the health risks in developing countries from inefficient solid fuel cookstoves, but do not address the technical variability among traditional stoves.

(Brook et al., 2004) link urban outdoor CO₂ to cardiovascular diseases, while (Guardino X., 2003), (Blondeau, 2005) and (Wu & Takaro, 2007) emphasize poor ventilation in indoor environments; this work extends these findings to rural dwellings in Platería, integrating previously unavailable local data.

(Piantadosi A., 2002) describes the pathophysiological mechanisms of lethal CO poisoning, while (Fine et al., 2002) characterize ultrafine emissions (soot) from biomass combustion; this study contributes quantitative measurements of indoor CO in rural high-Andean dwellings in Camata/Platería, Puno, data which were previously unavailable.

(INSTH, 2010) and (Carballo B. et al., 2010) establish limits of 20 and 50 ppm (8h) as determined by OSHA (USA), protecting workers; here, these limits are applied to the rural non-working population, innovating in community health with an emphasis on chronic effects (Murcia-Salud, 2007;OMS, 2006).

For this study, the following was considered: Exposure limit values according to International Organizations for carbon monoxide in parts per million (ppm) for 8h exposures and for short duration exposures for 15 min provided by different institutions:(Table 1)) (Carballo B. et al., 2010;INSTH, 2010;WorkSafeBC, 2026).The threshold value that should not be exceeded at any time during the workday.

Table 1
Exposure limit values

Country	Standard	Daily exposure (8h)	Short-term exposure (15 min)
USA	OSHA (PELs)	50	
USA	NIOSH (RELs)	35	200g
USA	ACGIH (TLV)	25	
Australia	NOSH (OES)	30	
Canadá	OHSR (PEVs)	25	100
España	INSHT (VLA)	20	100g

Exposure to carbon monoxide produces acute effects: headache, dizziness, fatigue, drowsiness, hallucinations, seizures, confusion, loss of vision/consciousness. Extreme effects: carboxyhemoglobinemia (bright red skin, shortness of breath, collapse, coma, death). It inhibits cellular oxidation (hypoxia).

Mild manifestations include: frontal/temporal pain, fatigue, shortness of breath, dizziness; it aggravates heart conditions (heart attack). Moderate manifestations include: severe pain, nausea, vomiting, syncope, tachycardia, ataxia, tinnitus, hallucinations. Severe manifestations include: seizures, incontinence, dysrhythmias, pulmonary edema, coma, death.

Short to medium-term effects (days later) may also include: vegetative state, parkinsonism, amnesia, dementia, psychosis, spasms, blindness, irritability/aggression. Chronic (months/years): cardiac/nerve damage, fetal risks in pregnancy (Murcia-Salud, 2007).

MATERIALS AND METHODS

This study employed a quantitative, exploratory approach, utilizing a descriptive field design based on the collection of numerical data on carbon monoxide (CO) concentrations in 12 randomly selected homes in the community of Camata, Platería district, Puno (3850 m above sea level). A 24-hour continuous monitoring system was used, employing a CO-USB cataloger. This system generated 1440 daily replicates distributed across three periods: morning (4:30 am to 12:00 pm), afternoon (12:01 pm to 5:59 pm), and evening (6:00 pm to 11:59 pm). The device was positioned 1.5 meters above the ground, with georeferenced readings recorded in UTM-WGS84 coordinates using GPS. Data were processed in Microsoft Excel® with downloads at 15 minutes, 1 hour, and 8 hours, allowing for temporal comparisons. The instrumentation included the CO-USB datalogger (ppm), WIN-USB software for download and analysis, and Garmin GPS for georeferencing, complemented with auxiliary transport material and stationery.

RESULTS AND DISCUSSION

The results shown in the following table, which displays the highest concentrations recorded in 15 minutes (Table 1), 1 hour (Table 2), and 8 hours (Table 3), with the maximum concentrations occurring in one minute, were analyzed and compared according to Air Quality Standards, carbon monoxide (CO) exposure limits established by International Organizations, WHO Recommended Indicative Values, and Health Threshold Limits. The following results were obtained:

Table 2

Average highest CO concentrations in ppm over 15 minutes, emitted in homes in the Camata area.

CODE	TIME	AVERAGE IN 15 MINUTES
CO 1	18:42 a 18:56	405.56
CO 2	05:02 a 5:17	314.5
CO 3	8:31 a 8:45	617.67
CO 4	8:52 a 9:06	105.83
CO 5	8:05 a 8:19	1.3
CO 6	6:08 a 6:22	142.97
CO 7	19:04 a 19:18	83.97
CO 8	12:08 a 12:21	68.4
CO 9	11:29 a 11:43	4.167
CO 10	9:33 a 9:47	122.9
CO 11	17:10 a 17:24	139.5
CO 12	9:14 a 9:28	59.87

The highest carbon monoxide concentrations in 15 minutes occurred in the morning, with 67% of residents in the evaluated homes exceeding the 2.5% carboxyhemoglobin level in 15 minutes, according to the WHO. 91.67% of those who breathed 30 ppm of carbon monoxide in 15 minutes is equivalent to smoking 20 cigarettes.

Table 3

Average of the highest CO concentrations in ppm in 1 hour, emitted in homes.

CODE	TIME	AVERAGE IN 1 HOUR
CO 1	6:57 a 07:56	346.5
CO 2	4:33 a 05:32:	245.63
CO 3	7:30 a 08:30	525.27
CO 4	8:37 a 09:36	69.23
CO 5	8:05 a 09:04	0.35
CO 6	6:08 a 07:07	86.83
CO 7	19:04 a 20:03	52.47
CO 8	12:00 a 13:01	32.04
CO 9	10:59 a 11:58	1.04
CO 10	9:48 a 10:47	54.67
CO 11	07:25 a 08:24	83.09
CO 12	9:14 a 10:13	27.12

The highest carbon monoxide concentrations over 1 hour also occurred in the morning, with 83% of residents experiencing 30 ppm of carbon monoxide, equivalent to smoking 20 cigarettes a day, according to Murcia-Salud, and exceeding the 2.5% carboxyhemoglobin level (1 hour) according to the WHO. 83% of the homes evaluated exceed the Environmental Quality Standard (ECA) for 1 hour.

Table 4

Averages of the highest CO concentrations in ppm over 8 hours, emitted in homes.

CODE	TIME	AVERAGE IN 8 HOURS
CO 1	15:57 a 23:56	122.73
CO 2	22:33 a 6:32	91.12
CO 3	5:31 a 13:30	243.69
CO 4	6:37 a 14:36	15.01
CO 5	7:05 a 15:04	0.04
CO 6	00:07 a 8:07	32.03
CO 7	17:04 a 1:03	10.48
CO 8	5:01 a 13:00	4.90
CO 9	10:59 a 18:58	0.13
CO 10	7:48 a 15:47	13.35
CO 11	16:25 a 00:24	20.12
CO 12	8:14 a 16:13	5.87

Over an 8-hour period, 33% of homes exceeded the carbon monoxide exposure levels established by ACGIH, NIOSH, and INSHT. 25% of homes exceeded the levels established by OSHA, NIOSH, and OHSR. Forty-two percent of the population exposed to 30 ppm of carbon monoxide for 8 hours, this is equivalent to smoking 20 cigarettes a day, and 75% exceeded the carboxyhemoglobin level for 8 hours according to the WHO. 66% of the homes evaluated exceeded the Environmental Quality Standard (ECA) for 8 hours. The highest carbon monoxide concentrations occurred in the morning, with 67% of homes in the Camata sector, Platería District, Puno Province, experiencing the highest emissions.

The peak carbon monoxide concentrations were recorded in the morning, with 67% of homes in the Camata sector, Platería District, Puno Province, registering the highest levels.

According to the results of tables 2, 3 and 4, 8% of the people living in the evaluated homes have presented a slight headache, nausea, vertigo and mental symptoms according to Murcia-Salud due to CO exposure; as well as people who have heart disease may suffer a worsening either in any of its stages of 15 minutes, 1 hour and 8 hours.

DISCUSSION

When burning fuels indoors for cooking or heating, the pollutants resulting from incomplete combustion can significantly leak into the indoor space, causing high levels of air pollution and health risks (Men et al., 2025), which are common and indeed harmful.

The highest CO concentrations in one hour occurred in the morning (83%), but (Sánchez M. et al., 2022) indicate that 14% of the concentrations are due to the amount of firewood consumed per person, increasing the carbon monoxide concentration by 442.62 ppm. This suggests that CO concentration is not only affected by the time of day, but also by needs, food preparation processes, cooking emergencies, etc.

Organizations such as ACGIH, NIOSH, and INSHT indicate that 33% of homes exceed CO concentrations, and 25% exceed the levels recommended by OSHA, NIOSH, and OHSR. Furthermore, 75% exceed the carboxyhemoglobin level for 8 hours according to WHO guidelines. 66% of the homes evaluated exceed the Environmental Quality Standard (ECA) for 8 hours. However, according to (Chavarria A., 2015), 94% of women use stoves more than once a day, being exposed for 5 to 10 hours daily. This suggests an adaptive system or human resistance to cooking with firewood, particularly among women in Guatemala.

Rural households depend entirely on biomass, exceeding the values recommended by the WHO (Enyew et al., 2023). Both studies concur, indicating that people exposed to this are vulnerable to health risks, which can be exacerbated by the duration of exposure.

Eight percent have experienced mild headaches, nausea, vertigo, and mental symptoms, according to (Murcia-Salud, 2007), (Hwang et al., 2025) indicate that there is a greater risk of migraines over time due to carbon monoxide exposure, as well as a worsening of heart conditions. Poverty is a contributing factor, particularly in areas where gas stoves are used and traditional cooking methods are employed, such as using wood, dung, dried plants, and other fuels, without ventilation ducts or windows. Furthermore, (Halder et al., 2024) indicate that lung disease, cough, diabetes, and depression related to CO exposure are associated with a higher likelihood of poor sexual health in India, where it impacts not only lifestyle habits but also reproduction.

According to (Cai et al., 2023), each 1 mg/m³ increase in CO concentration is associated with a 14% increase in respiratory illnesses (asthma, COPD, upper respiratory tract infections, and pneumonia/influenza). This underscores the need for further studies on the impact of industry on health to verify the incidence and mortality rates in different countries.

CONCLUSIONS

The problem of carbon monoxide air pollution in adobe houses in the Camata sector of Puno is strongly linked to poverty and construction with rustic materials lacking adequate ventilation, which exacerbates the health risks for occupants. In these homes, the use of traditional stoves that burn firewood and dung generates high concentrations of carbon monoxide,

with significant peaks detected mainly in the morning (67% for 15 minutes, 83% for 1 hour). According to international standards, 29% of homes exceed acceptable exposure limits, and 75% exceed permitted concentrations for short periods, reflecting a serious environmental and health problem. This exposure results in high levels of carboxyhemoglobin in 75% of the population, with frequent symptoms such as headaches, nausea, dizziness, and effects comparable to smoking 20 cigarettes a day, highlighting a silent risk to public health in the region. Interventions that improve housing conditions and promote cleaner combustion are urgently needed to mitigate these negative consequences.

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COMMUNITY AGROFESTIVAL CALENDAR TO STRENGTHEN LEARNING AT THE TAQUILE SECONDARY CRAFT SCHOOL, 2026.

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ABSTRACT

The communal calendar is an integral expression of ancestral peasant knowledge, rooted in a profound connection with nature and the cosmos. This calendar guides agricultural activities such as sowing and crop management within a framework of mutual nurturing with the land. To identify how the communal agro-festive calendar contributes to student learning, a qualitative ethnographic study was conducted with a sample of 2nd and 5th-grade students. Data collection involved learning guides, ethnographic community records, and participant observation of agricultural activities and rituals. The results indicate that the agricultural festival calendar in the community of Taquile plays a fundamental role in strengthening student learning by promoting practical skills, such as oral and written communication, alongside essential values like environmental stewardship. Furthermore, festivities and rituals such as San Isidro and Carnivals, integrating spirituality, agriculture, and social cohesion, fostering cultural identity and connecting students with natural cycles. Notably, the textile art of the calendar sash serves as a vital educational tool that symbolizes these cycles, ensuring the intergenerational transmission of ancestral knowledge. In conclusion, the agro-festive calendar not only fosters comprehensive learning but also secures the continuity of traditions among younger generations.

Keywords: Learning, agricultural calendar, Andean culture, cultural identity, ancestral knowledge.

INTRODUCTION

In our society, exogenous cultural legacies of aristocratic and colonialist domination persist. Internalized by the population particularly by students and rural communities these legacies perpetuate ideological and cultural conceptions of the past, often intersecting with the alienating elements of contemporary global consumer culture. Nevertheless, community knowledge remains resilient through productive practices, collective labor, and a harmonious relationship with nature (Alcántara, 2014).

Within the Taquilean community context, students possess prior knowledge rooted in ancestral wisdom transmitted intergenerationally through their families. This creates epistemological tensions between the globalized knowledge frameworks embedded in the formal curriculum and locally constructed community knowledge (Achata & Vilca, 2020). Such dissonance has significant implications for student learning processes, as culturally embedded forms of knowledge such as the traditional agricultural calendar are frequently marginalized or undervalued.

Consequently, students encounter difficulties in articulating school-acquired knowledge with the cultural and productive practices of their community, thereby constraining their capacity for holistic and meaningful learning (García & Cabrera, 2018).

Within the educational context, Essterman (2013) argues that the communal calendar constitutes an integral expression of ancestral peasant knowledge, grounded in a relational worldview that emphasizes interconnectedness with nature and the cosmos. This epistemological framework regulates agricultural practices such as sowing and crop stewardship within a paradigm of reciprocity and mutual sustenance between human communities and the land.

Arnold & Yapita (2017) assert that the agro-festive calendar is conceived as a key tool for developing a sense of community organization, deeply connecting people with their territory and promoting harmonious coexistence between humans and nature. Similarly, Rengifo (2008) refers to the agro-festive calendar in rural communities, alluding to the space-time events of the pacha (Andean time and space), which are closely connected to and determined by the annual solar cycle. This annual cycle integrates a diversity of climatic, agricultural, astronomical, festive, ritual, and organizational phenomena. These are expressed as a sequence of interrelated activities that unfold continuously, forming a chain of sequential events (Flores, 1990).

Consequently, students encounter difficulties in articulating school-acquired knowledge with the cultural and productive practices of their community, thereby constraining their capacity for holistic and meaningful learning (García & Cabrera, 2018).

Within this educational context, Estermann (2013) argues that the communal calendar constitutes an integral expression of ancestral peasant knowledge, grounded in a relational worldview that emphasizes interconnectedness with nature and the cosmos. This epistemological framework regulates agricultural practices such as sowing and crop stewardship within a paradigm of reciprocity and mutual sustenance between human communities and the land.

Arnold and Yapita (2017) assert that the agro-festive calendar is a key tool for developing community organization, deeply connecting individuals with their territory and promoting harmonious coexistence with the environment. Similarly, Rengifo (2008) describes the agro-festive calendar in rural communities as an embodiment of the Pacha (Andean space-time), which is intimately linked to and determined by the annual solar cycle. This cycle integrates a diversity of climatic, agricultural, astronomical, and ritual phenomena, expressed as a sequence of interrelated activities that form a continuous chain of sequential events (Flores, 1990).

Regarding this, Guilcamaigua and Chancuisid (2008) argue that the communal calendar is conceptualized as “agro-festive” because life in Andean communities is fundamentally organized around agricultural and artisanal activities, each accompanied by its corresponding ritual practices. This framework reflects not only the sociocultural life cycle of the community but also the cyclical processes governing animals, plants, and the broader natural environment, thereby integrating productive, spiritual, and ecological dimensions into a coherent worldview.

In this regard, Mayer (2002) draws an analogy between the care devoted to agricultural fields and the nurturing of a human being, comparing the developmental process of crops to that of a child. This metaphor underscores the affective, ethical, and relational dimensions embedded in Andean agrarian practices, wherein cultivation is conceived not merely as an economic activity but as a reciprocal, life-sustaining relationship between humans and the land.

Conversely, Maurial (2021) identifies the coexistence of two distinct epistemological frameworks within rural communities: indigenous knowledge systems and formal school-based knowledge. The latter is generally transmitted through abstract and predominantly passive pedagogical models, where the teacher assumes a central and often unilateral role in the instructional process.

Bidaseca and Vommaro (2023) conceptualize agroecology as a form of harmonious resistance that reconfigures the relationship between human societies and nature, emphasizing sustainability, reciprocity, and ecological balance. Similarly, Iño (2022) examines how Aymara communities in the Bolivian highlands mobilize ancestral knowledge to adapt to environmental conditions, underscoring the critical role of local wisdom in natural resource management and its contribution to environmental sustainability.

In the same vein, Inquilla and Apaza (2021) highlight the significance of biodiversity and indigenous knowledge systems in safeguarding Andean epistemologies and strengthening community resilience in the face of environmental change.

Furthermore, the intergenerational transmission of ancestral and productive knowledge contributes significantly to strengthening emotional well-being, enhancing self-esteem, and fostering social recognition within community settings (MIDIS, 2018).

Villares and Villares (2011) argue that the Andean agro-festive calendar functions as a formative and pedagogical instrument for children, youth, parents, educators, and technical practitioners alike, particularly in processes related to the restoration and sustainable management of agricultural lands.

Sandí (2016) highlights those innovative pedagogical proposals such as the Wawa chakra learning environment integrate ancestral knowledge with transdisciplinary education. Based on the Andean agricultural calendar, this culturally situated pedagogical space promotes experiential learning through collective knowledge, strengthening the bonds between participants and the natural environment.

In this regard, Schmidt (2006) demonstrated that competency development necessitates prioritizing learning processes over mere instructional delivery, thereby strengthening cognitive and practical skills, as well as attitudinal dispositions, through integrated and systematic pedagogical strategies.

Similarly, Villares and Villares (2011) argue that the transmission of Andean knowledge structured around the agricultural calendar and supported by demonstration plots fosters agrodiversity, ecological justice, and harmonious coexistence between human societies and the natural environment. This integrative approach articulates tradition and modernity, reinforcing environmental education within a culturally grounded and sustainability-oriented framework.

Conversely, Bustinza and Quispe (2024), together with Chávez et al. (2023), underscore the imperative of integrating ancestral knowledge systems into educational practice. Specifically, Bustinza and Quispe (2024) propose the agro-festive calendar as a pedagogical instrument aimed at strengthening students' cultural identity, while Chávez et al. (2023) demonstrate that its incorporation into classroom dynamics enhances students' engagement with their cultural traditions.

Similarly, Campos (2003) emphasizes the relevance of embedding Andean knowledge within educational activities such as literacy primers and community radio programming highlighting rural lived experience as a fundamental pedagogical resource. Collectively, these authors converge on the premise that educational processes should be grounded in students' cultural roots to foster meaningful, contextually situated, and transformative learning.

At a broader analytical level, Alcántara (2014) and Lozano (2021) assert that educational processes must be rooted in community-based knowledge systems. Alcántara (2014) underscores how Andean ethics and cosmology regulate the interaction between human beings and their environment in Taquile, emphasizing a relational ontology that structures social and ecological practices. Similarly, Lozano (2021) argues that intercultural bilingual education should be rooted in the promotion of biological diversity and the integration of human–nature relationships as foundational pedagogical principles.

Nevertheless, nuances emerge in their specific approaches to cultural expression. For instance, Bellenger (2015) examines the Andean worldview through its musical expressions, highlighting how ritual performance and music embody the symbolic relationship between the cosmos and community life. In contrast, Ortiz (2014) centers on the symbolism of the Taquile calendar belt, interpreting its woven ideograms as representations of Andean beliefs, cosmology, and social organization. Although both scholars recognize these manifestations as fundamental to collective identity, they focus on different semiotic channels: musical performance in one case and textile iconography in the other.

MATERIALS AND METHODS

This study employed a qualitative methodology grounded in an ethnographic design with a descriptive orientation to examine the pedagogical role of the communal agro-festive calendar in fostering culturally contextualized learning among students at the “Institución Educativa Secundaria Artesanal Taquile”. The ethnographic approach enabled an in-depth exploration of the sociocultural meanings and educational practices embedded within the community's daily life.

Access to the research setting was secured through formal authorization from the school administration, in coordination with the Parents' Association (APAFA) and the teaching staff. The objectives and ethical considerations of the study were clearly communicated to participants to ensure informed consent and institutional collaboration. Prolonged engagement in the field facilitated contextual immersion and enhanced the credibility and trustworthiness of the findings.

Participants were selected through purposive sampling, focusing on individuals with active involvement in agro-festive activities and experiential knowledge of ancestral agricultural practices. The sample consisted of ten fifth-grade secondary students, identified as key informants due to their role in the intergenerational transmission of communal knowledge.

Data collection methods included semi-structured interviews and participant observation, supported by structured protocols aligned with the research objectives. Fieldwork was conducted during both classroom sessions and agro-festive communal events, during which systematic field notes were recorded. Data were analyzed using thematic analysis, involving iterative coding and categorization to identify recurrent patterns, shared meanings, and cultural representations associated with the integration of the communal calendar into formal educational processes.

RESULTS AND DISCUSSION

The results, as well as the main concepts and ideas used in this qualitative research, can be synthesized and represented using effective resource tables:

Table 1

Community Agro-festive and Learning Calendar

Category	Subcategory	Indicators	Instruments
Community Agro-festive Calendar	Ancestral Knowledge	Agricultural activities, nature signs, and ritual festivities	Interviews, documentary analysis
Cultural Identity	Sense of belonging	Strengthening students understanding	Participant observation
Educational Process	Student empowerment	School reinforcement and metagognition	Participant observation
Pedagogical Strengthening	Curricular contextualization	Integration of the community calendar	Interviews and social groups.

First Specific Objective

The aim is to describe the ancestral knowledge embedded in the agricultural calendar and its contribution to learning at the Taquile Secondary Artisanal Educational Institution in 2026. This calendar guides sustainable practices, involves students in agricultural tasks and rituals to Pachamama, and transmits ecological values through symbolic representations in the “calendar belt.”

Second Specific Objective

The objective is to identify the festivities and rituals that strengthen learning in Taquile. These celebrations act as pedagogical tools that reinforce cultural identity and environmental connection, while transmitting communal values and preserving intangible heritage. Major festivities such as San Isidro, the Feast of the Cross, and Carnival integrate spirituality with agricultural cycles, complemented by symbolic acts like pijcheo, challa, and the ritual use of coca leaves.

Third Specific Objective

The goal is to describe the significance of textile art in the Taquile calendar sash (calendario faja) and its role in learning. Students develop weaving skills through family-based observation of mothers and grandmothers working with alpaca or sheep wool and traditional tools, fostering appreciation of raw materials and mastery of complex techniques, thereby strengthening cultural transmission.

DISCUSSION

The seed festival, as a pillar of the agro-festive calendar, serves as a vital pedagogical bridge by integrating ancestral knowledge into the formal learning process. The findings of this study align with existing literature suggesting that such festivities strengthen cultural identity and

foster an inclusive educational environment. Specifically, Schmidt (2006) emphasizes that the integration of localized knowledge and attitudes significantly improves the comprehension of communal customs. This is complemented by Villeras and Villera (2011), who argue that agro-festive calendars act as catalysts for student motivation, promoting deeper, more meaningful learning experiences.

Furthermore, the ethical dimension of this education is highlighted by Alcantara (2014), who notes that the Andean worldview regulates the symbiotic relationship between the Taquileño people and their environment. This perspective is reinforced by Lozano (2021), who advocates for an intercultural bilingual education rooted in biological diversity and a harmonious relationship with nature. Both authors converge on the idea that traditional values are indispensable for sustainable education. Recent studies by Bustinza and Quispe (2024) and Chavez et al. (2023) further validate that these calendars are not merely pedagogical tools but essential mechanisms for revitalizing identity through community-wide involvement. Finally, as Rengifo (2008) suggests, anchoring formal knowledge in the “everyday life” of the Andean worldview ensures that learning remains relevant and culturally grounded.

CONCLUSIONS

The ritual agro-festive cycle in the Taquile community, inextricably linked to music and ancestral melodies, plays a foundational role in developing essential social skills. This study demonstrates that these practices foster empathy, active listening, assertiveness, and teamwork competencies that are vital for holistic educational development. Furthermore, the calendar sash emerges as a central pedagogical instrument for cultural transmission; it facilitates a deep understanding of natural cycles and their symbiotic relationship with agricultural activities, festivities, and rituals of gratitude, thereby securing both cultural identity and ecological balance.

This textile masterpiece serves as a living record of Taquileño history and daily life, utilizing iconographic symbols organized into twelve distinct sections that represent the months of the year and the seasonal agricultural stages. While its use significantly strengthens the bond between students and their communal heritage, a critical finding persists: although educators and students recognize the value of this cultural approach, parents advocate for a more systematic and integrated curriculum.

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THE PROCEDURE “DELIVERY, ACCOUNTING, AND CONTROL OF ELECTRICAL MATERIALS AND SUPPLIES” AND ITS IMPACT ON THE ASSET MANAGEMENT DEPARTMENT OF ELECTRO PUNO S.A.A. - 2021

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ABSTRACT

The study examines the persistent failure to account for supplies at Electro Puno S.A.A., a situation that affects the Asset Management Department by delaying the achievement of its objectives and creating additional work to reconcile information and report it to the Accounting Department. Although there is an approved procedure for controlling materials and supplies, it has not yielded the expected results. The main problem stems from non-compliance by technical staff, leading to an accumulation of unreconciled supplies and reduced operational efficiency. The specific objectives were to analyze how the reconciliation of electrical supplies is carried out in the Asset Management Department, evaluate the discrepancies in the reconciliations and their impact on the department's results, and propose improvements, including the use of a software application within the procedure to increase efficiency. The research was conducted using a quantitative approach, focused on the collection and analysis of measurable data through structured instruments such as questionnaires, observation forms, and documentation forms. The sample consisted of 82 employees. The results show that more than 20% of the reports are not submitted. Errors were also identified in the creation of the inventory and in the order of supply issuance. Only 53% of employees submit reports in accordance with the procedure, and only 16% do so by the deadline. Furthermore, consumption is recorded for all supplies withdrawn.

Keywords: Debits, asset management, procedure, reporting, supplies Introduction

INTRODUCTION

This research arises from the recurring failure of company employees to properly account for supplies, a situation that hinders the achievement of optimal monthly results and leads to the gradual accumulation of unreported materials. This problem has affected the Asset Management Department of Electro Puno S.A.A., limiting the timely fulfilment of annual objectives and requiring the analyst to perform additional tasks to regularize information for the Accounting Department, thereby reducing operational efficiency and weakening internal control. Although the (Empresa Regional de Servicio Público de Electricidad de Puno S.A.A., 2022) has an approved procedure for the control of materials and supplies, the expected results have not been achieved. Persistent non-compliance in reporting electrical supplies, particularly among technical staff, continues to generate significant accumulation of unreported materials. In response, this study

proposes improvements to the “Procedure: Delivery, Reporting, and Control of Materials and Supplies,” including periodic training for new personnel, strengthened supervision mechanisms, and unannounced field inspections to verify the effective installation of supplies in feeders.

(Bartolo, 2017) “In his research, he concludes that the company is using an incorrect accounting method, which results in an increase in expenses for a given period. The control of spare parts inventory affects the company’s statement of financial position, as these items represent one of the most significant line items, and their incorrect recognition impacts cost of sales and consumption of supplies.”

(Zela, 2019) “The primary goal of a country’s economic policy is to implement responsible public policies that contribute to its development. Therefore, one of the objectives to date has been for the public sector to manage resources effectively and provide better services at lower costs.”

(Humpiri, 2018) “The supply chain is best managed by the company’s key stakeholders, with technology supporting distribution and delivery decisions.”

(Gonzales, 2020) “Now that the report is complete, we can state with certainty that the implementation and integration of a materials management system reduces costs and improves customer service. Furthermore, we recognize the risks associated with the improper management of materials and/or equipment, which can disrupt and delay production schedules, as well as create hazardous situations that jeopardize the well-being of staff. Consequently, all of this results in additional costs within the organization, which could be considered expenses.”

(Torres, 2013) “The design of documents for materials control is important because it helps to support business transactions and approvals (signatures) by the managers of each department, assuming that each will act responsibly and perform the necessary reviews in every situation.”

(Salavarría, 2010) “The General Business Chart of Accounts combines indirect materials, supplies, and spare parts into a single account. Under the Revised General Chart of Accounts, these items were recorded separately in Account 24: Raw and Auxiliary Materials (indirect materials) and Account 26: Miscellaneous Supplies. Indirect materials refer to goods used in production processes or in the provision of services.”

(KPMG, 2022) “Electro Puno S.A.A. defines its inventory as follows: inventory consists of materials, auxiliary items, supplies, and spare parts held in warehouses, used for the maintenance of distribution substations and electrical installations in general, and is stated at the lower of cost and net realizable value, using the weighted-average method. The company records an allowance for the impairment of materials against the period’s results in cases where the carrying amount exceeds its recoverable amount, based on a technical analysis performed by management, which includes the physical condition of the asset.”

(Superintendencia de Mercado de Valores, 2022) “Auxiliary materials, supplies, and spare parts consist of items used for the operation and maintenance of electrical installations, which are consumed during the current period. The company must provide maintenance and replacement services for residential connections when necessary, an activity that is performed periodically using supplies, third-party services, its own personnel, and other associated costs. These costs must be charged to the deferred liability that the company records at the time of recognition;

likewise, upon providing the service, the company must recognize the corresponding revenue, given that there is a transfer of control to the customers.”

According to (Superintendencia Nacional de Bienes Estatales, 2014), “The objectives of asset management include establishing a record-keeping system and conducting audits to identify and document all assets that make up the entity’s assets, as well as keeping those records up to date.”

(Empresa Regional de Servicio Público de Electricidad de Puno S.A.A., 2022) “The procedure establishes the phases for the delivery, handover, and control of materials and supplies, which allow management to incorporate the methods currently used by the company; these methods must be included in the quality management system.”

(Sema, 2025) “Finally, it is concluded that inventory control has a positive impact on the profitability of a retail business, since the lack of proper tracking of shortages and surpluses, as well as incorrect or incomplete recording of information, distorts logistics results, which negatively impacts finances.”

(Mamani, 2020) “The importance of having a verified physical inventory and an up-to-date inventory database is recognized, as it serves as a reference tool to meet order demand.”

MATERIALS AND METHODS

The research was conducted using a quantitative approach, focused on the collection and analysis of measurable data using structured instruments such as questionnaires, observation forms, and documentation forms. This approach made it possible to quantify information related to the procedure for “Delivery, accountability, and control of materials and supplies” in the Asset Management Area, facilitating statistical processing, hypothesis testing, and the formulation of conclusions based on empirical evidence. The study population consisted of workers who collect supplies at Electro Puno S.A.A., and the sample was a census sample, comprising 82 workers who handle the storage of these supplies.

The study is applied in nature, as it seeks to resolve a specific problem related to non-compliance in the rendering of supplies, proposing practical improvements to strengthen internal control and optimize administrative processes. It also has a descriptive-analytical level: descriptive, because it characterized the current situation of the procedure, identifying its stages, actors, and deficiencies; and analytical, because it examined its components, evaluated regulatory compliance, and established well-founded proposals for improvement. Descriptive, analytical, and deductive methods were used, the latter for the formulation and verification of hypotheses based on general principles applied to the case studied.

Data collection techniques included direct observation, document analysis, and surveys. Observation allowed for the identification of behaviours and situations in the area evaluated, using the observation form as an instrument.

RESULTS AND DISCUSSION

The results of this study, obtained through the application of various methods and techniques, are presented in tables organized according to specific objectives. The study analyses the settlement of electricity bills, the outstanding balances resulting from these settlements, and their impact on the results of the Equity section.

Table 1

Number of reports submitted to the Heritage Office for the accountability of electrical supplies.

2021	Quantity	Percentage
Total reports to be submitted	451	100%
Submitted reports	352	78%
Unsubmitted reports	99	22%

Note. Survey conducted at Electro Puno S.A.A.

Table 2

Review of the generation of supply reservations.

2021	Quantity	Percentage
Workers who correctly generate reservations	69	84%
Workers who make errors in generating reservations	13	16%
Total	82	100%

Note. Survey conducted at Electro Puno S.A.A.

Table 3

Review of orders used for the withdrawal of supplies.

2021	Soles	Percentage
Withdrawal of supplies with correct order	S/ 4,531,326.43	97%
Withdrawal of supplies with incorrect order	S/ 140,352.77	3%
Total supplies withdrawn from the warehouse	S/ 4,671,679.20	100%

Note. Survey conducted at Electro Puno S.A.A.

Table 4*Time required for report submission.*

	Quantity	Percentage
1 to 6 days	13	16%
1 to 3 weeks	26	32%
1 to 3 months	23	28%
More than 3 months	20	24%
Other (specify)	0	0%
Total	82	100%

Note. Survey conducted at Electro Puno S.A.A.**Table 5***Outstanding reports not submitted.*

2021	Amount (PEN)	Percentage
Supplies returned and/or re-entered into the warehouse	S/ 973,495.68	21%
Supplies accounted for through reports	S/ 2,985,322.52	64%
Supplies pending reporting	S/ 712,861.00	15%
Total	4,671,679.20	100%

Note. Survey conducted at Electro Puno S.A.A.**Table 6***Details of supply consumption.*

Item	2021	2020
Electrical supplies	S/ 3,698,183.52	S/ 2,201,500.40
Other supplies	S/ 602,623.76	S/ 97,589.63
Total	S/ 4,300,807.28	S/ 2,299,090.03

Note. Survey conducted at Electro Puno S.A.A.

Table 7

Electric supplies consumption.

Item	2021	Percentage	2020	Percentage
Total supplies withdrawn from warehouse	S/ 4,671,679.20	100%	S/ 2,688,720.71	100%
Returned to warehouse	S/ 973,495.68	21%	S/ 487,220.31	18%
Total electrical supplies consumed	S/ 3,698,183.52	79%	S/ 2,201,500.40	82%

Note. Survey conducted at Electro Puno S.A.A.

According to Table 1, in 2021, 22% of employees failed to submit their reports, complicating the work of the asset analyst and requiring management to issue memos. According to Table 2, 16% of employees made errors in generating reserves, mainly due to staff changes, which makes it difficult for the asset analyst to identify those responsible and request corrections. According to Table 3, 3% of supply withdrawals had incorrect orders, a reduction achieved through asset supervision, although the analyst must continue to correct errors in SAP. According to Table 4, only 16% of employees submit electrical supply accountability reports on time within the established deadline, while 84% do so after the deadline; reports received late cannot be recorded in the SAP ERP and remain solely as internal controls for the department. According to Table 5, in 2021, 15% of the total, equivalent to S/ 712,861.00, was pending accountability; these amounts were not reported in a report nor returned to the warehouse, so they are reflected in the asset management area's records as outstanding debts pending accountability by the workers. According to Table 7, the consumption of electrical supplies was 82% in 2020 and 79% in 2021, relative to the total number of supplies removed from the warehouse; however, this calculation is based on the total number of items removed, which may result in an inaccurate figure when reporting supply consumption in the financial statements.

(KPMG, 2022) "Electro Puno S.A.A. defines inventory as follows: Inventory consists of materials, auxiliary items, supplies, and spare parts held in warehouses, used for the maintenance of distribution substations and electrical installations in general, and is reported at the lower of cost or net realizable value, using the average cost method."

Torres (2013) "The design of the document used to track materials is important because it helps document business transactions and the approvals (signatures) of the managers in each department, on the understanding that each will act responsibly and perform the necessary reviews in every situation."

(Bartolo, 2017) "The investigation concludes that the company is using an incorrect accounting method, which results in an increase in expenses for a given period. The control of spare parts inventory affects the company's statement of financial position, as these items represent one of the most significant line items and their incorrect recognition impacts cost of sales."

(Humpiri, 2018) "The supply chain is managed more efficiently by the company's key stakeholders, with technology supporting distribution and delivery decisions."

CONCLUSIONS

Based on the results obtained, it is concluded that the inventory analyst responsible for managing inventory reports spends more time than expected, as they must identify missing reports and request them again. Furthermore, when errors occur in reservations or orders, it is difficult to locate the correct recipient in the SAP ERP system, which requires coordination with the warehouse department to make the corrections. Consequently, these non-compliances and errors increase the time required for the process.

It is also concluded that the asset analyst, in addition to reviewing and requesting overdue reports, must send repeated reminders to ensure that employees submit them on time, as these reports must be submitted monthly to the accounting department for review. However, many reports are submitted after the deadline, which requires the analyst to follow up on their submission and results in a greater time burden. Furthermore, the consumption of supplies is recorded based on the total amount removed from the warehouse, which can distort the results in the financial statements, as items that have not been used or supported by a report are also recorded as consumed.

Finally, it is concluded that improvements need to be made to the current procedure, including training, unannounced inspections, and the implementation of the Survey app. This app would allow for the collection of information regarding the generated reservation, the order, the cost centre, and the feeder data where the supplies are installed, as well as the creation of a photographic record. In this way, the property management department would have greater certainty that the supplies are indeed installed in the various feeders.

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THE NEED FOR INTERCULTURAL EDUCATION PROMOTED BY REGIONAL INITIATIVES TO ADVANCE EDUCATIONAL DECENTRALIZATION IN PERU

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ABSTRACT

The study analyzed the need to promote intercultural education promoted by the regions as a strategy to strengthen educational decentralization in Peru. It was based on the recognition of the cultural and linguistic diversity of the country and the limitations presented by a centralized educational model to respond to local realities. The objective was to examine the extent to which regional protagonism contributed to a more relevant, inclusive and contextualized educational management, the research was developed under a qualitative approach, with a descriptive-analytical design. A documentary review of regulations, academic research and institutional reports on decentralization and intercultural education was carried out. Likewise, regional experiences were analyzed, considering criteria such as community participation, curricular adaptation and institutional strengthening. The information was systematized through content analysis, the results showed that the initiatives promoted from the regions favored a greater incorporation of local knowledge in the curriculum and promoted a more active participation of the educational communities. It was also observed that decentralized management allowed decision-making more in line with the socio-cultural characteristics of each territory. However, limitations were identified related to insufficient resources, limited specialized teacher training, and weak intergovernmental coordination, it was concluded that intercultural education promoted from the regions constituted a key component to consolidate educational decentralization in Peru, by contributing to a more equitable, relevant and respectful education of cultural diversity.

Keywords: Bilingual, culture, decentralization, intercultural education, regions.

INTRODUCTION

Education in many regions remains a centralized process, which limits the ability to adapt to the specific needs of each community (Stephen J. Ball 1994). It argues that central governance imposes homogeneous regulatory frameworks that do not always take into account social and cultural particularities. (Michael W. Apple 2021). The decentralization of education involves transferring authority and responsibility for the planning and implementation of education policies to the regional and local levels. (Welsh and Noel F. McGinn 1999) educational decentralization implies movements of authority and responsibility in decision-making, planning, management and other functions from the central government to regional, local or school levels with varying degrees of autonomy. The change seeks to bring education management closer to contexts closer to the needs of communities and optimize the planning and implementation of educational policies.

Intercultural Bilingual Education in Peru faces the challenge of centralized management that limits the autonomy of the regions, despite their cultural diversity. This paper raises the need to decentralize educational policies to recognize the identities, aspirations and particularities of each region. The imposition of curricula, evaluation models, and management actions from the capital generates inequities, especially in territories with greater cultural wealth, which at the same time have high rates of poverty, anemia, low infrastructure, school dropouts, and migration due to economic deprivation (Bonetti et al., 2018)

In recent years, the Ministry of Education has promoted an intercultural approach through the development of materials and resources, although these often do not respond to local realities. In Puno, for example, workbooks for Aymara students are difficult to understand for teachers, while in urban areas linguistic diversity (Aymara and Quechua) makes it difficult to apply resources designed under a rigid territorial classification. Likewise, the accreditation of bilingual teachers, provided for in Law No. 27818, is not always respected, which limits adequate attention to students in their native language (Macassi Zavala, 2021; Ministry of Education, 2013).

According to Bermejo (2020), Intercultural Bilingual Education was conceived by indigenous peoples as a means to achieve significant social and educational transformation. However, after more than four decades of implementation in rural schools in Puno, the has not been able to reverse the initial conditions.

Taking into account the diversity of cultures in Peru implies differences from the thought, feeling, customs, manifestations of each culture, language, clothing, food, etc., it is understood that education must respond to the needs of each culture and it is the duty of the teacher to promote an intercultural education that responds to the improvement of his region, without neglecting their identity, the values they practice, but at the same time practicing tolerance and respect for other cultures.

MATERIALS AND METHODS

The research was developed under a qualitative approach of a descriptive-analytical type. A documentary review of national regulations related to decentralization and intercultural education was carried out, as well as academic studies and institutional reports published in recent years. Likewise, regional experiences in the implementation of intercultural educational policies were examined, considering criteria of cultural relevance, community participation and decentralized management. The information collected was systematized using the content analysis technique, which allowed the identification of categories and patterns relevant to the study.

1. Exploratory Phase:

Interviews: In-depth interviews were conducted with educators, community leaders, and students in different regions and Local Educational Management Unit Puno, to understand their experiences and perspectives on intercultural education.

Focus Groups: Focus groups were organized to discuss the challenges and opportunities of intercultural education from our region.

2. Data Collection Phase:

Surveys: Surveys were distributed to teachers and students to collect quantitative data on the level of satisfaction with intercultural education and its effects on academic performance.

Data Analysis: Statistics and data analysis were used to evaluate the effectiveness of intercultural education programs in our region.

3. Analysis Phase:

Mixed Methods: Both qualitative and quantitative data were combined to obtain a more complete view of the problem.

Triangulation: We checked the results of quantitative research with qualitative data to increase the validity of the findings.

RESULTS AND DISCUSSION

The analysis of the collected data allowed the identification of consistent patterns regarding the implementation of Intercultural Bilingual Education in decentralized contexts.

First, a significant gap was identified between national education policies and their implementation in local contexts. The interviewed teachers indicated that the educational materials provided do not reflect the linguistic or cultural realities of their students, especially in areas where Aymara and Quechua coexist. This situation creates difficulties in pedagogical planning and reduces the effectiveness of the teaching–learning process.

Second, survey results showed a moderate to low level of teacher satisfaction with IBE, mainly associated with the lack of relevant training and limited context-based pedagogical support. Likewise, students reported difficulties in understanding content when it is not delivered in their mother tongue.

Another relevant finding was the weak implementation of bilingual teacher certification, which directly affects the quality of intercultural education. In several cases, it was found that teachers do not fully master the predominant native language of the community.

On the other hand, the regional experiences analyzed showed that initiatives with greater community participation tend to achieve better educational outcomes. The inclusion of local knowledge, cultural practices, and community actors enhances the relevance of learning and strengthens students' cultural identity.

Finally, the triangulation of qualitative and quantitative data confirmed that centralization limits regional innovation capacity, restricting the adaptation of policies to the specific needs of each territory.

DISCUSSION

The results obtained are consistent with theoretical approaches that criticize educational centralization as an obstacle to equity and cultural relevance (Tedesco, 2000; Benavides, 2015). The evidence shows that, although efforts exist at the central level to promote interculturality, these are not effectively implemented in diverse local contexts (Ministry of Education of Peru, 2017).

The lack of adaptation of educational materials and the limited regional autonomy reflects a contradiction between the discourse of interculturality and actual educational practice (Walsh, 2009; López, 2006). In this sense, decentralization should not be understood merely as an

administrative transfer, but as a process that enables regions to design context-based educational proposals (National Council of Education of Peru, 2014).

Likewise, the limited implementation of bilingual teacher certification reveals structural weaknesses in the educational system, where regulations are not always enforced in practice (Ministry of Education of Peru, 2020). This directly affects students' right to receive education in their mother tongue and within a culturally relevant environment (UNICEF, 2016).

On the other hand, the findings highlight the value of community participation as a key element in building effective intercultural education (Freire, 1970). Successful experiences suggest that the inclusion of local actors not only improves learning outcomes but also strengthens social cohesion and cultural identity (CEPLAN, 2018).

In this context, decentralization emerges as a necessary condition for advancing toward more equitable education (Brunner, 2010). However, this process must be accompanied by institutional strengthening, teacher training, and coordination mechanisms among different levels of government (OECD, 2020).

Reflections on the Ministry of Education's Policies on Intercultural Bilingual Education:

According to Bonetti et al. (2018), it is essential to reflect on the differences between interculturality as a public policy approach and Intercultural Bilingual Education as an educational modality. This distinction represents a theoretical and political stance regarding intercultural policies. In the educational field, the concept of Intercultural Bilingual Education or interculturality is often limited to projects, plans, or policies promoted and developed by the State. These initiatives are mainly directed toward populations associated with Indigenous and/or Afro-descendant identities, typically located in rural areas. Thus, the limitation of intercultural bilingual education lies in its reduction to a state-driven plan.

Walsh (2009) argues that, since its origins, interculturality has represented a field of struggle in which issues such as cultural identity, rights, difference, autonomy, and nationhood are constantly contested. It is therefore not surprising that education constitutes a central space for this struggle, as a political, social, and cultural institution where values, attitudes, identities, and hegemonic state power are constructed and reproduced. For this reason, positioning interculturality as a central educational principle is essential. However, its development in the educational field has been marked by tensions and disputes.

According to Bermejo (2020), Intercultural Bilingual Education was conceived by Indigenous peoples as a means to achieve significant social and educational transformation. However, after more than four decades of implementation in rural schools in Puno, Intercultural Bilingual education has not been able to reverse initial conditions.

According to the National Institute of Statistics, Puno is the second region with poverty rates ranging between 32.4% and 36.1%, and extreme poverty between 7.7% and 9.8%. Furthermore, poverty disproportionately affects populations whose mother tongue is a native language, reaching 21.6% in urban areas and 44.8% in rural areas. The 2017 National Census revealed that 42.9% of the population identifies as Quechua and 27% as Aymara, totaling more than 70%. Regarding education in rural areas of Puno, only 13% of students who begin schooling complete higher education. Additionally, according to Saavedra and Suárez, out of every 1,000 children

who start primary school in Puno, only 773 complete sixth grade, with many repeating grades multiple times.

CONCLUSIONS

This research concludes that educational decentralization is a fundamental element for the development of relevant intercultural education in Peru, especially in regions with high cultural diversity such as Puno. Intercultural education from the regions is a key component, as it contributes to a more equitable, relevant, and culturally respectful education.

First, the centralization of educational policies limits the capacity to respond to local needs, generating gaps in the quality and relevance of education. Second, Intercultural Bilingual Education has not achieved the expected results due to implementation challenges, such as inadequate materials, a lack of certified bilingual teachers, and insufficient contextualization of pedagogical strategies.

Likewise, active community participation is key to improving educational outcomes, as it enables the integration of local knowledge and strengthens students' cultural identity.

Finally, it is necessary to promote regional initiatives with greater autonomy in educational decision-making, supported by policies for teacher development, the production of context-based materials, and effective monitoring mechanisms.

In summary, advancing toward high-quality intercultural education in Peru requires not only political will but also a decentralized approach that recognizes and values cultural diversity as a fundamental resource for educational and social development.

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REMOTE SENSING-BASED ASSESSMENT OF SOIL SALINITY

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ABSTRACT

Soil salinization is a growing threat to agricultural productivity, requiring efficient monitoring tools for sustainable management. This quantitative study evaluated soil salinity using remote sensing techniques combined with electrical conductivity measurements in rural communities of Desaguadero, Peru. Sentinel-2 and Landsat-8 imagery were analyzed through 13 salinity indices and validated against laboratory data from 48 sampling points. Linear regression revealed that 60% of samples exhibited excessive salinity. Moderate correlations were observed, ranging from 0.406 to 0.575 for Sentinel-2 and 0.339 to 0.484 for Landsat-8, with Int2 providing the highest predictive accuracy ($r = 0.575$). Findings demonstrate that remote sensing enables moderately precise estimation of soil salinity, highlighting its potential as a practical tool for large-scale monitoring and agricultural decision-making.

Keywords: Electrical conductivity, soil degradation, salinity indices, Landsat-8, Sentinel-2.

INTRODUCTION

Soil is an essential component for the development of life, as it hosts biodiversity ranging from microorganisms to complex ecosystems (Brevik et al., 2015). Its adequate physical, chemical, and biological condition enables plant growth and, indirectly, supports fauna by facilitating processes such as water infiltration, storage, and nutrient cycling (Masoud et al., 2019). When these functions are altered, ecological balance and productive sustainability are compromised.

Soil degradation may result from natural factors, anthropogenic activities, or their interaction (Stavi et al., 2021). Among the most relevant processes is soil salinity, which alters soil structure, reduces its capacity for water infiltration and storage, and increases runoff and erosion (Brevik et al., 2015; Daliakopoulos et al., 2016; Rengasamy, 2006). If persistent, it can lead to desertification, particularly in arid or exposed areas (Ding & Yu, 2014). The accumulation of salts induces physical and chemical changes that decrease soil fertility and limit agricultural productivity (Mohamed et al., 2018).

Soil salinity can be classified as primary (natural origin) or secondary (anthropogenic origin), the latter mainly associated with inadequate irrigation practices. Globally, it affects approximately 20% of irrigated agricultural lands, equivalent to 45 million hectares, representing around 25% of total food production. It is projected that by 2050, up to 50% of agricultural soils could be affected (Almeida & Serralheiro, 2017; Bartels & Sunkar, 2005). Historically, salinity has influenced changes in agricultural practices and the expansion of irrigation systems (Leidi & Pardo, 2002; Rhoades et al., 1992).

From a pedological perspective, salinization occurs due to high concentrations of soluble salts, particularly sodium. In sodic soils, sodium exceeds 15% of exchangeable cations, displacing other bases and causing clay dispersion, structural degradation, and reduced permeability (Szabolcs, 1994). This process is associated with arid climates, high evaporation rates, irrigation with saline water, excessive fertilizer use, low vegetation cover, and reduced organic matter content (Ramos et al., 2022). In Cuba, nearly one million hectares of agricultural land are affected, while 1.5 million hectares are at potential risk, mainly due to anthropogenic causes (Gonzales et al., 2000).

In Peru, soil salinity has been evident since the 1970s and 1980s, particularly in arid and semi-arid coastal regions (Aimituma et al., 2023). Approximately 300,000 hectares present drainage deficiencies and salinity-related issues in these areas (Hurtado, 2019). Although most studies focus on northern coastal valleys, this problem may also occur in high Andean regions. In southern Peru, factors such as low precipitation, high evaporation, rock weathering, irrigation with saline water, and improper fertilizer management contribute to salt accumulation (Rojas et al., 2015). It is estimated that nearly 50% of Peru's cultivable soils show increasing salinity levels, a situation that may worsen in the southern Andes (Campoverde, 2012; Rocha & Gomero, 2019).

To mitigate this issue, sustainable agricultural practices are required, including the use of high-quality water, rational fertilization, incorporation of organic matter, and vegetation cover to improve soil structure (Mata et al., 2014; Sastre et al., 2015). However, the implementation of effective measures requires accurate information on the spatial distribution of soil salinity.

Traditionally, salinity assessment has been conducted through field sampling and laboratory analysis, which are costly and time-consuming at regional scales. Remote sensing has emerged as an efficient alternative for monitoring and mapping saline soils over large areas (Wang et al., 2020). The use of multispectral satellite imagery, such as Landsat, SPOT, ASTER, and MODIS, has provided reliable results since the 1990s (Allbed & Kumar, 2013; Farifteh et al., 2006; Metternicht & Zinck, 2006). The accuracy of these approaches depends on the spatial and spectral resolution of the sensors (Peng et al., 2019; Vermeulen & Van Niekerk, 2017) and may be limited by dense vegetation cover.

The integration of remote sensing with descriptive and inferential statistical analyses enhances interpretation and adaptability to different soil types (Golestani et al., 2023). In this context, the present study aims to assess soil salinity using remote sensing techniques and electrical conductivity measurements, determine the relationship between electrical conductivity and salinity indices, and identify the index that provides the best fit with this variable.

MATERIALS AND METHODS

The study was conducted under a quantitative approach, with an applied scope, a non-experimental design, and a descriptive - correlational level, aimed at assessing soil salinity through spectral indices and their relationship with laboratory measured electrical conductivity (EC).

Two main data sources were used: satellite imagery and field data. Landsat-8 OLI images (July 21, 2025), obtained from the United States Geological Survey (USGS), and Sentinel-2A images (July 24, 2025), provided by the European Space Agency (ESA), were employed. Scenes with less than 2% cloud cover over the study area were selected (Kumar et al., 2024). Atmospheric corrections were performed using QGIS 3.34.9 for Landsat-8 OLI imagery, while Sentinel-2A imagery was used with its pre-applied atmospheric correction (García et al., 2021).

Based on the processed imagery, salinity indices reported in previous studies (García et al., 2021) were calculated and used as a basis for the selection of sampling points (Table 1).

Table 1
Equations used for soil salinity index analysis

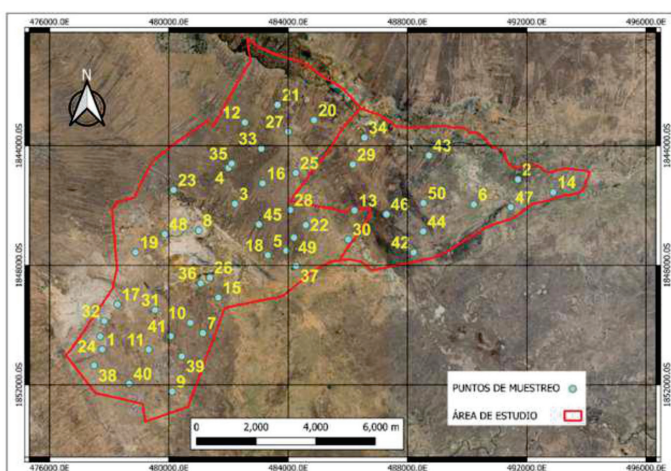
N°	Salinity Index	Abbreviation	Band Relationship	Reference
01	Normalized Difference Salinity Index	NDSI	$(R - NIR) / (R + NIR)$	Khan et al. (2005)
02	Vegetation Soil Salinity Index	VSSI	$2 \times G - 5 \times (R + NIR)$	Dehni y Lounis (2012)
03	Brightness Index	BI	$\sqrt{(R^3 + NIR^3)}$	Khan et al. (2005)
04	Salinity Index	SI	$(R \times G) / B$	Allbed et al. (2014)
05	Salinity Index 1	SI1	$\sqrt{(G \times R)}$	Douaoui et al. (2006)
06	Salinity Index 2	SI2	$\sqrt{(R \times NIR)}$	Dehni y Lounis (2012)
07	Salinity Index 3	SI3	$\sqrt{(G^2 + R^2 + NIR^2)}$	Douaoui et al. (2006)
08	Salinity Index 4	SI4	$\sqrt{(G^2 + R^2)}$	Yahiaoui et al. (2015)
09	Salinity Index 5	SI5	B / R	Abbas y Khan (2007)
10	Ratio Spectral Index	RSI	B / NIR	Kahaer y Tashpolat (2019)
11	Intensity Index 1	Int1	$(G + R) / 2$	Bouaziz et al. (2011)
12	Intensity Index 2	Int2	$(G + R + NIR) / 2$	Bouaziz et al. (2011)
13	Simple Ratio	SR	$(R - NIR) / (G + NIR)$	Dehni y Lounis (2012)

Where: B = Blue, G = Green, R = Red, NIR = Near-Infrared

Fieldwork was conducted from July 28 to 30, 2025, in the rural communities of Santa Cruz de Ayrihuas and Collpacotaña, located in the Desaguadero district, at the end of the dry season, when surface salt accumulation is highest. Sampling points were defined based on the spectral variability observed in band relationships generated in QGIS, as well as accessibility criteria (Figure 1) (Abuelgasim & Ammad, 2019).

Figure 1

Location of soil sampling points.



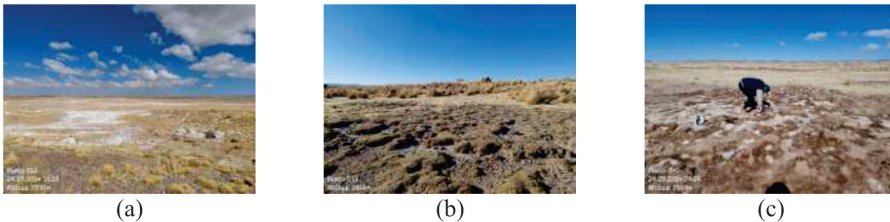
A total of 48 sampling points were established across the study area. Soil samples were collected at the center of each pixel within a ± 5 m margin, considering GPS accuracy, to ensure soil–pixel correspondence. Following standard guidelines and accounting for soil variability, samples were taken to a depth of 15 cm.

Figure 2

Saline areas with bare surfaces (a), areas covered by salt crusts and halophytic species (b), and surface salt crystals and soil profile (c).

Figure 2

Saline areas with bare surfaces (a), areas covered by salt crusts and halophytic species (b), and surface salt crystals and soil profile (c).



Finally, the samples were analyzed in the laboratory to determine electrical conductivity (EC) and classified into six categories (Table 2), which allowed the relationship between measured values and salinity indices derived from remote sensing to be established.

Table 2

Soil classification for soil analysis in Georgia.

Category	Soil Salinity Class	Soil Electrical Conductivity (dS/m)	Description
1	Non-saline	0 – 0.15	Very low: plants may suffer from nutrient deficiency.
2	Slightly saline / low salinity	0.16 – 0.50	Low: soil lacks organic matter; satisfactory if organic matter content is high.
3	Moderately saline / medium salinity	0.51 – 1.25	Medium: satisfactory range for established plants.
4	Strongly saline / high salinity	1.26 – 1.75	High: suitable for most established plants; too high for seedlings or cuttings.
5	Very highly saline	1.76 – 2.00	Very high: plants are generally stunted or chlorotic.
6	Excessively saline	> 2.00	Extremely high: plants are severely stunted; seedlings and rooted cuttings frequently die.

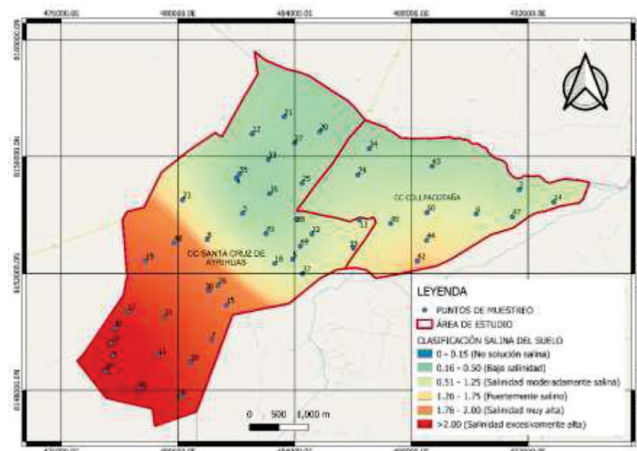
Note: Values adapted from Brown et al. (1954).

RESULTS AND DISCUSSION

Salinity values ranged from 0.075 to 18.63 dS/m and were classified into categories 1 to 6. Figure 3 illustrates the spatial distribution of soil salinity using the Kriging interpolation method, which allows the estimation of variable values in unsampled locations.

Figure 3

Spatial distribution of soil salinity using the Kriging interpolation method.



Of the 48 soil samples collected, 37 were from Santa Cruz de Ayrihuas, where most exhibited high salinity, with 23 classified as excessively saline. In Collpacotaña, 6 samples also showed excessive salinity. Overall, 60% of all samples presented excessively high salinity levels.

These soils showed limited vegetation cover due to high salinity, which is consistent with Gómez et al. (2012), who reported that EC values above 2 dS/m negatively affect plant growth, with only a few species showing tolerance to highly saline conditions. The observed variability in EC is consistent with Ramos et al. (2022), who found that EC becomes more homogeneous with increasing depth. In this study, the maximum sampling depth was 0.15 m, which may explain the higher variability, as surface layers are more influenced by environmental factors and agricultural activities that alter their physical and chemical properties.

The results differ from those reported by Wang et al. (2020), who obtained maximum salinity values of up to 77.90 dS/m, whereas the maximum value in this study was 18.63 dS/m. This discrepancy may be attributed to differences in land use, as their study area consisted of abandoned agricultural land with severe degradation. Similarly, Golestani et al. (2023) reported higher EC values, reaching 59.4 dS/m in winter and 69.5 dS/m in summer, which they attributed to increased evaporation and salt accumulation during warmer periods. In contrast, Abbas and Khan (2007) found that approximately 94% of their study area exhibited normal salinity levels, indicating lower soil degradation compared to the present study, where less than 10% of samples were classified as slightly to moderately saline. However, similar trends were observed with Allbed et al. (2014), who reported high proportions of strongly saline soils (87.5%, 60%, and 67.35%) across different sites. Despite similarities in proportional distribution, their EC values were significantly higher (190.4, 154.2, and 202 dS/m), indicating more severe degradation levels.

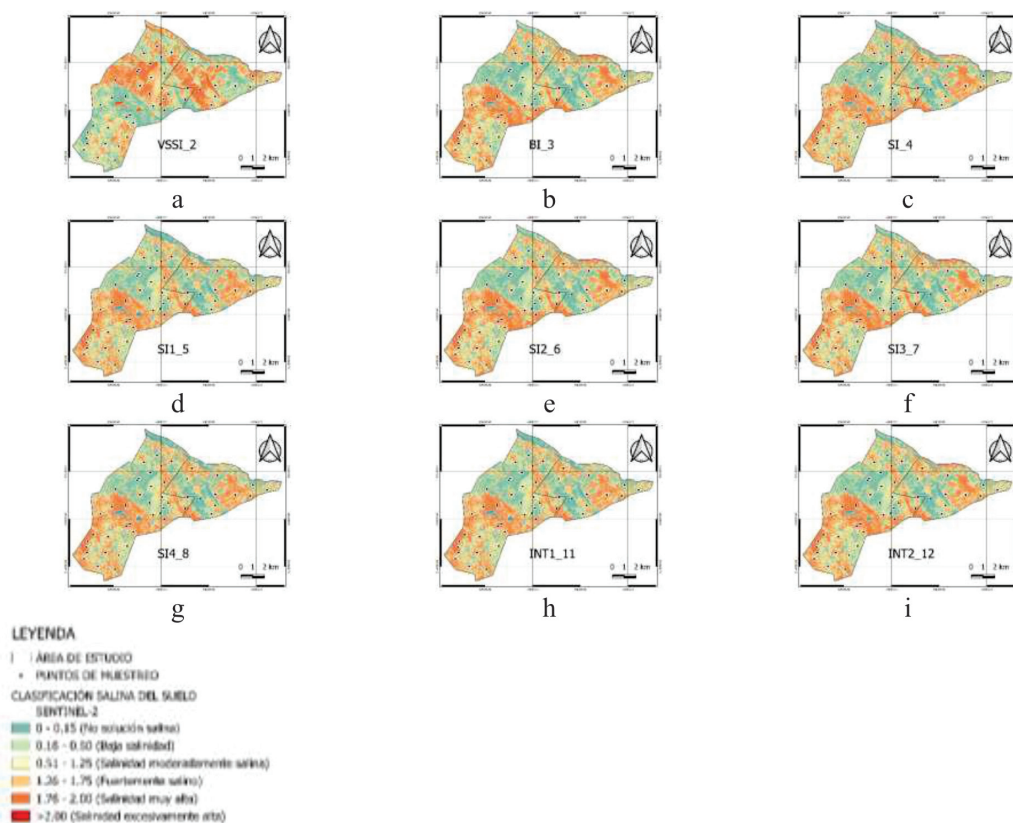
Soil salinity maps derived from the selected spectral indices showed variations in their ability to explain electrical conductivity, depending on the satellite used. For Landsat-8, the VSSI exhibited the highest coefficient of determination ($R^2 = 0.265$), explaining 26.5% of the variability in soil salinity and representing the best predictor. Other indices, such as BI and SI2, also showed

considerable explanatory capacity, with R^2 values ranging from 0.179 to 0.224. For Sentinel-2, the best-performing indices were BI, SI2, and SI4, with R^2 values around 0.214–0.215, indicating a significant relationship with EC. Indices such as Int1 and SI1 showed moderate predictive capacity for both satellites, with R^2 values between 0.138 and 0.178.

Figures 4a–i illustrate soil salinity maps generated using the indices that showed the strongest relationship with electrical conductivity. As reported by Gorji et al. (2020), similarities were observed among maps derived from different indices and satellite data in terms of the spatial distribution of salinity classes. The nine salinity indices for Landsat-8 and Sentinel-2A revealed a band of excessively high salinity with varying widths, indicating differences in the detection of highly saline areas. These variations are attributed to differences in spatial resolution and spectral characteristics of the sensors. Landsat-8 uses blue, green, red, and near-infrared (NIR) bands with a spatial resolution of 30 m, whereas Sentinel-2A uses similar bands but with a higher spatial resolution of 10 m, allowing for more detailed detection of soil salinity.

Figure 4

Soil salinity classification using Sentinel-2 indices. (a) Vegetation Soil Salinity Index (VSSI); (b) Brightness Index (BI); (c) Salinity Index (SI); (d) Salinity Index 1 (SI1); (e) Salinity Index 2 (SI2); (f) Salinity Index 3 (SI3); (g) Salinity Index 4 (SI4); (h) Intensity Index 1 (Int1); (i) Intensity Index 2 (Int2).



CONCLUSIONS

The communities of Santa Cruz de Ayrihuas and Collpacotaña, located in the Desaguadero district, showed that 60% of the evaluated soil samples had electrical conductivity (EC) values greater than 2 dS/m. Additionally, 4.2% of samples ranged between 1.76 and 2.00 dS/m, 2.1% between 1.26 and 1.75 dS/m, 4.2% between 0.51 and 1.25 dS/m, 14.6% between 0.15 and 0.50 dS/m, and the remaining 14.6% between 0 and 0.15 dS/m.

The salinity indices NDSI, SI5, RSI, and SR derived from Sentinel-2 and Landsat-8 showed significance levels greater than 0.05, indicating no correlation with electrical conductivity. In contrast, the indices BI, SI, SI1, SI2, SI3, SI4, Int1, and Int2 from both satellites showed significance levels lower than 0.05, indicating a statistically significant, moderate, and positive correlation with EC. The VSSI index also showed statistical significance ($p < 0.05$), but exhibited a moderate negative correlation.

The indices NDSI, SI5, RSI, and SR did not show influence on EC due to their lack of statistical significance. The Int2 index presented a coefficient of determination (R^2) lower than 10% for both satellites, indicating low explanatory power. The indices VSSI, BI, SI, SI1, SI2, SI3, SI4, and Int1 showed R^2 values between 10% and 26.5%, also indicating low influence on EC. However, the highest correlation with EC was obtained for Int2, with coefficients of 0.575 for Sentinel-2 and 0.484 for Landsat-8.

The comparison between Landsat-8 and Sentinel-2 indicates that both satellites can estimate soil salinity with moderate accuracy, although differences exist in their predictive performance. Landsat-8 stands out with the VSSI index, which showed the highest coefficient of determination ($R^2 = 0.265$), representing the best predictor of EC. In contrast, Sentinel-2 distributes its predictive capacity among several indices, such as BI, SI2, and SI4, with R^2 values around 0.214–0.215. These differences are likely related to variations in spectral composition and spatial resolution, which influence the detection of soil salinity variability.

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DIGITAL TOOLS AND THEIR IMPACT ON SALES GROWTH IN THE COMMERCE SECTOR OF PERU

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ABSTRACT

This study examined the impact of digital tools on sales growth in businesses in the commerce sector in Peru, focusing on dimensions such as the use of social media, video editing, e-commerce platforms, and customer relationship management systems. Employing a quantitative, applied approach with an experimental design, the research targeted business owners in the Puno region, from which a sample of 959 participants was selected. Data collection was carried out through surveys administered at two measurement points in 2025, with the purpose of evaluating the changes following the implementation of a training program digital tools usage. Hypothesis testing was conducted using paired t-tests to evaluate the influence of digital tools on sales performance. Results showed a significant increase in sales after the training program, confirming the positive effect of digital tool adoption on commercial activities. The findings underscore the strategic value of digital tools in enhancing business management and expanding market reach within the commerce sector.

Keywords: Video Editing, Digital Tools, Sales Increase, Social Networks, Electronic Commerce Platform, CRM Customer Relationship Management Systems.

INTRODUCTION

Global trends in consumer behavior, particularly the preference for online shopping, have driven companies and organizations to integrate digital tools in order to sustain competitiveness. The development of high-speed internet, mobile devices, and e-commerce platforms has facilitated this transition, which in Peru is reflected in the rapid growth of social media, CRM systems, and digital editing applications. Increased internet access in urban areas has further promoted the adoption of these tools, although challenges remain regarding technological infrastructure and digital inclusion in rural regions, where traditional sales practices and limited training hinder implementation.

Global transformations in consumer behavior, particularly the preference for e-commerce, have driven the adoption of digital tools as a key strategy for business competitiveness. In Peru, this process is evident in the expansion of digital platforms and social networks, supported by greater internet access in urban areas, though gaps in infrastructure and training persist in rural regions. In the Puno region, whose economy relies on primary and commercial activities, the predominance of traditional practices and limited incorporation of digital technologies restrict local business growth. Within a context of economic slowdown, exacerbated by the COVID-19 pandemic and political crisis, it is essential to propose digitalization strategies that strengthen

competitiveness and contribute to the recovery of the regional commerce sector, particularly in districts and provinces with the highest commercial activity.

The incorporation of digital tools represents a strategic factor for the economic development of the Puno region, as it fosters job creation, income growth, and the consolidation of a business culture oriented toward digital transformation. The use of resources such as social media, e-commerce platforms, and CRM systems emerges as a mechanism to stimulate sales in the commercial sector, particularly in the face of persistent traditional methods with declining results. Within this context, the research aims to analyze the impact of these tools on the sales growth of commercial businesses in the region in 2025, with the purpose of understanding their implications and providing evidence to support strategic decision-making.

Romero, La Paz, and García (2024), in their study *Impacto de las herramientas tecnológicas en las ventas de empresas chilenas*, employed a descriptive approach and a linear regression model to examine technological variables influencing business performance. Their findings reveal that the incorporation of ICT specialists, ERP systems, social media, broadband, websites, electronic devices, and Big Data is positively associated with sales growth, with ERP systems and specialized human capital emerging as the most impactful factors. Furthermore, the study highlights a growing trend in the use of digital channels and mobile applications by consumers, who increasingly rely on diverse electronic payment methods, thereby confirming the consolidation of online commerce as a predominant practice.

Chinchay Cruz and Jiménez Fernández (2023) define digital marketing as a strategy aimed at promoting products and services through digital channels such as email, search engines, social media, and websites, emphasizing its capacity to expand market reach, strengthen customer interaction, and enhance sales conversion. Similarly, Guerrero-Cantos et al. (2022) conceptualize e-commerce as the process of buying and selling through electronic means, which fosters the digital transformation of SMEs and contributes to increased productivity and profitability. In the same vein, Cuzco-Beltrán et al. (2022) argue that, during the pandemic, digital tools became indispensable resources for stimulating sales, improving market positioning, and reinforcing the economic sustainability of entrepreneurial ventures.

Santistevan-Villacreses, Sánchez-Chávez, and Arias-Haro (2022), in their study *Las plataformas digitales y su impacto en las ventas de las pequeñas empresas del cantón Paján*, examined the use of digital platforms by local merchants, showing that although adoption was limited prior to COVID-19, during the pandemic these tools became a relevant resource for commercialization. Using a documentary methodology and observational surveys, they identified that entrepreneurs primarily rely on social media but face significant technical management deficiencies. Consequently, the authors recommend implementing training processes to strengthen the effective use of these digital tools.

Gonzales Medina (2022), in *Mejoramiento del uso de las herramientas digitales e imagen institucional de los comerciantes del Progreso año 2022*, concluded that limited graphic identity and insufficient knowledge in the use of digital tools negatively affect institutional image. Consequently, the study proposes the implementation of visual enhancement strategies and the development of a brand manual as key measures to strengthen corporate identity.

Malpartida-Maíz, Román-Córdova, and Salas-Canales (2023) point out that e-commerce in Peru has experienced sustained growth as a response to organizational changes brought about

by the COVID-19 pandemic, prompting companies to rethink their sales strategies. In the same vein, Gonzales (2020) emphasizes that global competition represents the main challenge for Latin American SMEs, which operate in a globalized environment marked by external pressures and rapid technological transformation. He highlights the economic relevance of SMEs in Colombia due to their significant contribution to GDP and employment, and therefore considers the adoption of digital tools as a structural process that requires a comprehensive strategic reconfiguration to maintain business competitiveness.

MATERIALS AND METHODS

This research employed a quantitative, applied, and experimental design to analyze the impact of digital tools on sales growth among businesses in the commercial sector of the Puno region during 2025. Data collection was conducted through surveys and interviews administered in two quarterly sampling processes, encompassing a total of 959 business owners. Sampling followed a simple random procedure, validated through a pilot test and based on the arithmetic mean for a finite population. The study was carried out in the Puno region, with emphasis on the cities of Puno and Juliaca, which concentrate the largest population and the highest density of commercial establishments.

The instruments and resources utilized included: (i) a data registration form containing business owners' personal information; (ii) merchant registries from the main markets of Puno and Juliaca; (iii) a training plan for the adoption of digital tools; (iv) route planning for training activities; (v) cloud storage for interview data; and (vi) JASP statistical software for data processing.

For statistical analysis, the paired t-test (dependent samples t-test) was applied to determine whether significant differences existed between the mean values of two related groups, with a threshold of $p > 0.05$. Data processing was performed using JASP, a free and open-source program for statistical analysis.

RESULTS AND DISCUSSION

Descriptive Results

The survey results from 959 business owners in the commercial sector of Puno and Juliaca revealed a growing adoption of digital tools in business activities. Social media, video editing, e-commerce platforms, and customer relationship management systems were among the most frequently used, facilitating customer communication and expanding marketing opportunities. The detailed results are presented in the following tables.

Table 1*Social Media Before and After*

Measure 1	Measure2	Test	Statistic	Z	df	p
N°RedesSocialesantes	N°RedesSocialesdespues	Student	-58.598		958	< 0.001
		Wilcoxon	2977.5	-25.364		< 0.002

Note: This table showed $p < 0.05$, indicating a significant difference in its use after the implementation of digital tools training.

Table 2*Descriptive Statistics of Social Media Before and After*

	N	Mean	SD	SE	Coefficient of variation
N°RedesSocialesantes	959	0.405	0.963	0.031	2.381
N°RedesSocialesdespues	959	2.929	1.043	0.034	0.356

Note: This table presented the mean, variance, standard deviation, and coefficient of variation, indicating greater consistency and lower variability in its use as a digital tool.

Table 3*Video Editing Before and After*

Measure 1	Measure2	Test	Statistic	Z	df	p
N°Videoeditingbefore	N°Videoeditingafter	Student	-58.598		958	< 0.001
		Wilcoxon	4.5	-26.811		< 0.001

Note: This table showed $p < 0.05$, indicating a significant difference in its use after the implementation of digital tools training.

Table 4*Descriptive Statistics of Video Editing Before and After*

	N	Mean	SD	SE	Coefficient of variation
N°Videoeditingbefore	959	0.216	1.581	0.051	7.324
N°Videoeditingafter	959	16.887	8.838	0.285	0.523

Note: This table presented the mean, variance, standard deviation, and coefficient of variation, indicating greater consistency and lower variability in its use as a digital tool.

Table 5*E-commerce Platforms Before and After*

Measure 1	Measure2	Test	Statistic	Z	df	p
N°Plataformasantes	N°Plataformasdespues	Student	-6.42		958	< 0.001
		Wilcoxon	0.000	-5.968		< 0.001

Note: This table showed $p < 0.05$, indicating a significant difference in its use after the implementation of digital tools training.

Table 6*Descriptive Statistics of E-commerce Platforms Before and After*

	N	Mean	SD	SE	Coefficient of variation
N°Plataformasantes	959	0.001	0.032	0.001	30.968
N°Plataformasdespues	959	0.112	0.534	0.017	4.785

Note: This table presented the mean, variance, standard deviation, and coefficient of variation, indicating greater consistency and lower variability in its use as a digital tool.

Table 7*CRM Before and After*

Measure 1	Measure2	Test	Statistic	Z	df	p
N°CRMantes	N°CRMdespues	Student	-23.882		958	< 0.001
		Wilcoxon	1428.000	-17.185		< 0.001

Note: This table showed $p < 0.05$, indicating a significant difference in its use after the implementation of digital tools training.

Table 8*Descriptive Statistics CRM Before and After*

	N	Mean	SD	SE	Coefficient of variation
N°CRMantes	959	0.017	0.128	0.004	7.681
N°CRMdespues	959	0.505	0.621	0.020	1.231

Note: This table presented the mean, variance, standard deviation, and coefficient of variation, indicating greater consistency and lower variability in its use as a digital tool.

Merchants who incorporated digital tools, as presented in Table 9, reported a greater reach of potential customers, as well as an improvement in the dissemination of promotions and offers, which contributed to enhancing commercial activity in the participating businesses.

Table 9*Digital Tools Before and After*

Measure 1	Measure2	Test	Statistic	Z	df	p
N°Herradigitalesantes	N°Herradigitalesdespues	Student	-84.591		958	< 0.001
		Wilcoxon	0.000	-26.204		< 0.001

Note: This table showed $p < 0.05$, indicating a significant difference.

Inferential Results

In order to test the research hypothesis, the Student's t-test for related samples was applied, which allowed for the comparison of business sales levels before and after the implementation of digital tools as part of the training program.

The results of the statistical analysis presented in Table 10 demonstrated the existence of significant differences between the sales recorded before and after the application of digital tools.

The inferential analysis showed a level of statistical significance of $p < 0.05$, indicating that the observed increase in sales was not due to chance.

Table 10

Sales Revenue Before and After

Measure 1	Measure2	Test	Statistic	Z	df	p
Ingresosantes	Ingresosdespues	Student	123.868	-	958	< 0.001
		Wilcoxon	0.000	-26.826		< 0.001

Note: This table showed $p = 0.001 < 0.05$, indicating a statistically significant difference.

Consequently, the null hypothesis was rejected and the alternative hypothesis was accepted, leading to the conclusion that digital tools had a positive and significant impact on the increase in sales of businesses in the commercial sector in the Puno region during the year 2025.

DISCUSSION

The results of the present study demonstrated that the implementation of digital tools significantly influenced the increase in sales of businesses in the commercial sector in the Puno region. This finding confirmed the relevance of digital transformation as a key strategy to strengthen business competitiveness, especially in contexts where traditional commercial practices predominated.

The results obtained were consistent with those reported by Romero, La Paz, and García (2024), who identified that the incorporation of digital technologies, such as enterprise resource planning systems, social media, and e-commerce platforms, was positively associated with increased sales in companies. Similarly, the present study showed that the use of digital tools facilitated customer interaction and expanded marketing channels, which contributed to the growth of business revenues.

Likewise, the results supported the arguments proposed by Chinchay Cruz and Jiménez Fernández (2023), who stated that digital marketing enabled companies to promote their products through digital channels such as social media, search engines, and websites, thereby expanding their reach and improving sales conversion. In the case of businesses in the commercial sector in Puno, the adoption of these tools improved product visibility and attracted new customers.

In the same vein, the findings were consistent with those of Santistevan-Villacreses, Sánchez-Chávez, and Arias-Haro (2022), who demonstrated that although the use of digital platforms by merchants had been limited prior to the pandemic, the health crisis promoted their adoption as a strategy to sustain and boost sales.

In the context of the Puno region, where traditional economic activities predominated and limitations in technological infrastructure and digital training existed, the incorporation of digital tools represented an opportunity to strengthen the competitiveness of local businesses. In this regard, the study findings suggested that training programs focused on the use of digital tools could significantly contribute to improving the technological capabilities of merchants and enhancing the development of the commercial sector.

CONCLUSIONS

The study confirmed that the implementation of digital tools had a positive and significant effect on sales growth among businesses in the Puno region's commercial sector. Statistical analysis using the paired Student's t-test demonstrated significant differences in sales before and after tool adoption, validating the research hypothesis.

The integration of social media, video editing, e-commerce platforms, and customer relationship management systems enhanced business visibility, customer interaction, and market expansion, thereby fostering commercial dynamism and economic opportunities.

Training in digital competencies proved essential for adoption, enabling merchants to design innovative strategies that improved commercial performance. In a context marked by traditional practices and limited technological infrastructure, digital transformation emerged as a strategic pathway to strengthen competitiveness, increase income, and promote regional development.

The findings provide empirical evidence supporting the promotion of policies and training programs that encourage digital technology adoption in small businesses, contributing to innovation, competitiveness, and economic recovery in the commercial sector.

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INFLUENCE OF MINING ACTIVITY ON THE FLORA AND VEGETATION OF A HIGH-ANDEAN HYDROMORPHIC BOFEDAL HABITAT – POTONI – SAN ANTONIO DE PUTINA

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ABSTRACT

The objective was to evaluate the effect of mining activity on the habitat, as well as on the floristic and vegetation structure of a high-Andean hydromorphic bofedal. The research is applied in nature, with a quantitative approach and a descriptive-comparative level. The 7.5-hectare study area was divided into: stratum 1 (near the mine), stratum 2 (control), and stratum 3 (far from the mine). Nine replicates were conducted in stratum 1, and ten in strata 2 and 3, characterizing the vegetation using 0.0625 m² quadrats, and determining vegetation cover, biomass, productivity, abundance, and biodiversity. The population comprises the high-Andean hydromorphic bofedal. A non-probabilistic convenience sampling method was used. A climatic characterization was carried out using data from the Ananea station of SENAMHI; elevation was determined using a GPS; streamflow was calculated using the float method; and the life zone was identified based on the Ecological Map of Peru. The soil was described according to its land-use capability. The measurement of physicochemical parameters was carried out using a multiparameter probe. BOD₅, COD, and mercury were analyzed in the laboratory. For the statistical analysis, SPSS 21 and Minitab 17.1 were used. The months with the lowest precipitation, relative humidity, and temperature are from May to September. The elevation of the bofedal ranges from 4872 to 4905 m above sea level. The highest flow rate was recorded in stratum 1 (93.26 L/s). The life zone is Subtropical Alpine Rain Tundra. It has Histosol soils. The stratum with the highest anthropogenic intervention was stratum 1. The very abundant species was *Distichia* sp. The parameters that exceeded the Environmental Quality Standards were BOD₅ and COD in strata 2 (45 mg/L) and 3 (75 mg/L). Mercury concentrations exceeded Category 4 standards.

Keywords: High-Andean, Bofedal, Flora, Hydromorphic, and Vegetation.

INTRODUCTION

Bofedales are a particular type of high-altiplano wetland, a term specific to Bolivia, Peru, and Chile; they are located and distributed sparsely across the Altiplano and High-Andean ecoregions and are characterized by being extremely productive (Alzérreca et al., 2001).

It constitutes an important area of land, saturated with moisture because the soil is rich in organic matter (Gil, 2011). It is characterized by a highly undulating microrelief interconnected by channels, directly related to the presence of herbaceous species arranged in compact cushions (Vila, 2002).

They possess sociocultural, hydrological, ecological, biological, and economic value because they store water resources, support the development of rich and diverse vegetation, harbor endemic species of global importance, and are influenced by various factors that determine their structure and dynamics, such as temperature, latitude, longitude, altitude, precipitation, water availability, soil aridity, and human impact (Condori et al., 2001).

They are extremely sensitive to climate change (changes in glacier runoff, impacts of rising temperatures) and to human disturbance (land-use change, burning, mining activity, drainage) (Squeo et al., 2006).

The most severe alteration in Peruvian peatlands was found in mining sites (drainage, erosion, flooding, deposition of mineral sediments) (Salvador et al., 2014). The effects of mining pollution occur due to the high concentration of heavy metals, which are associated with elevated electrical conductivity levels (Lacerda & Fitzgerald, 2001).

The bofedales of Puno have experienced a significant decrease in their vegetation cover in recent decades due to anthropogenic and environmental factors (Maldonado, 2014).

Mining activity constitutes one of the main threats to high-Andean bofedales, as it alters the hydrological regime through groundwater extraction, artificial drainage, and modification of watersheds. These alterations reduce water availability, affecting the structure and ecological functioning of these ecosystems (Squeo et al., 2006).

Likewise, mining activity is one of the most important means available to the State for economic development and the improvement of social welfare in the country. A balance between mining activity and the environment is required (Goyzueta & Trigos, 1991). In view of this issue and the limited scientific information on the specific impact of mining activity on the structure, plant composition, and functionality of high-Andean bofedales in the Sina District, belonging to the province of San Antonio de Putina in the Carabaya mountain range—where mining activity has been increasing and could be affecting these highly vulnerable ecosystems. Therefore, it is necessary to conduct research that allows for the assessment of the state of these ecosystems and the determination of the effects of mining activities on their ecological dynamics.

In this context, the present study aimed to evaluate the effect of mining activity on the habitat, as well as on the floristic and vegetation structure of a high-Andean hydromorphic bofedal.

MATERIALS AND METHODS

The study was conducted between August and December 2013 in a high-Andean hydromorphic bofedal located in the Vizcachani area, Potoni peasant community, Sina District, San Antonio de Putina Province, Puno Region, Peru.

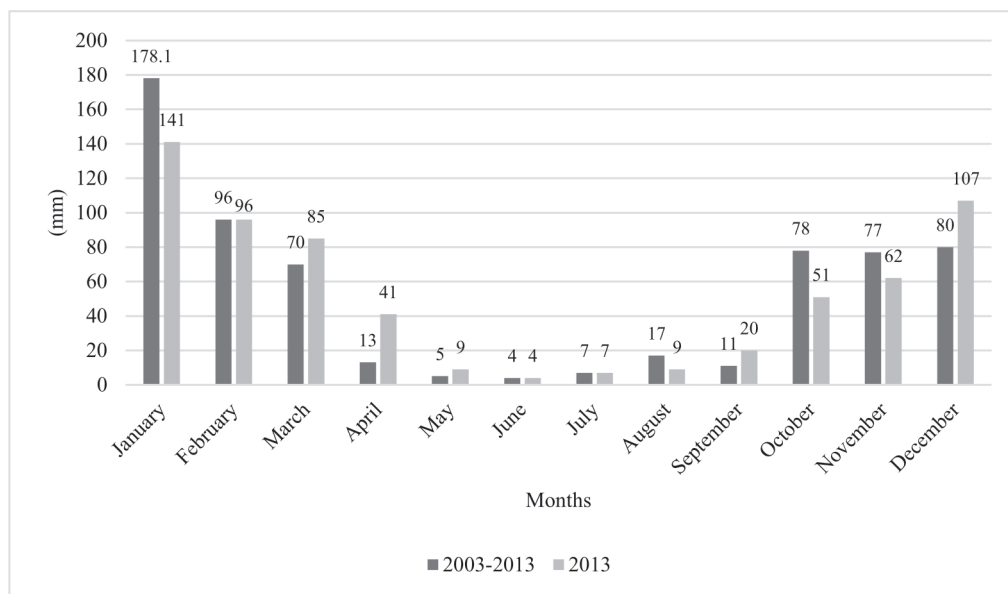
The research was applied in nature, with a quantitative approach and a descriptive–comparative level. The 7.5-hectare study area is located in the Azulcocha micro-watershed, in the upper part of the Inambari River basin, bordering the Suches River basin (Titicaca watershed), and was divided into three strata: Stratum 1 (near the mine), Stratum 2 (control), and Stratum 3 (far from the mine). A stratified, non-probabilistic convenience sampling method was employed. Vegetation was evaluated using 0.0625 m² quadrats, with nine replicates in Stratum 1 and ten in Strata 2 and 3. Vegetation cover (%), wet and dry biomass, productivity, abundance (Tansley and Chipp method),

and biodiversity (Simpson and Shannon–Weaver indices) were determined. The environmental characterization included temperature, precipitation, and humidity (data from the Ananea station of SENAMHI), altitude determined by GPS, streamflow measured using the float method, life zone according to the Holdridge diagram and the Ecological Map of Peru, and soil classification based on major land-use capability. Physicochemical water parameters (pH, temperature, dissolved oxygen, alkalinity, and redox potential) were measured with a multiparameter device, while BOD₅, COD, and mercury were analyzed in the laboratory. Anthropropic impact was evaluated using ANOVA and Tukey's b test (SPSS 21), with the F statistic calculated in Minitab 17.1.

RESULTS AND DISCUSSION

Figure 1

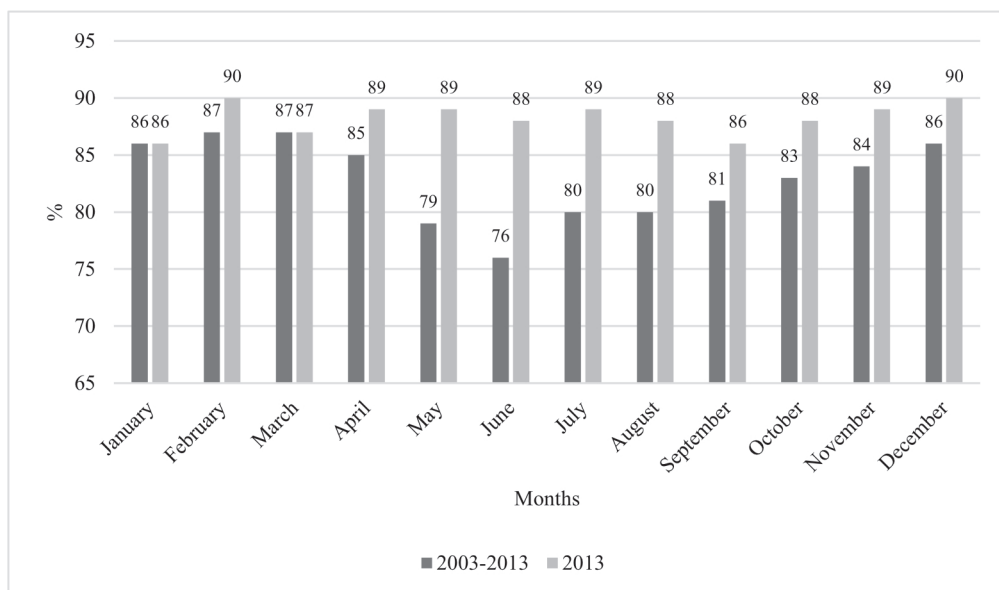
Monthly total precipitation (mm) from the Ananea meteorological station for the years 2003–2013 and for the year 2013.



Note: The monthly average was calculated over a 10-year period (2003–2013), with a total annual precipitation of 632 mm, a maximum of 141 mm in January, and a minimum of 4 mm in June.

Figure 2

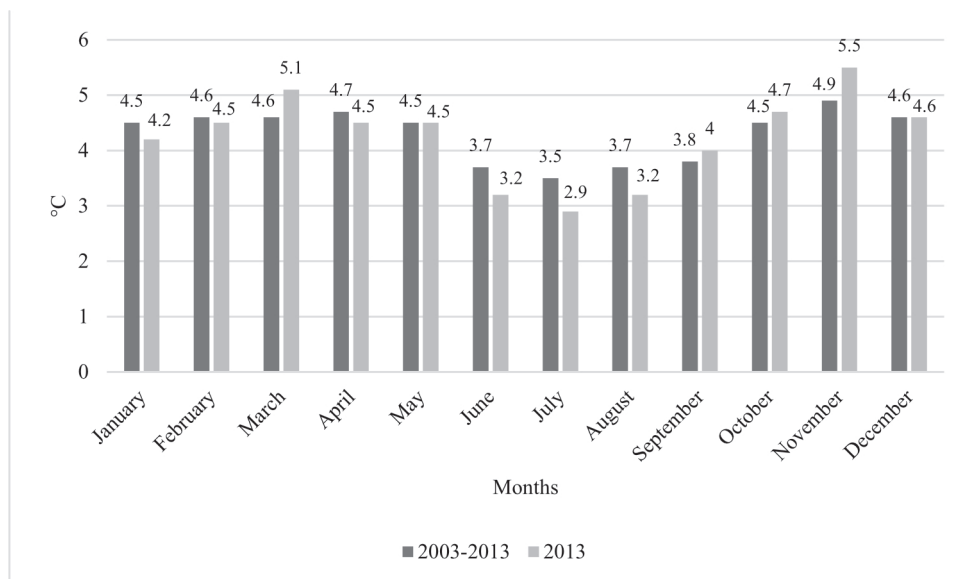
Average relative humidity at the Ananea meteorological station (%) for the years 2003–2013.



Note: The mean annual relative humidity was 82.8%. The distribution of values shows a maximum of 87% on average in February and March, and a minimum of 76% on average in June (Figure 2).

Figure 3

Monthly mean temperature (°C) at the Ananea meteorological station for the years 2003–2013 and for the year 2013.



Note: The average temperature at the analyzed station was 4.28°C, with abrupt changes in mean temperature; a maximum of 4.89°C occurred in November, and a minimum of 3.47°C in July (Figure 3).

The study area is located in the Alpine Subtropical Rainy Tundra altitudinal belt, with temperatures ranging between 1.5°C and 3°C. The ratio of evapotranspiration to total annual precipitation varies between 0.125 and 0.25, classifying this life zone in the humidity category: PERHUMID.

Table 1

Average altitude of the strata

Strata	Stratum 1	Stratum 2	Stratum 3
Average	4885.60	4893.70	4874.40

Note: Altitudewas determinedusingaGPS:Stratum1(nearthemine)4885.60m a.s.l.,Stratum 2 (control) 4893.70 m a.s.l., and Stratum 3 (far from the mine) 4874.40 m a.s.l. (Table 1). The soils present in the bofedal are Histosols.

Table 2

Flow rates of each stratum of the high -Andean hydromorphic bofedal, 2013

Strata	Flow (L/s)	Flow (m³/s)	Description
Stratum 1	93.2642	0.0933	Effluent from the Sedimentation Pond
Stratum 2	6.4709	0.0065	Control (U-shaped Glacier)
Stratum 3	32.6531	0.0327	Farthest part (effluent from Azulcocha Lagoon)

Note: The stratum with the highest flow was Stratum 1 (near the mine). Stratum 2 (control) receives its water from the U -s haped glacier, and Stratum 3 receives water from the Azulcocha Lagoon tributary.

Table 3

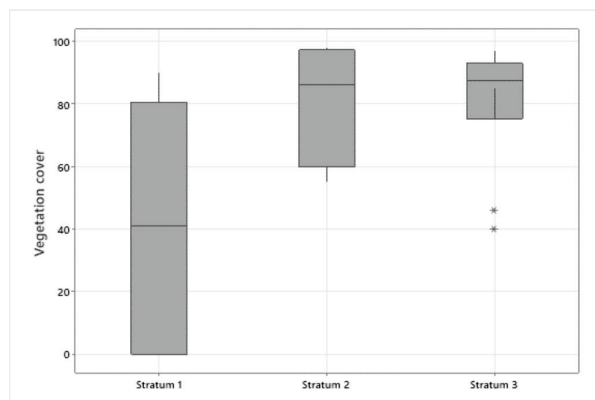
Vegetation cover in each stratum of the high -Andean hydromorphic bofedal, 2013

Points	Stratum 1	Stratum 2	Stratum 3
Average	42%	81%	81%

Note: The lowest vegetation cover was found in Stratum 1.

Figure 4

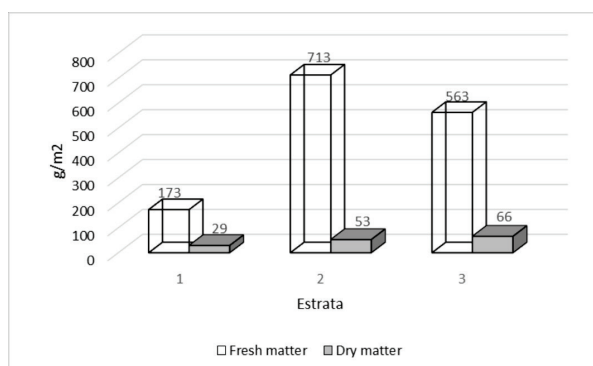
Boxplot of vegetation cover in the high -Andean hydromorphic boged, 2013



Note: The figure shows a clear gradient of vegetation cover: Stratum 1 exhibits the lowest cover and high variability, indicating greater disturbance; Stratum 2 shows intermediate to high cover, reflecting a transitional or recovering condition; and Stratum 3 has the highest cover and stability, representing a more conserved ecosystem.

Figure 5

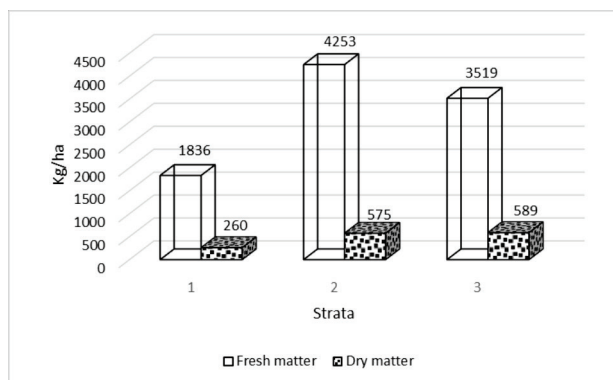
Biomass (g/m²) of the high -Andean hydromorphic boged, 2013



Nota: La figura representa el porcentaje de materia húmeda y seca en los tres estratos.

Figure 6 .

Productivity (kg/ha) of the high -Andean hydromorphic bofedal, 2013



Note: Stratum 1 (near the mine) exhibited the lowest vegetation cover (42%), the lowest biomass (173 g/m² wet matter and 29 g/m² dry matter), and the lowest productivity (1,836 kg/ha WM and 260 kg/ha DM). It also showed the highest variability (Table 3; Figures 4, 5, and 6).

Table 4

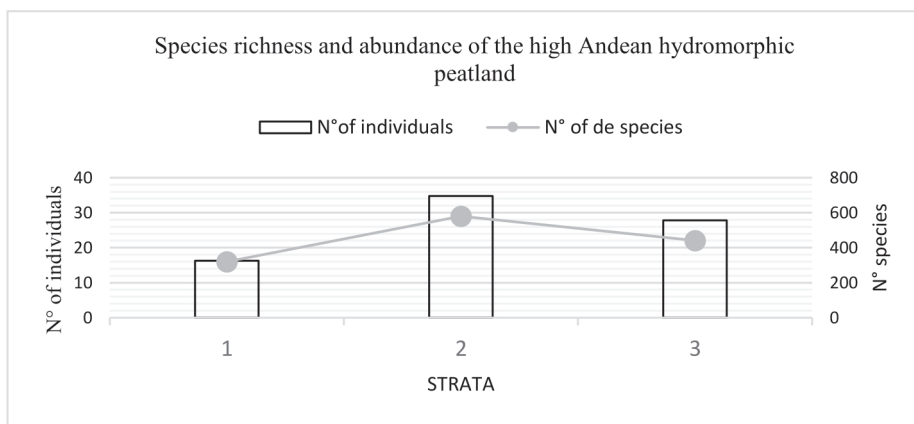
Number of individuals, species, and families in each stratum of the high -Andean hydromorphic bofedal, and biodiversity indices, 2013

Description	Stratum 1	Stratum 2	Stratum 3	Bofedal
No. of individuals	326	695	556	1,570
Total species	16	29	22	33
Total families	7	10	10	10
Biodiversity indices				
Shannon–Weaver index (H')	2.77	3.36	3.09	3.49
Simpson index (D)	0.81	0.92	0.89	0.91
Species richness	2.5	4.2	3.3	4.2

Note: Stratum 1 (near the mine) shows the lowest number of individuals (326), species (16), and families (7). It also exhibits low diversity (0.81) and species richness (2.5).

Figure 7

Number of individuals vs. number of species, 2013



Note: The lowest species richness was observed in Stratum 1 (near the mine).

Table 5

Results of the measurement of physicochemical parameters of the high -Andean hydromorphic bofedal, November 2014

Physicochemical Parameters	Units	Water Monitoring Points	D.S. No. 015-2015-MINAM	D.S. No. 010-2010-MINAM
		PMA-1	PMA-2	PMA-3
Calcium	mg/L	12.7	11.2	11.1
Conductivity	µS/cm	150	118	122
Dissolved Oxygen	mg/L	—	—	—
pH		6.55	6.76	6.83
Sodium (Na)	mg/L	6.33	5.87	5.55
Total Dissolved Solids	mg/L	76	59	61

Table 6

Results of the measurement of physicochemical parameters of the high -Andean hydromorphic bofedal, November 2014

Physicochemical Parameters	Units	Water Monitoring Points			D. S. N° 015-2015-MINAM		D. S. N° 010-2010-MINAM
		PMA-1	PMA-2	PMA-3	Category 3: Irrigation of Low- and High-Stem Vegetables	Category 3: Animal Drinking Water	Category 4: Aquatic Environment Conservation (Rivers – Coast and Highlands) Maximum Permissible Limits for Liquid Effluent Discharge from Mining-Metallurgical Activities
Calcium	mg/L	12.7	11.2	11.1	**	**	**
Conductivity	uS/cm	150	118	122	**	**	1000
Dissolved Oxygen	mg/L	-	-	-	4	5	≥ 5
pH		6.55	6.76	6.83	6.5 - 8.5	6.5 - 8.4	6.5 - 9
Sodium (Na)	mg/L	6.33	5.87	5.55	**	**	**
Total Dissolved Solids (TDS)	mg/L	76	59	61	**	**	**
Total Suspended Solids (TSS)	mg/L	-	-	-	**	**	≤ 25
							50.0000

Note: Stratum 1 (near the mine) showed the highest conductivity (150 $\mu\text{S}/\text{cm}$), the lowest pH (6.55), the highest sodium concentration (6.33 mg/L), and the highest total dissolved solids (76 mg/L).

Table 7

Results of mercury samples in each stratum of the high -Andean hydromorphic bofedal, October 2013.

Dissolved Oxygen	mg/L	-	-	-	4	5	≥ 5	**
pH		6.55	6.76	6.83	6.5 - 8.5	6.5 - 8.4	6.5 - 9	6.0 - 9.0
Sodium (Na)	mg/L	6.33	5.87	5.55	**	**	**	**
Total Dissolved Solids (TDS)	mg/L	76	59	61	**	**	**	**
Total Suspended Solids (TSS)	mg/L	-	-	-	**	**	≤ 25	50.0000

Note: In Stratum 1 (near the mine), the lowest mercury concentration was observed, due to the highest flow rate. All monitoring points exceed Category 4 of the national environmental quality standards.

DISCUSSION

The high Andean hydromorphic bofedal in Stratum 1 (near the mine) is being affected by mining activities such as soil compaction, road construction, and diversion of glacial waters, resulting in lower vegetation cover, wet biomass, and biodiversity. This partially agrees with Salvador et al. (2014), who reported that ‘the most severe alteration in Peruvian peatlands (bofedales) was found in mining sites (drainage, erosion, flooding, deposition of mineral sediments).

The high Andean hydromorphic bofedal exhibits a constant hydrological regime and is located near glaciers at an altitude between 4,874 m a.s.l. and 4,905 m a.s.l. We disagree with Condori and Choquehuanca (2001), who classify the High -Andean bofedal at altitudes between 4,100 m a.s.l. and 4,500 m a.s.l., as there are high -Andean bofedales existing above this altitude.

The diversity found in Stratum 1 (near the mine) with a Simpson index of 0.81, indicates low diversity; the Shannon Weaver index (0.81) suggests species dominance, and species richness is low (2.5). Mining activity has indirectly affected the bofedal in Stratum 1 by altering its habitat. This agrees with Moreno (2001), who states that ‘one of the environmental problems that has attracted the greatest global interest is biodiversity loss as a consequence of human activities, either directly (over exploitation) or indirectly (habitat alteration)

Mercury was detected in the study area at levels exceeding the national environmental quality standards for Category 4, even though the ‘Salvación Cunuyo’ mining concession of E.M. COMING SANTIBAÑEZ E.I.R.L. was in the exploration phase during 2012, 2013, and 2014. The presence of mercury is due to artisanal mining being carried out in the study area above 5,000 m a.s.l., where the mineral is extracted under artisanal conditions. Additionally, due to elevation differences, the waters carrying mercury flow into the aforementioned mining concession, explaining the presence of mercury in the area.

CONCLUSIONS

Stratum 1 (the one closest to the mine) was the stratum most influenced by mining activity. It exhibited the lowest vegetation cover (42%), biomass (173 g/m² wet matter and 29 g/m²

dry matter), and productivity (1,836 kg/ha WM and 260 kg/ha DM), as well as low diversity (Shannon–Weaver 2.77; Simpson 0.81) and species richness (2.5). It also showed the highest variability and the highest flow rate (93.26 L/s), which explains the low mercury concentrations (0.00041 mg/L). Additionally, it presented the highest conductivity (150 μ S/cm), the lowest pH (6.55), the highest sodium concentration (6.33 mg/L), and the highest total dissolved solids (76 mg/L), with an average altitude of 4,885.60 m a.s.l.

The specific study area is located between 4,874 and 4,905 m a.s.l. At this altitude, there is no meteorological station; therefore, the Ananea meteorological station was used as a reference. Using the Holdridge diagram and the Ecological Map of Peru, the life zone was determined to correspond to the Alpine Subtropical Rainy Tundra altitudinal belt, with temperatures ranging from 1.5°C to 3°C. The annual evapotranspiration to precipitation ratio varies between 0.125 and 0.25, placing this life zone in the PERHUMID humidity province, with Histosol soils present.

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IMPLEMENTATION OF ISO 45001-BASED OCCUPATIONAL HEALTH AND SAFETY SYSTEM AND OPERATIONAL RELIABILITY OF OXYGEN GENERATION PLANT FOR COVID-19 CARE AT JULIACA ESSALUD HOSPITAL

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ABSTRACT

This study addresses the implementation of an Occupational Health and Safety Management System (OHSMS) at the medical oxygen generation plant of Hospital III EsSalud (Peruvian Social Health Insurance) in Juliaca, aligned with the requirements of the ISO 45001:2018 standard. The purpose was to strengthen safety conditions, prevent occupational hazards, and ensure the operational continuity of the service. The main objective was to assess the level of compliance with regulatory requirements and to design a system that enables effective management of occupational risks. A qualitative methodology was employed, based on interviews, and structured into four stages: situational diagnosis, document development, risk assessment using the IPER matrix, and activity planning. The study's relevance lies in its capacity to identify risks and guide the implementation of preventive measures within the organization. Findings revealed deficiencies in staff knowledge regarding occupational safety and a lack of adequate tools to perform tasks under safe conditions. In response, procedures, records, and instructions consistent with regulatory frameworks were developed to strengthen occupational health and safety management. It is concluded that the implementation of the OHSMS enhances workplace risk control, optimizes the plant's operational performance, and ensures compliance with current regulations, thereby contributing to safer and more efficient working conditions for operational personnel.

Keywords: diagnosis, implementation, ISO 45001, risks, safety, system

INTRODUCTION

The production of medical oxygen is essential for the treatment of acute respiratory illnesses, and was especially critical during the COVID-19 pandemic. This study focuses on the oxygen generation plant at Hospital III EsSalud Juliaca, highlighting the importance of implementing an Occupational Health and Safety Management System (OHSMS) in accordance with ISO 45001.

The OHSMS aims to prevent work-related injuries and illnesses, ensuring safe environments through the identification, assessment, and control of risks (ISO.45001, 2018).

Adopting this system strengthens a preventative culture, guarantees safe conditions, and ensures operational continuity, complying with occupational health and safety regulations (Ley. N°.29783, 2016).

In the hospital setting, the efficient management of occupational safety and health takes on even greater importance due to the complexity of technical processes and the presence of risks associated with the operation of specialized equipment (Ley.30222, 2023).

Adopting this system strengthens a preventative culture, guarantees safe conditions, and ensures operational continuity, complying with occupational health and safety regulations. (D.S.N°.005-2012-TR, 2016).

OSH management is linked to social responsibility by promoting safe conditions, improving quality of life, and strengthening institutional sustainability and competitiveness. (Ley.30222, 2023).

From an organizational perspective, the effectiveness of occupational health and safety management systems is measured by their ability to prevent workplace accidents, reduce occupational illnesses, optimize resource usage, and meet the expectations of workers and the organization. (Ospina, 2020).

In this sense, contemporary management models have evolved from traditional approaches focused solely on risk control towards comprehensive systems oriented towards continuous improvement, active worker participation, and strategic management of workplace safety (MAPFRE, 2019).

In recent decades, safety and health management systems have evolved from traditional approaches focused on risk control towards comprehensive models of preventive management (Jurado, 2023). These models prioritize continuous improvement, active worker participation, and the integration of safety into organizational planning (Flores, 2020).

In this process, atmospheric air is filtered and compressed in several stages, which allows its volume to be reduced and its pressure to be increased (Aguirre, Castillo, & Tous, 2019). Subsequently, the air is cooled and dried to remove impurities such as moisture, carbon dioxide, and hydrocarbons, ensuring the purity of the gas obtained (Copco, 2023).

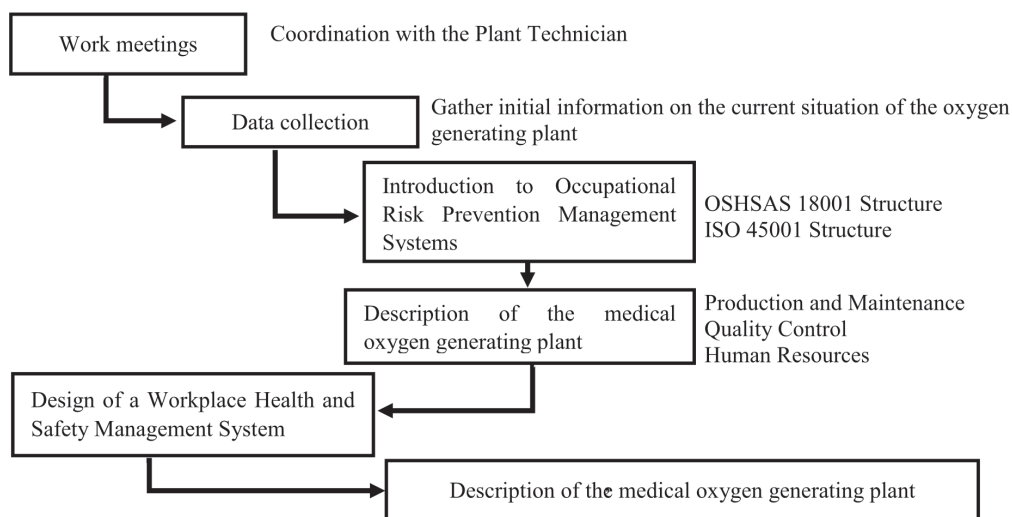
Compressed air is cooled to -175°C to separate gases such as oxygen, argon, and nitrogen; the oxygen is vaporized and delivered to patients (Quintero, 2022).

MATERIALS AND METHODS

A qualitative methodology was designed to analyze human behavior within the production processes of the medical oxygen-generating plant at Hospital Base III EsSalud in Juliaca. The research was developed through a set of structured methodological phases, aligned with the study objectives. The design procedure is defined in Figure 1.

Figure 1.

Model for the design of a health and safety management system at work for Essalud workers



ISO 45001 requires management commitment, worker participation and a focus on risks, generating a level of compliance from 0% to 100% and improving labor protection (Ugaz Flores, 2022) (Table 1):

Table 1.

Leyenda del cuestionario ISO 45001:2018

	Description	Weight
RNA	Restriction not applicable according to the elimination criteria of ISO 45001:2018	0%
RA	Applicable Requirement, without having been designed, perfected or implemented.	10%
REP	Requirement in the process of being delineated or refined as a description of the SGSST	25%
DOCUMENTED	Requirement exploited, with consequences, data, and experiments.	50%
IMPLEMENTED	Applied and audited requirements with satisfactory results.	75%
IMPLEMENTATION RECORDS	Applied, controlled, and continuous improvement requirements	100%

Note. (Ugaz and Flores 2022).

RESULTS AND DISCUSSION

Table 2.

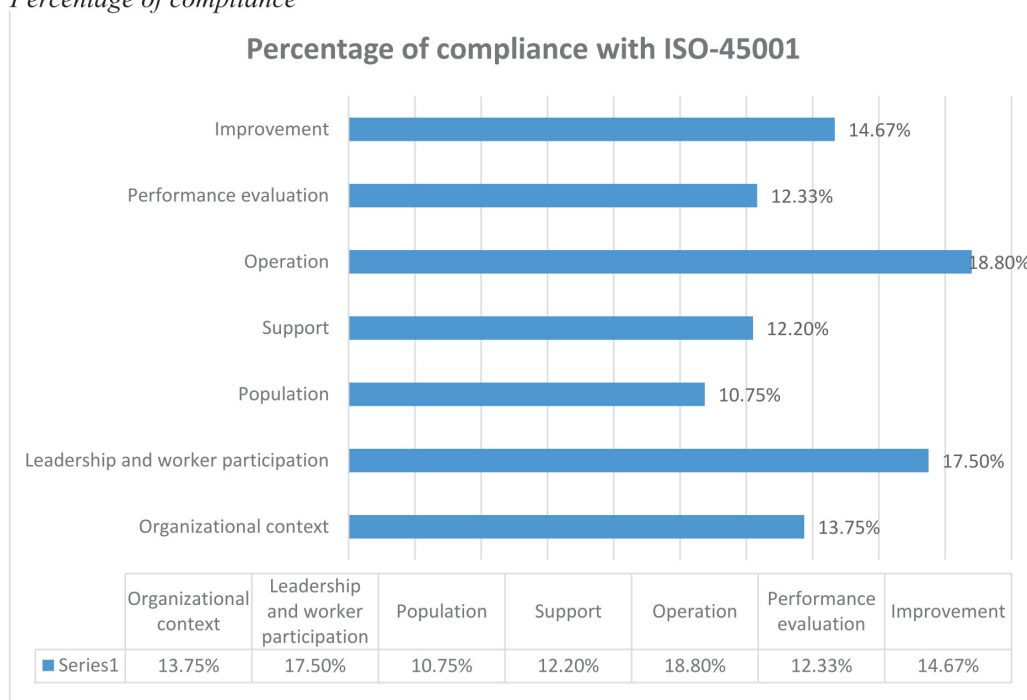
Results of compliance with the requirements of ISO-45001:2018

Organizational context	13.75%
Leadership and worker participation	17.50%
Planning	10.00%
Support	11.20%
Operation	16.00%
Performance evaluation	10.00%
Improvement	11.67%

RESULTS AND DISCUSSION

Figure 2.

Percentage of compliance



Note. *Percentage of compliance with the ISO 45001:2018 assessment of the medical oxygen-generating plant.*

The results show an overall low level of compliance with ISO 45001, indicating that the system is still in an early implementation phase. The greatest progress is observed in Operations (18.80%) and Leadership (17.50%), while the lowest level corresponds to Population (10.75%), highlighting weaknesses in personnel management. Similarly, Support and Performance Evaluation show low scores, reflecting limitations in resources, monitoring, and control. In summary, compliance is insufficient and requires comprehensive strengthening to achieve an effective system.

Table 3.

Stakeholders of the medical oxygen-generating plant

Internal Stakeholders
Plant workers
EsSalud hospital staff
Senior Management
Ministry of Labor
EPPS Suppliers
Users

Identifying stakeholders allows us to recognize the key players in the plant, whose participation is essential to ensuring workplace safety and service quality.

Table 4.*Resources needed at the medical oxygen-generating plant*

Available resources	Unavailable resources
Human Resources	Preventive Culture
Material Resources	SST Teams
Technological Resources	Financial Resources

***Note:** A medical oxygen-generating plant can be a significant investment.*

The assessment indicates that, although human, material, and technological resources are available, there are deficiencies in the preventive culture, occupational safety and health equipment, and funding, which adversely affect both safety and operational efficiency.

Table 5.*Comparative table of technological systems*

Technology	Licuefaction	PSA
Main equipment	Cooling	Sieve
Pharmaceutical Form	Liquid	Gaseo
Purity	99.5%	93 – 96%
Mandatory analysis of additional chemical parameters	None	CO, CO ₂ , Moisture, Hydrocarbons, Particles
Economic Investment	Major	Minor
Production Scale	Major	Minor

The comparison chart shows that liquefaction technology produces liquid oxygen with 99.5% purity and greater capacity, although it requires a larger investment. In contrast, PSA technology produces gaseous oxygen with 93%–96% purity and lower cost, but requires additional quality controls.

DISCUSSION

The results show low compliance with ISO 45001:2018; leadership (17.50%) and operation (16.00%) stand out, while planning and evaluation (10.00%) are the lowest, indicating an initial stage of the OHSMS and limited effectiveness in risk prevention (Rimac, 1920). According to ISO 45001, its implementation requires integrating risk management, organizational leadership, and continuous performance evaluation in OSH (ISO.45001, 2018).

Leadership and worker participation show greater compliance, with management commitment and active participation being key to strengthening the preventive culture (Arias Arias, 2022). Employee involvement in hazard identification and safety decisions significantly contributes to reducing workplace accidents and illnesses (Ospina, 2020).

Poor results in planning and evaluation highlight weaknesses in risk management, objectives, and monitoring key aspects for continuous improvement and the effectiveness of preventive actions (ECOGASES, 2022). The lack of formal assessment processes limits the ability to adequately manage risks in plant operations (MAPFRE, 2019).

The identification of stakeholders recognizes the key actors in the system, whose interaction is fundamental to complying with regulations and strengthening workplace safety, highlighting participation and shared responsibility according to Law No. 29783 (Ley.Nº.29783, 2016)

The analysis shows that, although human, material, and technological resources exist, there are limitations in preventive culture, OSH equipment, and financing, affecting the implementation of the OSH Management System and the safety of personnel (Flores, 2020).

Technical analysis shows that liquefaction produces 99.5% oxygen and is suitable for large scales, although with high investment; while PSA technology offers 93%–96% purity, lower cost, and requires additional quality controls (Copco, 2023).

In hospitals, the choice of oxygen technology depends on capacity, costs, and resources; PSA stands out for its speed and lower cost, but in all cases, implementing an HSMS is key to controlling operational risks (Quintero, 2022).

The results highlight the need to strengthen the OSHMS through improved planning, resource allocation, training, and continuous evaluation to ensure workplace safety and operational continuity (Malagon Saenz & Garcia Mogollon, 2021).

CONCLUSIONS

An initial diagnosis of the plant was carried out , revealing a weak OSH culture and a lack of tools to work in safe conditions.

An IPER matrix was developed to identify and assess risks, establishing corrective measures that prevent incidents and protect workers.

Procedures, instructions and records were developed to comply with ISO 45001:2018 and ensure the effective implementation of the OHSMS.

The design of the SG-SST will allow the plant to manage risks and improve its performance and continuous operation.

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ASSESSMENT OF FROST AND DROUGHT TOLERANT POTATO (*Solanum tuberosum* L.) CLONES IN THE AGROECOLOGICAL ZONE OF TAHUACO–YUNGUYO, PUNO.

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ABSTRACT

This applied research, framed within an experimental quantitative approach, was conducted during the 2017/2018 growing season at the Tahuaco Research and Production Center (INIA-Puno). The study aimed to: (a) identify potato clones (*Solanum tuberosum* L.) tolerant to frost and drought, and (b) evaluate the effects of these stress factors on agronomic performance and yield. The experimental material comprised 18 genotypes (16 clones and 2 control varieties) arranged in a completely randomized block design (CRBD) with four replications. Agronomic and yield traits were recorded, and data were analyzed using analysis of variance and Duncan's multiple range test. Results revealed highly significant differences among clones. Clone RC 20-01-17 exhibited the highest yield (51.907 kg ha⁻¹) and the lowest frost damage (11.25%), followed by RC 2-96-43B and RC 20-01-01. Frost events caused mild and transient effects, with subsequent plant recovery. Similarly, several clones demonstrated drought tolerance, with damage levels below 20%. In conclusion, clones RC 20-01-17, RC 2-96-43B, and RC 20-01-01 show high productive potential and strong adaptation to adverse climatic conditions, representing promising genetic material for future breeding programs.

Keywords: potato, clones, frost, drought, yield

INTRODUCTION

The potato (*Solanum tuberosum* L.) is a crop native to Peru, domesticated approximately 10,000 years ago. (Spooner, 2005), it is the fourth most important crop worldwide (FAO, 2004). In the Puno region, potato cultivation is of great economic and social importance, being the predominant crop and the staple of the local diet. However, yields are low due to limiting factors, especially climate change, such as frosts and droughts, which cause considerable damage to yields or low production.

Frosts can cause losses of more than 90% of production, depending on their intensity and duration, the crop's phenological stage, and crop management (CIP, 1980). Drought also has a negative impact, with losses of up to 85%, depending on its intensity, duration, the crop's phenological and health status, crop management, and the incidence of pests and diseases.

Various studies have demonstrated the potato's vulnerability to water stress. In this regard, (Harris, 1978) found that water deficit affects crop yield, leading to the need to develop new varieties with greater tolerance to these conditions. On the other hand, (Cahuana, 2003) notes

that droughts have been a historical constant, including in pre-Hispanic times, when the Inca civilization implemented storage strategies to mitigate their effects, highlighting the importance of ancestral knowledge in food security.

Mendoza and Estrada (1979) indicated that there are potato species that survive frosts due to their morphological and physicochemical characteristics, opening the door to research on cold tolerance mechanisms.

With regard to tolerance to low temperatures, (Mendoza & Estrada, 1979) identified potato species capable of withstanding frost, attributing this ability to specific morphological and physicochemical characteristics. Likewise, (Cahuana & Arcos, 2015) successfully developed and released seven potato varieties, notably Andina, Tahuaqueña, and San Juan, which are currently widely cultivated due to their high yield, tolerance to frost and drought, and ability to recover from these adverse events.

In this context, it is essential to evaluate advanced potato clones in order to identify materials with tolerance to frost and drought, as well as high productive capacity and quality (Cahuana, Arcos, Bareda, Quenallata, & Holguin, 2012). Therefore, the objective of this research was to evaluate the performance of 16 potato clones in Tahuaco, Yunguyo, Puno, with the aim of selecting those with the best agronomic performance under adverse conditions. In this way, the study seeks to contribute to the identification of germplasm of interest for genetic improvement programs, promoting the adaptation of potato cultivation to climate change scenarios and contributing to the strengthening of food security.

MATERIALS AND METHODS

The experimental research was conducted during the 2017–2018 growing season at the Tahuaco Research and Production Center (INIA-Puno), located in the Province of Yunguyo, Department of Puno. Eighteen cultivars (16 potato clones and 2 control varieties) were evaluated under a completely randomized block design (CRBD) with 4 replications, for a total of 72 experimental units. Data on yield, plant height, number of stems, number of tubers, tuber size, and plant vigor were recorded. Additionally, a physicochemical analysis of the experimental soil was conducted. Climatic data were obtained from the CIP Tahuaco Meteorological Station. The data were subjected to analysis of variance and Duncan's multiple range test. This methodological approach allowed for a rigorous evaluation of the agronomic performance of the potato clones under controlled conditions, providing reliable and comparable results.

RESULTS AND DISCUSSION

In the evaluation of the clones, highly significant differences ($p \leq 0.01$) were found in response to frost, drought, and agronomic characteristics, indicating significant genetic variability under stress conditions.

Regarding frost tolerance, clone RC 20-01-17 recorded the lowest percentage of damage (11.25%), followed by RC 2-96-43B and 308555.3 with 13.75%. In contrast, the most susceptible clones exhibited damage ranging from 16.25% to 23.75%, as shown in the table.

Table 1*Frost damage (%) in potato clones.*

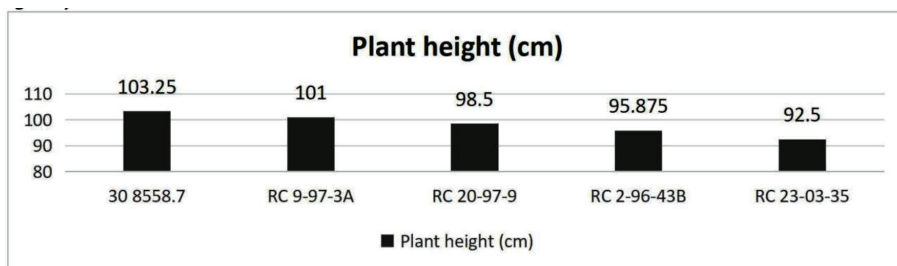
Clone	Damage (%)
RC 20-01-17	11.25
RC 2-96-43B	13.75
308,555.3	13.75
RC 20-01-01	13.75
Other clones	23.75

Regarding drought tolerance, some clones showed a lower level of impairment (<20%), notably RC 20-01-01, RC 2-96-43, 308555.3, RC 20-01-17, and 308554.21, while others exhibited greater sensitivity to water stress. As shown in Table 2.

Table2*Drought damage (%) in potato clones.*

Clone	Damage (%)
RC 20-01-01	<20
RC 2-96-43	<20
308555.3	<20
RC 01/17/20	<20
308554.21	<20
Other clones	>20

Regarding agronomic characteristics, plant height showed highly significant differences (CV = 7.84%), with clones 308558.7, RC 9-97-3A, RC 2-96-43B, and RC 20-01-17 exhibiting the greatest vegetative growth, as shown in Figure 1.

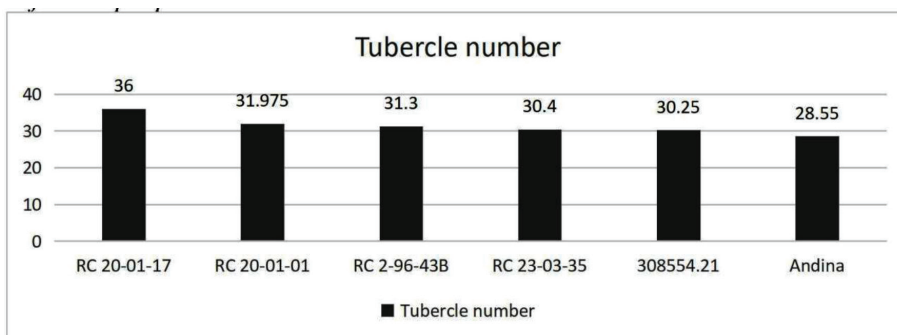
Figure1*Plant height by clone.*

Likewise, the number of stems per plant varied among clones, with higher values observed in those with greater vigor.

The number of tubers per plant, shown in Figure 2, also showed significant differences (CV = 20.13%), reflecting the variability in the productive capacity of the evaluated materials.

Figure2

Number of tubers per plant.



Regarding yield, highly significant differences were observed among clones. Clone RC 20-01-17 achieved the highest yield (51.907 kg ha⁻¹), followed by RC 2-96-43B (47.066 kg ha⁻¹) and RC 20-01-01 (47.032 kg ha⁻¹). On the other hand, the control varieties Andina and Qompis had the lowest yields, as shown in Table 3.

Table3

Yield and tubers (kg ha⁻¹)

Clone	Yield (kg ha ⁻¹)
RC 20-01-17	51.907
RC 2-96-43B	47.066
RC 20-01-01	47,032
308,555.3	High
308554.21	High
Andean	Low
Qompis	Low

DISCUSSION

The results show that there is variability among the clones in their ability to tolerate adverse conditions such as frost and drought. In particular, the good performance of clone RC 20-01-17 suggests that it possesses characteristics that allow it to adapt better to low temperatures, reducing damage to its tissues. This behavior is consistent with what has been reported by (Mendoza & Estrada, 1979) who notes that frost tolerance in potatoes is associated with specific physiological and morphological characteristics.

Likewise, the recovery observed in several clones following frost events reflects a significant capacity for resilience. This aspect has been identified as key in high-Andean systems, where climatic conditions are variable, and its influence on yield has been documented (Hijmans, 2003)

Regarding drought, the clones that showed less damage demonstrate better adaptation to water deficit, possibly associated with greater water-use efficiency. Similar results have been reported by Monneveux et al. (2013), who highlight the importance of drought tolerance in crop yield stability.

On the other hand, differences in plant height, number of stems, and number of tubers demonstrate the influence of the genetic component on agronomic performance. Greater vegetative

development and a higher number of stems are associated with greater photosynthetic capacity and a greater number of tuberization sites, which is consistent with the findings of (Struik & Wiersema, S, 1999).

Finally, the yield results confirm that clones with less stress damage and better agronomic development achieved higher production levels. This behavior has been widely documented, indicating that tolerance to abiotic stresses is directly related to the crop's yield stability (International Potato Center, 2010). Among the study's strengths is the evaluation of multiple clones under field conditions. However, a limitation is that it was conducted over a single growing season; therefore, it is recommended that these results be validated in different regions.

CONCLUSIONS

The RC 20-01-17 clone was selected for its high yield potential and tolerance to frost and drought. In terms of agronomic performance, less severe frosts caused mild and temporary effects, with subsequent plant recovery. The clones RC 20-01-17, RC 2-96-43B, and RC 20-01-01 achieved the highest yields, demonstrating their productive capacity, tolerance to frost and drought, good foliage growth, greater plant height, and numerous tubers. These findings highlight the importance of selecting and genetically improving potato clones adapted to the adverse climatic conditions of the Andean region, in order to ensure food production and improve the quality of life of local communities.

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CIVIL REPARATION AND EVIDENTIARY STANDARDS IN PERUVIAN MILITARY POLICE DESERTION: COMPENSABLE HARM IN ENDANGERMENT OFFENSES

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ABSTRACT

This study explores how compensable harm can be meaningfully understood and demonstrated when civil reparation is imposed for military police desertion, an offense doctrinally framed as endangerment of institutional interests. Using a qualitative, documentary, and dogmatic approach, the research combined normative analysis of the Military Police Criminal Code with content analysis of six jurisdictional decisions issued between 2023 and 2025. The findings reveal a pattern of recurring awards most often 250 soles, occasionally 300 soles supported by repetitive reasoning that relies on generic references to service impairment or institutional training. These decisions lacked itemized components, evidentiary support for actual costs, and clear methods of quantification. To address this gap, the study proposes a two stage model: first, recognizing presumed institutional impairment as relevant to typicity; second, requiring concrete, demonstrable harm to justify civil reparation. The model includes a minimum evidentiary checklist and differentiated reasoning standards for trial judgments and abbreviated proceedings. Ultimately, the study argues that civil reparation in desertion cases is only legitimate when judicial reasoning connects proven facts to a concrete harm hypothesis and applies a rational quantification criterion, ensuring legality, proportionality, and sufficient justification.

Keywords: desertion; civil reparation; compensable harm; abstract endangerment offenses; military criminal justice.

INTRODUCTION

Desertion was typified as a functional offense affecting discipline and continuity of service and criminalized without requiring patrimonial injury as a constitutive element; this choice was linked to safeguarding institutional interests associated with national defense and operational functionality (Congreso de la República del Perú, 2010; Fuero Militar Policial, n.d.).

Doctrinally, desertion is explained as an endangerment offense, mainly abstract endangerment, because punishability rests on creating an inadmissible risk to service; however, civil reparation presupposes compensable harm, causation, and a reasoned award, so endangerment is not equivalent to compensable harm (Calsin Coila, 2022; Mejía Mendo, 2022).

Peruvian scholarship has debated the offense's legitimacy: one line emphasizes minimum intervention in peacetime; another proposes decriminalization from the legal-interest and criminal-policy perspective (Cueva Quispe & Loza Ticona, 2022; Mendoza Benavente, 2018).

These approaches do not resolve a practical issue: Military Police jurisdiction bodies often award civil reparation using recurring amounts and standardized reasoning, without specifying compensable harm or evidentiary support for quantification, undermining intersubjective review (Calsin Coila, 2022; Tribunal Superior Militar Policial del Sur, 2023, 2024, 2025).

This article clarifies how compensable harm should be conceptualized and evidenced in desertion to support civil reparation consistent with legality, proportionality, and sufficient reasoning, using normative analysis and jurisprudential content analysis (Fuero Militar Policial, n.d.; Mayring, 2022).

MATERIALS AND METHODS

A qualitative, documentary, and dogmatic study was conducted to reconstruct legal categories and contrast them with decisional practices through content analysis (Mayring, 2022; Krippendorff, 2019).

A purposive sample comprised six Military Police jurisdiction decisions (2023–2025) addressing civil reparation in desertion; variables were coded for harm type, evidentiary support, causal nexus, and quantification criterion, using an ordinal reasoning scale (0–3) for comparison (Tribunal Superior Militar Policial del Sur, 2023, 2024, 2025).

RESULTS AND DISCUSSION

The corpus showed award standardization: five decisions set 250 soles and one set 300 soles, without itemized components, cost evidence, or a verifiable method; harm was asserted generically through references to service impairment or institutional training (Tribunal Superior Militar Policial del Sur, 2023, 2024, 2025).

Figure 1

Analyzed corpus and observed variables in civil reparation determinations

Case	Decision (year)	Procedure	Amount (PEN)	Harm invoked	Evidence/quantification
A	Judgment No. 59-2025	Trial judgment	250	Training/institutional impairment	No itemization; no costs; adopts request
B	Judgment No. 121-2024	Trial judgment	250	Training/institutional impairment	No itemization; split payment without method
C	Case 0055-2023 (2024)	Trial judgment	300	Training/institutional impairment	250→300 change without criterion
D	Judg. No. 0202-2023	Trial judgment	250	Training/institutional impairment	1,000 request in hearing; no bridge
E	Conforming judgment (2024)	Abbrev. by agreement	250	Amount set by agreement	Formal control; harm not substantiated
F	Case 0059-2023 (2024)	Trial judgment	250	Training/institutional impairment	No itemization; no costs; adopts request

DISCUSSION

The analysis of six Military Police jurisdictional decisions between 2023 and 2025 reveals a consistent pattern in the determination of civil reparation for desertion. Trial judgments relied on a repetitive template: a generic definition of civil reparation, an assertion of institutional harm derived from breach of functional duty, and the adoption of the amount requested by the State. This reasoning was not accompanied by itemized components, evidence of actual costs, or measurable indicators of operational disruption (Calsin Coila, 2022; Tribunal Superior Militar Policial del Sur, 2024, 2025).

The uniformity of awards, primarily 250 soles, with one case reaching 300, suggests a mechanical practice rather than a reasoned judicial exercise. The deficit becomes particularly evident when the claim varies during hearings and the final amount is set without explaining the transition, as in Case C and Case D. In abbreviated proceedings, agreements may facilitate payment and procedural efficiency, but they cannot substitute the minimum judicial duty to review reasonableness, especially in endangerment offenses where institutional interests are at stake (Tribunal Superior Militar Policial del Sur, 2023, 2024; Congreso de la República del Perú, 2010).

This pattern raises concerns about the legitimacy of civil reparation determinations. Without a clear link between proven facts, concrete harm, and rational quantification, awards risk becoming symbolic rather than compensatory. The absence of evidentiary substantiation undermines proportionality and legality, leaving judgments vulnerable to criticism for insufficient reasoning.

To overcome these shortcomings, the study proposes a two stage model. First, presumed institutional impairment should be recognized as sufficient to establish typicity. Second, civil reparation must be grounded in demonstrable harm, supported by a chain of facts, harm, evidence, causation, and quantification. This model incorporates a minimum evidentiary checklist and differentiated reasoning standards for trial judgments and abbreviated proceedings (Mejía Mendo, 2022; Pacheco Palacios, n.d.).

By adopting this framework, judicial practice could move beyond formulaic reasoning toward decisions that are transparent, proportionate, and consistent with constitutional principles. Ultimately, civil reparation in desertion cases should not be reduced to a ritualized amount but should reflect a rational assessment of institutional damage, thereby reinforcing both legality and trust in military police justice.

CONCLUSIONS

Civil reparation in desertion is admissible only if concrete harm is identified and evidenced (preferably verifiable patrimonial costs or measurable organizational disruption), causation is made explicit, and a rational quantification criterion is justified; the observed pattern of standardized awards and generic reasoning supports adopting evidentiary and reasoning standards to align civil reparation with legality and proportionality in endangerment offenses (Calsin Coila, 2022; Mejía Mendo, 2022).

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DIGITAL FATIGUE AND SERVICE QUALITY AMONG STAFF OF THE LOCAL EDUCATIONAL MANAGEMENT UNIT (UGEL) OF SAN ROMÁN, PUNO REGION, 2025

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ABSTRACT

The rapid expansion of digital technologies has transformed education and public management, but it has also intensified digital fatigue a condition of physical and mental exhaustion caused by prolonged screen exposure and information overload. This study investigates the relationship between digital fatigue and service quality among staff at the San Román Local Educational Management Unit (UGEL) in Puno during 2025. A quantitative, non experimental, cross sectional, and descriptive correlational design was employed, using the hypothetical deductive method to test associations between variables. Data were collected through expert validated questionnaires administered to 60 public agents, selected via non probabilistic sampling. Spearman's Rho was applied to analyze correlations. Findings revealed a very high, negative, and statistically significant relationship between digital fatigue and service quality ($\text{Rho} = -0.919$; $p = 0.000$). Specifically, 41.7% of staff reported high levels of digital fatigue, while 46.7% demonstrated low service quality. Symptoms included visual strain, headaches, and cognitive difficulties, which directly undermined the ability of personnel to provide effective services to students, parents, and the wider community. The study concludes that digital fatigue significantly reduces institutional service quality, highlighting the need for strategies to mitigate technological exhaustion. Addressing this issue is essential to strengthen staff well being and ensure the delivery of high quality educational services in public management.

Keywords: digital fatigue, service quality, education management, public sector, technology use

INTRODUCTION

Currently, the intensive use of technology has profoundly transformed multiple sectors, including education (Acero, 2019). Digital fatigue is an increasingly prevalent phenomenon affecting individuals who spend extended hours in front of electronic devices such as computers, smartphones, and other digital equipment. This physical and mental exhaustion, triggered by prolonged screen exposure and information overload, can have significant consequences for health and well-being, impairing concentration, emotional stability, and productivity (Aguirre & Ramírez, 2021).

Within the context of the Local Educational Management Unit (UGEL) San Román, state agents are particularly exposed to digital fatigue due to the demands of digital environments in educational management, communication with the educational community, and administrative

tasks requiring constant technological use. Service quality is a fundamental concept that assesses users' perceptions of efficiency, effectiveness, and satisfaction in the services they receive (Alegría & Alarcón, 2022). In the educational field, service quality depends not only on employees' knowledge and skills but also on their ability to remain focused, motivated, and committed to their work (Alegría, Alarcón, & López, 2023). Levels of digital fatigue can directly influence service quality, as exhaustion and demotivation derived from excessive digital workloads reduce staff capacity to deliver high-quality services, thereby affecting the attention provided to students, parents, and other stakeholders (Altamirano, 2021).

Digital fatigue is defined as the negative effects resulting from excessive use of digital devices, including visual strain, headaches, and cognitive decline (Rodríguez et al., 2024). Davila and López (2025) conceptualize digital fatigue in terms of how prolonged interaction with digital technologies impacts individuals' mental and physical performance. Similarly, Terán et al. (2021) identify digital fatigue as a set of symptoms associated with stress and informational overload caused by continuous technology use. Service quality, in turn, refers to the extent to which a service meets client or user expectations and needs (Inca, 2015). According to the SERVQUAL model, service quality is evaluated based on the client's perception of the service received compared to prior expectations (Canzio, 2019). Furthermore, service quality in service management is understood as the consistent fulfillment of established standards and expectations (Ramírez, 2016).

This study focuses on analyzing the relationship between digital fatigue and service quality among UGEL San Román personnel, with the objective of understanding how technology-related exhaustion may affect work performance and, consequently, user satisfaction. Although digital fatigue and service quality may appear to be independent variables, it is essential to explore their interrelation and examine how the level of digital fatigue may alter staff capacity to provide efficient and satisfactory services. Through this research, it was determined whether employees experiencing high levels of digital fatigue face difficulties in meeting quality standards in their performance and service delivery, and whether measures can be implemented to mitigate these effects.

MATERIALS AND METHODS

The study employed the hypothetico-deductive method, which allowed researchers to begin with general knowledge about the relationship between digital fatigue and service quality, and then empirically compare this knowledge with the reality observed at the San Román Local Education Management Unit (UGEL). The study population consisted of 60 workers.

Table 1*Study population*

Area	N
Direction	13
Pedagogical Management	22
Institutional Management	25
Administrative Management	12
Human Resources Management	8
Institutional Control	5
Total	60

Note. Own elaboration (2025)

The all population of 60 UGEL workers was considered for the sample. Non-probability sampling was used.

Regarding the digital fatigue variable, a survey was administered to Local Education Management Unit UGEL employees. This instrument consists of 21 items distributed across three dimensions: visual fatigue, cognitive fatigue, and technological stress. For the service quality variable, a survey will be administered to UGEL employees to assess their self-evaluation of the quality of service they provide. The survey technique will be a questionnaire, consisting of 20 items and 5 dimensions: tangibility, reliability, responsiveness, assurance, and empathy. This measurement will be carried out using the Likert scale.

To test the hypothesis, the Spearman's Rho statistical design was used to determine the association of the variables, with the following formula:

$$r_R = 1 - \frac{6\sum_i d_i^2}{n(n^2 - 1)}$$

Where:

R = "Spearman's rank correlation coefficient".

D = "Range difference (X - Y)".

n = "Number of data".

RESULTS AND DISCUSSION

Results for the general objective: To determine the relationship between digital fatigue and the quality of service of the staff of the UGEL San Román in the Puno region, 2025

Table 2*Level of digital fatigue*

Levels	N	%
Low	13	21,7
Moderate	22	36,7
High	25	41,7
Total	60	100,0

The results show that, of the 60 workers surveyed at the San Román Local Education Management Unit (UGEL), 41.7% experienced high digital fatigue, indicating that a proportion of the staff faced intense technological demands. 36.7% reported a moderate level of digital fatigue, demonstrating that a considerable portion of the staff experienced a medium technological workload. Only 21.7% were found to be at a low level, indicating that a small percentage did not experience digital fatigue.

Table 3

Level of service quality

Levels	N	%
Low	28	46,7
Moderate	15	25,0
High	17	28,3
Levels	60	100,0

The table shows the results regarding the service quality level of the workers at the San Román Local Education Management Unit (UGEL). Of the 60 respondents, 46.7% reported a low level of service quality, indicating that almost half of the staff experienced difficulties in service delivery. 25.0% were at a moderate level, demonstrating that some staff maintained an intermediate level of service quality. Finally, 28.3% reported a high level of service quality, revealing that a portion of the staff managed to deliver superior quality services.

DISCUSSION

The overall objective of this study was to determine the relationship between digital fatigue and service quality among staff at the San Román Local Education Management Unit (UGEL) in the Puno region, 2025. The results showed a very high and statistically significant negative correlation between both variables ($Rho = -0.919$; $p = 0.000$), indicating that greater digital fatigue is associated with lower service quality. This finding aligns with international precedents, such as the definition of digital fatigue as the negative effects resulting from the excessive use of digital devices, including eye strain, headaches, and cognitive impairment (Rodríguez et al., 2024).

Davila and López (2025) define digital fatigue in terms of how prolonged interaction with digital technologies affects individuals' mental and physical performance. Similarly, Terán et al. (2021) identify digital fatigue as a set of symptoms related to stress and information overload caused by the continuous use of technology, and service quality refers to the degree to which a service meets the expectations and needs of the client or user (Inca, 2015). Therefore, it is shown that the quality of service in public institutions in Puno is usually perceived as fair or low, which agrees with the levels found in the UGEL San Román. Taken together, the background information supports the idea that digital fatigue is a determining factor affecting service quality, as evidenced by the results obtained.

The results obtained for specific objective 1 showed a strong negative correlation between visual fatigue and service quality, indicating that higher levels of eye discomfort are associated with a significant decrease in service quality. In summary, the background information supports

the association found between visual fatigue and service quality at the San Román Local Education Management Unit (UGEL).

Regarding the results for specific objective 2, they showed a strong negative correlation between cognitive fatigue and service quality, indicating that mental exhaustion reduces efficiency in user service. This result is consistent with background evidence showing that job performance in public institutions in Puno is generally average, which is reflected in a perceived service quality of low or medium. This aspect is related to the levels of cognitive fatigue observed in the staff of the San Román Local Education Management Unit (UGEL). This, the background evidence supports the influence of cognitive fatigue on the reduction of service quality.

In the results of specific objective 3, this study showed a strong negative correlation between technological stress and service quality, demonstrating that increased technological pressures negatively impact the service provided by staff. This finding aligns with international and local research, linking it to internal factors such as technology management and operational stress. Taken together, this research supports the conclusion that technological stress directly influences the service quality of the staff at the San Román Local Education Management Unit (UGEL).

CONCLUSIONS

A negative relationship exists between digital fatigue and the service quality of the staff at the San Román Local Education Management Unit (UGEL), 2025, with a correlation coefficient of -0.919. This result demonstrates that as workers experience higher levels of digital fatigue, their ability to provide efficient service decreases considerably. Digital fatigue, reflected in the general exhaustion caused by constant exposure to technological devices, affects attention, concentration, and the willingness to adequately serve users, this generating a notable deterioration in service quality.

There is a negative relationship between eye strain and staff service quality, with a correlation coefficient of -0.903. This demonstrates that as workers experience increased visual discomfort such as burning, blurred vision, and eye fatigue, their performance and quality of service decrease. Eye strain becomes a direct barrier to the effective completion of administrative tasks, affecting the accuracy and efficiency of customer service.

There is a negative relationship between cognitive fatigue and service quality, with a correlation coefficient of -0.778. This finding indicates that increased mental exhaustion, characterized by difficulty concentrating, slow information processing, and cognitive overload, reduces the effectiveness of the service provided. Cognitive fatigue affects decision-making, responsiveness, and courteous treatment of users all essential elements of institutional service quality.

There is a negative correlation between technological stress and the quality of service provided by staff at the San Román Local Education Management Unit (UGEL), with a coefficient of -0.821. This indicates that when employees experience pressure related to the use of digital tools, difficulties adapting to technological systems, or technological overload, the quality of service tends to decrease. Technological stress generates frustration, insecurity, and reduced performance, affecting the effective completion of administrative processes and the timely provision of services to users.

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IMPACT OF A TUTORSHIP PROGRAM ON THE DEVELOPMENT OF RESPECT AND SOLIDARITY AMONG PRIMARY SCHOOL STUDENTS IN PUNO, PERU

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ABSTRACT

This study examines the influence of the School Tutorship Program on the development of values, specifically respect and solidarity, among third-grade students at 70718 primary educational institution in Ilave in Puno, Peru. The research involved 20 students and employed an experimental, quantitative design with a basic-applied purpose and a socio-cultural approach. The objective was to determine the extent to which the tutorship program fosters the practice of values in the classroom. Results indicate a significant increase in students' demonstration of respect and solidarity following the implementation of the program. In conclusion, the School Tutorship Program exerts a positive and significant impact on the cultivation of values, strengthening respectful and supportive behaviors among primary school students.

Keywords: school tutorship program, respect, solidarity, values education, primary education

INTRODUCTION

Internationally, organizations such as the United Nations emphasize the importance of promoting values to prevent moral conflicts across societies (Lloyd, 2024). In Peru, however, there has been a concerning decline in the appreciation of human life, particularly in the values of respect and solidarity. Death has become a daily occurrence, often perceived as inevitable or even necessary, which reflects both social differences and the morbid curiosity it provokes (Brown, 2023). Within this context, the school tutorship program emerges as a vital space that offers students guidance, attention, and support on essential topics such as respect and solidarity (Sacks, 2018).

Every educational institution is established with a purpose: it is designed to fulfill specific objectives through coordinated work, activities, and roles. Such institutions exist only when two or more individuals come together to cooperate in achieving common goals that cannot be attained through individual effort alone. In this case, the Primary Educational Institution No. 70718 "Túpac Amaru" in Puno serves as an example (Brach, 2021). The behavior of each member within an educational institution is shaped by institutional factors, both external and, more importantly, internal, and it depends on how these factors are perceived by the individual. These perceptions are largely influenced by the activities, interactions, and experiences that each member has within the institution (Piketty, 2020).

At the Primary Educational Institution No. 70718 "Túpac Amaru" in Puno, a series of challenges have recently emerged that directly affect the school community. Among the most

pressing issues are the lack of respect toward teachers, classmates, and parents, as well as the limited presence of solidarity among members of the institution.

This situation reflects what many describe as a “crisis of values,” with growing concern that society is moving toward moral decline (Polleta, 2017). The school’s diagnostic assessment of values particularly respect and solidarity show a moderately acceptable level, but highlights the need for reinforcement through the tutorship program (Sandel, 2025). At both national and global levels, scholars and educators increasingly warn of the erosion of values, especially respect and solidarity (Bregman, 2023).

The consequences of this decline can lead to disorder within the educational center, the broader community, and among parents and teachers, particularly in relation to the values under study (Ignatieff, 2021). The symptoms of this crisis are becoming more visible: disrespect toward teachers, classmates, and parents, coupled with a lack of solidarity among members of the institution (Sassen, 2019).

MATERIALS AND METHODS.

The study was conducted with a sample of 20 third-grade students from the Primary Educational Institution No. 70718 “Túpac Amaru” in Puno, Peru. The total population consisted of 109 students. The research design was experimental and quantitative in nature, with a basic-applied purpose and a socio-cultural approach.

For data collection, standardized tests and test guides were employed as instruments to evaluate the practice of values, specifically respect and solidarity. Surveys were also applied as a complementary technique to gather perceptions and experiences related to the tutorship program.

The data obtained were processed using statistical methods. To determine the significance of the results, the student’s t-test was applied, allowing for the comparison of pre- and post-intervention outcomes and the measurement of the program’s effectiveness in strengthening values among students.

RESULTS AND DISCUSSION

Table 1

Did you enjoy the development of the tutoring program?

Category	No	%
High	11	55%
Moderate	7	35%
Low	2	10%
TOTAL	20	100%

Source: Tutoring program

According to Table 1 in relation to the appreciation for the tutorship program, 55% of students reported that their appreciation was high, 35% said it was moderate, and only 10% said it was low.

Table 2

How is the respect of students?

Category		
High	12	60%
Moderate	6	30%
Low	2	10%
TOTAL	20	100%

Source: Value test

According to table 2 regarding student respect, 60% of students said that their respect is high, 30% said it is moderate, and only 10% said it is low.

Table 3

What is student solidarity like?

Category	No	%
High	11	55%
Moderate	5	25%
Low	3	15%
TOTAL	19	95%

Source: Value test

According table 3 regarding student solidarity, 55% of students reported that their solidarity is high, 25% said that it is moderate, and only 15% said that it is low.

DISCUSSION

The application of the values program revealed a significant improvement in the dimensions of respect and solidarity among third-grade students (Aguirre, 2024; Almeyda, 2021). These findings confirm that the program has been effective in strengthening values within the Primary Educational Institution No. 70718 “Túpac Amaru” in Puno. Similar results have been reported in previous studies, which highlight the positive impact of structured interventions on values education (Alvares, 2019; Galván, 2023).

The promotion of respect and solidarity through the tutorship program fosters students' awareness and encourages the adoption of a life model rooted in fairness, viability, and meaningfulness (Capella, 2022; García, 2026). This aligns with contemporary perspectives on

values education, which emphasize the integration of ethical principles into everyday school practices.

Furthermore, Noriega (2024), in his thesis on the influence of educational programs on values, concluded that such initiatives facilitate the improvement of interpersonal relationships among students. This is consistent with the outcomes observed in the present study, where respect and solidarity were strengthened through program implementation. Likewise, Rubinstein (2023) underscores the relevance of new educational programs in shaping students' moral and social development.

In summary, the evidence suggests that the tutorship program not only enhances the practice of respect and solidarity but also contributes to the broader goal of fostering interpersonal harmony and ethical awareness in the school environment.

CONCLUSION

The implementation of the tutorship program at Primary Educational Institution No. 70718 "Túpac Amaru" in Puno has had a significant and positive impact on the development of values, particularly respect and solidarity, among third-grade students. Through targeted orientation and support activities, the program fostered greater awareness of ethical behavior and strengthened practices of peaceful coexistence and mutual support within the classroom. These results demonstrate the effectiveness of tutorship interventions in promoting values education and highlight their relevance as a strategy for improving interpersonal relationships and cultivating a culture of respect and solidarity in the school environment.

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LEARNING PERCEPTIONS OF BEGINNING-LEVEL ENGLISH STUDENTS IN A PAROCHIAL SCHOOL IN AYAVIRI

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ABSTRACT

The objective of this study was to analyze the perceptions of secondary school students with beginning-level English regarding their learning experience in a parochial school in Ayaviri, Peru, during 2025. A mixed-methods approach was employed, with a qualitative predominance, using a descriptive-interpretive method and a non-experimental, cross-sectional case study design. Data collection techniques included direct classroom observation and semi-structured interviews with students, supported by an observation checklist and an interview guide. The population consisted of 167 students, and due to the accessibility of the context, a census sample equivalent to the total population was used. Findings revealed predominantly unfavorable perceptions toward English learning, characterized by low interest, limited participation, a perceived lack of prior foundations, and criticism of the teaching methodology, which was described as repetitive and unmotivating. Students also expressed that the language felt difficult to understand and disconnected from their everyday reality. In conclusion, students' perceptions are shaped by methodological, motivational, and contextual factors. Therefore, it is essential to strengthen teaching strategies, incorporate more dynamic and engaging activities, and connect English learning with meaningful experiences to foster a more positive attitude among beginning-level learners.

Keywords: English learning, student perceptions, parochial school, beginning-level learners, Ayaviri

INTRODUCTION

In the international context, learning English in secondary education has become a curricular priority because of its relationship to academic mobility, access to information, and participation in globalized environments. However, the expansion of English as a foreign language has not guaranteed satisfactory learning experiences, especially when students begin with very limited proficiency and build their judgments about the subject from classroom practices that are not meaningful enough.

Recent literature shows that students' perceptions, beliefs, and attitudes play a decisive role in their willingness to learn. In Mexico, Manrique and Izquierdo (2024) found that secondary school students' perceptions of public English education varied according to their linguistic competence and school experiences; when proficiency was low, insecurity and negative evaluations of the process increased.

In Colombia, Arias Rodríguez (2020) reported that both teachers and students identified methodological limitations, a shortage of motivating strategies, and a strong need for more

active and contextualized classes. Along the same line, Villarreal Suárez et al. (2016) showed that students evaluated monotonous classes negatively and linked their interest in English to the variety of activities and the pedagogical treatment they received. Other studies reinforce this perspective.

Aziz and Quraishi (2017) showed that beliefs about learning English influence the motivation of secondary school students, while Getie (2020) emphasized that attitudes toward the language are shaped by the school environment, teacher support, and perceived usefulness. Complementarily, Ghazvini and Khajepour (2011) confirmed that motivation and a positive attitude are related to better conditions for learning, and Li and Wei (2023) warned that emotions such as anxiety, boredom, and low confidence can significantly affect achievement among beginning-level students. Taken together, these international antecedents suggest that the problem of learning English cannot be explained only by the difficulty of the language, but also by the way students interpret their educational experience.

In the Latin American sphere, the discussion has focused on understanding how the school context and didactic decisions influence the construction of students' perceptions. Jaime Romero et al. (2021) pointed out that English learning is crossed by intentions and resistances: many students recognize the social value of the language, but they become disinterested when they do not encounter methodologies connected to their reality.

Bastidas and Muñoz-Ibarra (2020) identified among Colombian high school students that factors such as limited practice, reduced interaction, and lack of methodological support directly affect the way students value the course. Pérez-Vargas et al. (2024) contributed that cooperative and participatory strategies foster a more positive perception of learning English by increasing interaction, confidence, and a sense of achievement. Similarly, Peralta-Castro (2023) showed that autonomy in secondary school students is strengthened when classroom experiences cease to be passive and are oriented toward conscious student participation.

These contributions are especially relevant in studies seeking to understand the perceptions of students at a beginning level, because they allow disinterest to be interpreted not as an isolated individual trait, but as a response constructed in the face of insufficient learning opportunities.

In Peru, the problem is even more sensitive. García Ponce et al. (2019) warned that fifth-year secondary school students in public schools in Lima still reached only incipient levels of English despite the presence of the language in the curriculum. Huamán Rosales (2021) explained that low English proficiency in Peruvian secondary education responds to structural weaknesses related to teaching, training, communicative practice, and limited pedagogical continuity.

At the regional level, Tipula Mamani and Tapia Ccallo (2019) found that in full school-day institutions in southern Peru, limitations in the oral approach persisted, affecting the development of competencies from early stages. Likewise, Mamani Hilasaca (2024) highlighted that achievement in English competencies improves when there are didactic conditions that promote self-regulation, participation, and a sense of progress.

Within this framework, the present study, conducted in 2025 in a parochial school in Ayaviri, Peru, gains relevance because it addresses a little-explored reality: the perceptions of secondary school students who are just beginning formal English learning and come from a local Andean context with restricted opportunities for contact with the language. Its originality lies in

centering attention on the student voice through a situated approach built from observation and direct dialogue, instead of limiting itself to measuring performance or academic achievement. Understanding how students interpret their difficulties, what meaning they attribute to the course, and what school factors they associate with their lack of interest enriches the scientific discussion on English teaching in contexts of low linguistic foundation. Based on the reviewed antecedents, the working hypothesis was that students' perceptions of their English learning would be predominantly unfavorable and would be associated with methodological, motivational, and contextual factors, especially the limited variety of teaching strategies, the lack of prior foundations, and the limited connection of content to their reality. Accordingly, the general objective of the study was to analyze the perceptions of secondary school students with beginning-level English about their learning in a parochial school in Ayaviri. The specific objectives were to identify the predominant perceptions regarding interest, difficulty, and usefulness of English; to describe the pedagogical and contextual factors that influence such perceptions; and to interpret, from the student experience, the reasons explaining their low motivation and participation in the classroom. Thus, the study sought to provide contextualized evidence to guide more pertinent pedagogical decisions in settings where English learning begins practically from zero.

MATERIALS AND METHODS

The study was conducted using a mixed-methods approach with a qualitative predominance, as it sought to understand students' perceptions through meanings expressed in dialogue while also organizing descriptive frequencies of emerging categories. A descriptive-interpretive method was applied within a non-experimental, cross-sectional case study design, appropriate for analyzing the reality of a specific school context without manipulating variables. The population consisted of 167 secondary school students from the parochial institution under study, and due to the manageable size and accessibility, a census sample equivalent to the entire population was used. Data collection techniques included direct classroom observation and semi-structured interviews, supported by an observation checklist and an interview guide focused on interest, participation, perceptions of teaching methodology, prior foundations, and perceived difficulty. Content validity was ensured through expert judgment by three specialists in education and research, while credibility was reinforced through triangulation of observations and testimonies, systematic recording, and consistency checks across categories. For data analysis, basic descriptive statistics were combined with thematic coding of responses, applying a referential significance level of $\alpha = .05$ for exploratory contrasts.

RESULTS AND DISCUSSION

The findings show that students' perceptions of learning English were predominantly unfavorable. Classroom observation recorded low spontaneous participation, limited responses to the teacher's questions, little initiative to carry out oral activities, and a tendency toward distraction when tasks centered on copying, repetition, or isolated translation. In the individual dialogues, students repeatedly stated that English was difficult for them, that they did not have sufficient prior foundations to understand what was being taught, and that classes were usually perceived as not very dynamic. When closed responses and emerging categories were systematized, the trends presented in Table 1 were obtained.

Table 1*Main Student Perceptions of Learning English (n = 167)*

Category Analyzed	Frequency	Percentage	Dominant Interpretation
Low interest in learning English	121	72.5 %	Disinterest and low spontaneous participation predominated.
Perception of insufficiently varied methodology	114	68.3 %	Classes were perceived as repetitive and centered on copying and mechanical exercises.
Lack of prior foundation to understand the course	124	74.3 %	Students reported not having basic vocabulary or foundational knowledge.
Low willingness to continue learning under current conditions	111	66.5 %	Demotivation and limited expectation of improvement without didactic changes were expressed.

Note. The table synthesizes the most recurrent themes identified in classroom observation and in individual dialogues with the students. The frequencies correspond to the systematization of convergent responses by category.

As can be seen, 72.5% of the students showed low interest in learning English, 68.3% considered the teaching methodology to be insufficiently varied, 74.3% stated that they lacked prior foundations for understanding the course, and 66.5% expressed little willingness to continue learning the language under the current conditions. Open-ended responses made it possible to better understand these figures. Students related their disinterest to classes centered on brief explanation, notebook copying, and repetitive exercise solving, with few opportunities to speak, play, listen to audio, or work collaboratively. They also pointed out that many contents appeared “all at once” and that, because they did not master basic vocabulary, they felt embarrassed or afraid of making mistakes in front of their classmates. During observation, these perceptions were reflected in prolonged silences, avoidance of participation, and low persistence in oral production tasks.

In the exploratory inferential analysis, no statistically significant differences were found by sex in the categories of low interest, negative perception of methodology, and absence of prior foundations (χ^2 , $p > .05$). Nor were significant differences identified among grade levels in most categories ($p > .05$), suggesting that the unfavorable perception of learning English ran through the population in a relatively homogeneous way. This result reinforces the idea that the problem was not concentrated in a particular subgroup, but rather constituted a shared experience for a large part of the students observed.

DISCUSSION

The results support the working hypothesis, since students' perceptions of learning English were mostly unfavorable and were associated with methodological, motivational, and contextual factors. The low interest and limited participation observed are consistent with what was reported by Manrique and Izquierdo (2024), Arias Rodríguez (2020), and Villarreal Suárez et al. (2016), who indicate that classroom experience and perceived usefulness decisively influence the

evaluation of English. Likewise, the idea of not having prior foundations helps explain why the language is viewed as difficult and distant; this finding is in dialogue with García Ponce et al. (2019) and Huamán Rosales (2021), who describe still incipient English proficiency in Peruvian secondary education. The perception of a poorly varied methodology is also consistent with Bastidas and Muñoz-Ibarra (2020) and Jaime Romero et al. (2021), by showing that disinterest does not arise only from the student, but from pedagogical practices that fail to generate involvement. Statistically, no significant differences by sex were identified in the main categories ($p > .05$), suggesting that the problem is transversal across the observed group. Consequently, the results support the idea that improving English teaching in beginning-level contexts requires more participatory, contextualized, and progressive strategies, as proposed by Pérez-Vargas et al. (2024) and Mamani Hilasaca (2024).

CONCLUSION

It is concluded that the perceptions of secondary school students with beginning-level English in the parochial school of Ayaviri were predominantly unfavorable, due to low interest, limited participation, the perception of language difficulty, and the limited value assigned to the teaching methodology. The general objective was achieved by identifying that such perceptions are shaped by pedagogical and contextual factors, especially the absence of prior foundations and the weak connection between classroom activities and the students' reality. Likewise, the specific objectives made it possible to recognize that English is viewed as generally useful, but not very accessible in the immediate classroom experience. Consequently, the study suggests strengthening didactic planning, diversifying teaching strategies, and promoting experiences that are closer, more communicative, and more motivating. These findings provide local evidence for rethinking English teaching in Andean contexts where learning begins practically from zero.

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ASSESSMENT OF URBAN DRINKING WATER SUPPLY SYSTEMS FOR SERVICE IMPROVEMENT AND COVERAGE EXPANSION: A CASE STUDY IN BELLA COPACABANA, JULIACA, PERU

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ABSTRACT

This study evaluates the drinking water supply system in the Bella Copacabana urbanization in Juliaca in Peru, with the objective of improving service provision and coverage. A quantitative, explanatory-level approach was applied to analyze the current condition of the drinking water and sewerage systems in the southern area of the city. Technical assessments included system performance, water demand and supply analysis, and identification of service coverage gaps. Results indicate that drinking water coverage is severely limited, with an average supply of only four hours per day and an approximate coverage of 19.64%, compelling residents to store water or rely on untreated sources. Infrastructure deficiencies were also identified, such as low network pressure and the absence of sewerage in several sectors, resulting in sanitary and environmental challenges. Two solution alternatives were evaluated, with Alternative I demonstrating superior technical and economic feasibility. This option involves water abstraction through two deep wells, construction of pumping stations, installation of a 6000 m³ reservoir, expansion of distribution networks, and extension of the sewerage system. Implementation of this alternative is expected to enhance service coverage and quality, mitigate sanitary risks, and improve the living conditions of the beneficiary population.

Keywords: drinking water, service coverage, sanitation, hydraulic infrastructure, water demand, environmental management

INTRODUCTION

The adequate provision of essential services such as potable water and sewerage systems is crucial to minimizing the spread of waterborne diseases and improving living conditions (Aquino Lampa, 2025). Despite ongoing efforts, significant gaps persist in the quality and coverage of these services in urban areas, underscoring the need for coordinated action among the Peruvian State, regional and local governments, and sanitation-related entities (Rendina, 2026). In Juliaca, the sanitation service provider SEDA JULIACA S.A. seeks to ensure continuous water supply that meets bacteriological and physicochemical standards, while progressively expanding access to peripheral sectors. Likewise, the company aims to strengthen sewerage infrastructure to enable proper wastewater disposal, reduce sanitary risks, and mitigate environmental pollution. Within this context, the present study examines opportunities and challenges in service provision, contributing to national objectives of universal access to basic services. Public service and housing policies emphasize the promotion of both public and private investment to guarantee access to water, sewerage, waste management, electricity, and telecommunications, with particular attention to populations in urban–rural transition zones.

The problem is identified by the limited coverage of the drinking water service, which originates from the insufficient quantity supplied, Jouravlev, A., (2004). In the Bella Copacabana residential area, residents receive only four hours of water supply per day, indicating a significant shortage. Consequently, the population relies on untreated and potentially contaminated water sources, as many households obtain water from artisanal wells and caissons. Furthermore, the community exhibits deficiencies in sanitation and environmental practices, as a considerable portion of the population lacks adequate hygiene habits, particularly in food handling and general cleanliness. This situation is especially critical in households that do not have access to potable water supply or proper wastewater disposal systems.

The urgent need for safe drinking water in Juliaca reflects both limited production capacity and insufficient attention from authorities, requiring effective solutions to reduce public health risks (Espinosa Ramírez, 2018). In the southern area, inadequate supply and poor quality of water contribute to waterborne diseases, higher healthcare costs, and environmental degradation, diminishing quality of life (World Health Organization, 2011). Vulnerable groups, particularly children and the elderly, are disproportionately affected by the consumption of untreated or contaminated water

Z. J., (2024). The implementation of the project is expected to generate adverse environmental impacts only during the construction phase, Enshassi, A., Kochendoerfer, B., & Rizq, E., (2014). Appropriate mitigation measures have been estimated to address these impacts. During the operational phase, no significant negative effects on the ecosystem are anticipated.

MATERIALS AND METHODS

This research employed a quantitative and applied approach to analyze and improve the drinking water supply system in the Bella Copacabana urbanization, located in the southern sector of Juliaca. A non-experimental design was adopted, as variables were evaluated in their real context without manipulation, and the study was conducted at a descriptive-explanatory level to characterize the existing system and identify the causes of deficiencies in service coverage, continuity, and quality.

The study area comprised several urbanizations with limited access to basic services, including Néstor Cáceres Velásquez, Jesús Nazareno, Taparachi, San Cristóbal, Amauta, Tahuantinsuyo, La Florida, and Santa Marcela (Figure 1). The population consisted of inhabitants within this area of influence, while the sample focused on representative sectors where the drinking water and sewerage systems were assessed.

Figure 1.

study area



Data collection techniques included:

- Direct observation, to evaluate the physical condition of infrastructure.
- Documentary analysis, through the review of technical and regulatory information.
- Socioeconomic surveys, to identify consumption patterns and service access.
- Laboratory testing, to determine physicochemical and bacteriological water quality.

The instruments used comprised data recording forms, measurement equipment, and specialized software for data processing and analysis. The methodological procedure was structured in stages: (i) diagnosis of the existing system, identifying low pressure, limited continuity, and inadequate coverage; (ii) collection of demographic and technical data to calculate water demand based on a per capita consumption rate of 180 L/inhabitant/day and population projections; (iii) evaluation of supply capacity, including water losses and infrastructure limitations; and (iv) determination of the gap between supply and demand, which revealed a significant service deficit.

Based on this analysis, technical solution alternatives were proposed. Alternative I demonstrated superior technical and economic feasibility, with a cost-effectiveness ratio of 450.99 compared to 573.07 for Alternative II. Both alternatives yielded similar performance indicators, with a Net Present Value (NPV) of 9,598,423.34 and an Internal Rate of Return (IRR) of 14.31%. The proposed measures included water abstraction through deep wells, construction of pumping stations, installation of a 6000 m³ reservoir, expansion of distribution networks, and extension of the sewerage system (Calla Apaza, 2024).

The project budget estimated S/. 49,717,483 at social prices, covering 117,751.30 linear meters of sewer network extension, installation of inspection chambers, and service connections for 9,480 households. Environmental mitigation measures were incorporated, including training programs on sanitation practices and water management. Although adverse impacts are expected during the construction phase, appropriate mitigation strategies have been proposed (Enshassi, Kochendoerfer & Rizq, 2014). No significant negative effects are anticipated during the operational phase.

RESULTS AND DISCUSSION

Drinking Water Demand

The adopted per capita consumption was 180 L/inhabitant/day, in accordance with technical criteria for populations in the Andean region. Population projections indicate sustained growth from 47,360 to 86,204 inhabitants over a 20-year evaluation horizon.

Table 1.

Population projection over the evaluation horizon.

Year	Population
0	47,360
5	55,010
10	63,895
15	74,216
20	86,204

Note. Projection based on an annual growth rate of 2.85%.

Service Coverage and Continuity

The results indicate that the drinking water supply system has limited coverage of 19.64%, reflecting restricted access to the service within the study area. Likewise, service continuity is approximately 4 hours per day, primarily concentrated during the morning period.

Table 2.

Coverage and continuity of the drinking water service.

Indicator	Value
Drinking water coverage	19.64 %
Service continuity	4 h/day
Days of service	7 days

Note. Data obtained from the diagnosis of the drinking water supply system.

Sewerage Coverage

The coverage of the sewerage system reaches only 9.52%, indicating a low availability of sanitation services in the study area.

Table 3.

Coverage of basic services.

Service	Coverage (%)
Drinking water	19.64 %
Sewerage	9.52 %

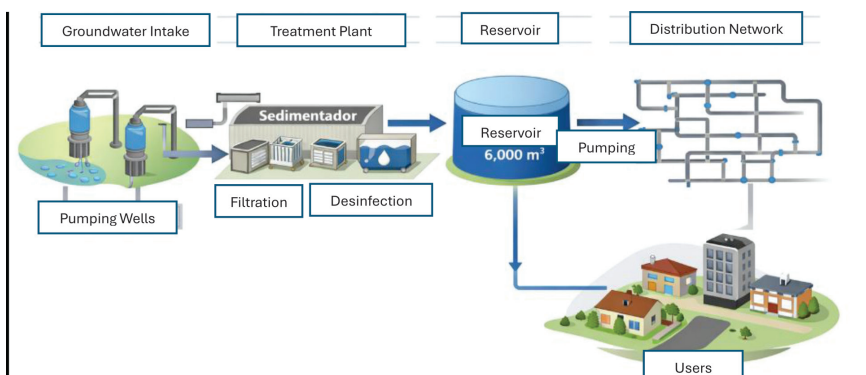
Note. Prepared by the authors based on the system diagnosis.

System Supply and Losses

The current system exhibits limitations in its supply capacity. Physical losses of approximately 50% of the produced volume were identified, primarily associated with infrastructure deterioration. The distribution network extends over 400 km and is composed of materials such as cast iron, asbestos-cement, and PVC.

Figure 2.

General schematic of the drinking water supply system.



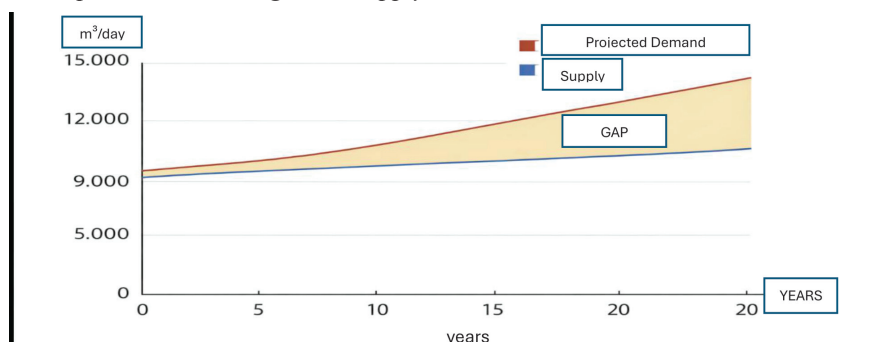
Note. Represents the abstraction, treatment, storage, and distribution components of the evaluated system.

Supply–Demand Gap

The analysis revealed a deficit in service provision, where the projected demand exceeds the supply capacity of the existing system, resulting in an increasing structural gap.

Figure 3

Gap between drinking water supply and demand.



Note. Illustrates the growing difference between projected demand and available supply.

Economic Evaluation

The evaluation of alternatives demonstrated that Alternative I presents a lower investment cost (S/. 76,254,320) compared to Alternative II (S/. 87,962,364). Furthermore, a Net Present Value (NPV) of S/. 9,598,423.34 and an Internal Rate of Return (IRR) of 14.31% were obtained, indicating economic feasibility.

Table 4

Economic evaluation of alternatives.

Indicator	Alternative I	Alternative II
Investment (S/.)	76,254,320	87,962,364
NPV (S/.)	9,598,423.34	—
IRR (%)	14.31	—

Note. Economic evaluation of the project.

DISCUSSION

The results of the research reveal that the drinking water supply system in the Bella Copacabana urbanization exhibits significant deficiencies in terms of service coverage and continuity, with coverage reaching only 19.64% and supply limited to approximately four hours per day. These values reflect a pronounced gap between supply and demand, confirming the inadequacy of the current system to meet the needs of the population.

The low efficiency of the system can be primarily attributed to structural and hydraulic factors. Physical water losses, estimated at approximately 50%, are associated with the deterioration of distribution networks and the aging of pipelines, which is consistent with the findings of Farley and Trow (2003), who indicate that poorly maintained systems exhibit high levels of non-revenue water. Additionally, the lack of sectorization leads to pressure imbalances, increasing head losses and reducing overall system efficiency, Rocha, (2007).

Regarding demand, the per capita consumption of 180 L/inhabitant/day adopted in this study is technically appropriate; however, the system is unable to meet this requirement due to sustained

population growth at an annual rate of 2.85%. This situation is consistent with the findings of the Pan American Health Organization (2015), which indicate that unplanned urban growth in Latin American cities often exceeds the capacity of sanitation systems.

On the other hand, in areas without access to the service, the population relies on the consumption of untreated water sources, leading to negative impacts on public health, as evidenced by the occurrence of gastrointestinal diseases. This behavior is consistent with Clavijo (2013), who establishes that the consumption of contaminated water is directly associated with an increase in diarrheal diseases, particularly among vulnerable populations.

From a physical and structural perspective, the use of deteriorated materials such as cast iron and asbestos-cement promotes corrosion processes, increasing the likelihood of system failures and leakages. According to Mosevoll (1994), corrosion is one of the main factors contributing to the degradation of distribution networks, which explains the low hydraulic performance observed. Furthermore, network topology and the lack of maintenance contribute to the operational inefficiency of the system.

Finally, the evaluation of alternatives demonstrates that Alternative I is the most technically and economically viable option, as it integrates groundwater abstraction, adequate storage, and network expansion. This solution enables improvements in pressure, service continuity, and coverage, thereby validating the proposed hypothesis and fulfilling the research objectives. In agreement with Alegria Mori (2013), the implementation of integrated water supply systems constitutes an effective strategy to ensure the sustainability of potable water services.

CONCLUSIONS

The results of the study demonstrate that the drinking water supply system in the southern area of the city of Juliaca presents significant limitations in terms of service coverage and continuity, with supply restricted to approximately 4 hours per day and coverage below 20%, confirming the system's inadequacy to meet current demand. This condition reflects a structural deficit in the provision of water resources.

Furthermore, it was determined that the existing infrastructure exhibits relevant technical deficiencies, such as deteriorated distribution networks, low pressure, and water losses of approximately 50%, which reduce the operational efficiency of the system and limit service availability for the population.

In relation to demand, population growth and the established per capita consumption of 180 L/inhabitant/day increase the pressure on the system, revealing a growing gap between supply and demand that cannot be addressed under current infrastructure conditions.

Additionally, the limited coverage of the sewerage system, below 10%, and the use of untreated water sources in unserved areas highlight deficient sanitary conditions that directly affect the population's quality of life.

Finally, the technical and economic evaluation of the proposed alternatives determined that Alternative I is the most viable option, as it presents better profitability indicators (positive Net Present Value and an Internal Rate of Return exceeding the opportunity cost), as well as greater efficiency in expanding coverage and improving service delivery.

Consequently, it is concluded that the implementation of the selected alternative fulfills the objective of the research by improving the provision, coverage, and quality of the drinking water service, thereby contributing to the optimization of supply conditions in the study area.

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