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Evaluating problem-solving and procedural skills of first-year students in a Peruvian higher education institution

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Abstract
In this study, we aim to compare the procedural and problem-solving skills of university students during their transition to higher education. A diagnostic test was administered to 374 first-year students at a Peruvian university in March 2023, assessing both their mathematical knowledge and the aforementioned skills. The results reveal that university entrants exhibit a deficient level of mathematical proficiency, with significantly lower scores in problem-solving skills compared to procedural skills. It is noted that while procedural skills are part of problem-solving skills, the discrepancy in scores suggests challenges in the practical application of mathematical knowledge by students. The study sheds light on the situation faced by university entrants in Peru and provides recommendations for improving mathematical skills in higher education. However, it emphasizes the limitation of generalizing the results to all universities due to the limited sample size and the scarcity of research in the field of higher mathematics education in Peru. Disparities based on gender and type of school are observed, indicating that males slightly outperform females in both skills, and students from private schools outperform those from national schools. These differences are analyzed in the article, offering a more comprehensive understanding.

Keywords: diagnostic tests, procedural skills, problem-solving skills, mathematics education, higher education

INTRODUCTION

The COVID-19 pandemic has triggered a significant shift in various aspects of society, and the educational system is among the most profoundly affected. Mobility restrictions imposed to mitigate the virus's transmission had detrimental consequences for students across all levels of education. These repercussions can be attributed to deficiencies in digital transformation strategies, inconsistencies in teacher preparedness, and the absence of digital pedagogy (Cevikbas & Kaiser, 2023; García-Peñalvo, 2021; Mifsud & Day, 2022). The mandated closure of schools in Peru during 2020-2021 resulted in recorded learning losses estimated by the World Bank to be equivalent to a setback of ten years (UNICEF, 2022). Consequently, educators from diverse university disciplines are becoming increasingly concerned, particularly those involved in mathematics courses. This concern is rooted in the fact that the development of mathematical skills in schools has been profoundly influenced by this dramatic transition. As observed by various authors, the development of these skills is pivotal for the future professional growth of individuals across all fields (Barham, 2020; Faulkner et al., 2020; Khalid et al., 2020).

Over the last few decades, the teaching of mathematics has undergone a significant transformation in its approach. It has shifted from the mere transmission of theoretical knowledge to an emphasis on cultivating practical and applicable mathematical skills for real-life situations. However, despite this progress, in countries like Peru, there are still challenges in effectively implementing this approach. Limited access to technological and material resources, along with inadequate teacher training in modern pedagogical strategies, are some of the obstacles hindering the

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Contribution to the literature

- The results indicate that university entrants have an inadequate level of knowledge and mathematics skills. Specifically, their problem-solving skills are lower in comparison to their procedural skills.
- This study contributes to the enhancement of mathematics education and suggests an approach centered on problem-solving as a crucial component in higher education institutions. The authors recommend the inclusion of career-relevant topics, where students can apply their knowledge in practical situations. To achieve this, they propose the coordination of mathematics curriculum development with subject matter experts from various career disciplines.
- The findings of this study support the need for a reevaluation of the structure of introductory mathematics courses in Peruvian universities and highlight the insufficient mathematical skills of students upon completing their secondary education.

comprehensive development of mathematical skills among Peruvian students.

In many Peruvian schools, this has led to the overemphasis on algebraic and arithmetic aspects in mathematics subjects, resulting in students acquiring shallow knowledge without a deep understanding, thus encouraging students to seek mechanistic solutions without fostering creativity (Khalid et al., 2020) and leading them to prioritize procedural skills at the expense of important aspects like contextualization (Garcés-Córdova & Font-Moll, 2022; Garcés Córdova et al., 2021). Consequently, students pass through a learning process of mathematical concepts without gaining a profound understanding or a sense of practical application, ultimately resulting in a deficiency in problem-solving skills. In some cases, these deficiencies persist as students' progress into higher education.

Considering the aforementioned challenges and aligning with the research conducted by Faulkner et al. (2020), the present study addresses the inadequacy of current educational approaches in equipping students with the requisite mathematical skills essential for their professional development. A focused examination of this issue is crucial, as it directly impacts the ability of students to apply mathematical knowledge effectively in practical contexts. Through this research, we aim to identify specific shortcomings and contribute insights that will inform the development of targeted interventions in mathematical education, ensuring students are better prepared for the demands of their future professions.

LITERATURE REVIEW

Mathematics plays an undeniably crucial role in education. The definitions, theorems, properties, and overall content covered in mathematics courses serve as the foundation for various academic subjects. Additionally, engagement with mathematics promotes critical reasoning, decision-making, metacognition, among many other skills (Saha et al., 2020), all of which are imperative for success in today's rapidly changing world (Said et al., 2023). Particularly, two of the most important are procedural and problem-solving skills, and although efforts to enhance the teaching of mathematics are ongoing worldwide, including in Peru, where the existing mathematics education model in schools and universities is being examined for potential transformation and improvement (Garcés-Córdova & Font-Moll, 2022; Garcés Córdova et al., 2021; Maraví Zavaleta, 2021), recent studies revealed that the development of mathematical skills still requires a long process of improvement (Faulkner et al., 2020).

Mathematics Teaching in Peru

Before the COVID-19 pandemic, mathematics education in Peru was undergoing a process of continuous improvement. According to the results of the program for international student assessment (PISA) in 2018, Peru had the fastest growth rate in Latin America (OECD, 2019a). However, the performance of 15-year-old students (8,028 students in 342 schools) still lagged behind the average of the Organization for Economic Co-Operation and Development (OECD), as illustrated in **Figure 1**. Peru ranked 64th out of 77 countries, with a mathematics score of 400, while OECD average was 489. Moreover, only about 1% of students in Peru achieved the highest levels of proficiency (level 5 and level 6). This suggests that only 1% of students were able to mathematically model complex situations and select, compare, and evaluate appropriate problem-solving strategies for addressing them (OECD, 2019a, 2019b).

In Peruvian universities, the current state of mathematics education does not appear to be much better. While the continuous development of the Peruvian mathematics curriculum owes much to the efforts of educators and researchers engaged in scientific educational research (Maraví Zavaleta, 2021), there remains a noticeable lack of research in mathematics education within degree programs in Peru (Garcés Córdova et al., 2021). Additionally, Garcés Córdova et al. (2021) have recently found that fundamental science courses are primarily delivered through a lecture-based and procedural approach, lacking innovations, real-world applications, and modeling. Specifically, mathematics instructors tend to employ an algorithmic, mechanistic, and repetitive approach, characterized by a

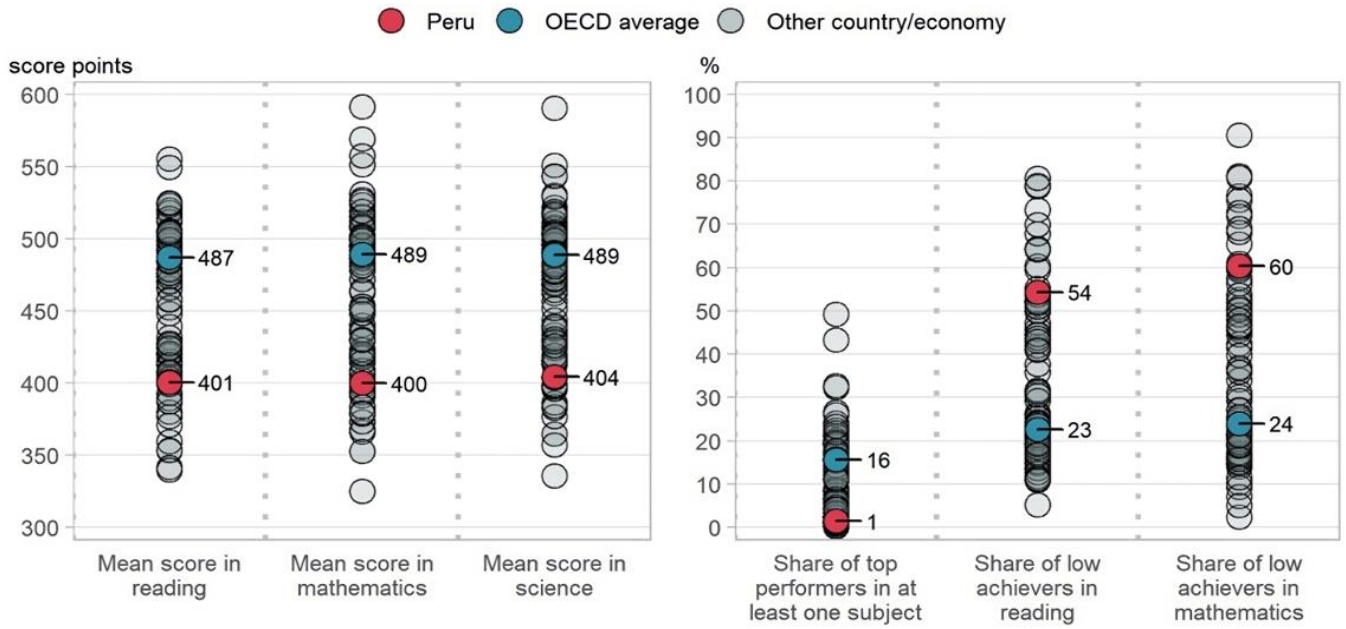

Figure 1. Student performance in Peru in the last PISA 2018 test compared to international students (OECD, 2019a)

strict and formalistic style that hinders students from attaining a deep understanding of mathematical concepts and their practical applications. Consequently, future professionals may struggle to apply mathematics in problem-solving within their respective careers (Garcés-Córdova & Font-Moll, 2022).

However, in the post-pandemic new normalcy of society, certain trends and phenomena have emerged that are driving efforts to enhance teaching and learning in academic subjects, particularly within the mathematics curriculum. These enhancements encompass aspects such as the integration of creativity, digital skills, literacy, intercultural skills, values, and disciplinary knowledge, as suggested by Maraví (2021). Therefore, in preparation for future developments in education and the advancement of a more mathematically proficient society, he advocates for the inclusion of orientations in the mathematics curriculum for Peruvian basic education. These orientations should encompass various elements, including a focus on problem-posing and problem-solving approaches.

Procedural & Problem-Solving Skills

Given the paramount importance of mathematics, numerous research endeavors are dedicated to identifying optimal pedagogical approaches for enhancing its teaching. These efforts aim to improve students' learning performance, confidence, and attitudes toward learning (Cevikbas & Kaiser, 2023). Among the multifaceted benefits of mathematics education, two crucial skills that students acquire are procedural and problem-solving abilities (Chiu et al., 2022; Gilmore et al., 2017; Khalid et al., 2020; Mendezabal & Tindowen, 2018), which are highly sought after by institutions of higher education and employers (Faulkner et al., 2020).

While a unanimous consensus on their precise definition remains elusive, it is noteworthy that all authors whose research was examined underscore the paramount significance of these factors in shaping mathematical competence. Particularly, procedural skill is, according to Hiebert and Lefevre (as cited in Gilmore et al., 2017, p. 2), the "ability to carry out a sequence of operations accurately and efficiently" and has been shown to be closely linked to both current and future mathematics achievement. Also, providing students with procedural feedback may help alleviate their cognitive load, enabling them to focus on understanding the concepts (Stovner & Klette, 2022, p. 9).

Nevertheless, recent studies have revealed an overreliance on algebra and mechanization, with a noticeable absence of modeling processes in traditional mathematics teaching methods, which predominantly adopt a highly procedural approach (Garcés Córdova et al., 2021). Fortunately, procedural skills do not operate in isolation but are situated within a broader framework that encompasses other abilities; Applying the theory of George Pólya (as cited in Nasir & Syartina, 2021, p. 2), procedural skill, which encompass the process of implementing a planned strategy to find a solution, is part of problem-solving skills.

Problem-solving is defined as "a process by which the learner combines previously learned elements of knowledge, rules, techniques, skills, and concepts to provide a solution to a novel situation" (as cited in Barham, 2020, p. 1). According to George Pólya (as cited in Nasir & Syartina, 2021, p. 2), it is a multifaceted process involving four key steps: understanding the problem; planning a settlement strategy; implementing the planned settlement strategy, which is procedural skill; and re-checking the answers that have been found.

Problem-solving is considered the heart of mathematics education by many investigators (Faulkner et al., 2020; Geisler & Rolka, 2021; Maraví Zavaleta, 2021). It nurtures critical thinking, creativity, and adaptability, preparing students to tackle real-world problems and excel in their careers. Mastering problem-solving in mathematics enhances analytical skills and equips students with the practical expertise needed for various professions that demand mathematical proficiency. Hence, its learning is not only relevant for professionals but also for the general population, as mathematics is present in every aspect of life itself. Therefore, modern education necessitates a transition from conventional instructional methods towards approaches that prioritize the integration of problem-solving, including its procedural aspects.

METHOD

The research design applied in this investigation is cross-sectional and adopts a quantitative approach. It aims to assess and compare both procedural and problem-solving skills among Peruvian university students at the beginning of their professional education. To achieve this goal, a test designed by Faulkner et al. (2020) was applied, which was specifically designed to measure the mentioned skills through a set of 18 paired questions. These pairs consist of nine questions dedicated to assessing procedural skills and nine questions aimed at assessing problem-solving skills. It is worth mentioning that, for the application of this test, it is being considered that procedural skills are part of problem-solving skills; How this test works will be further explained in the "diagnostic testing" subsection.

The sample for this study consisted of a total of 374 students from three different degree programs at a Peruvian university. All of them undertook the test in March 2023, during their first session of the mathematics virtual subject. The "study group and data collection" subsection further explains this process. The collected data was analyzed using the statistical package for the social sciences (version 27), to compare the scores of procedural and problem-solving skills and to identify significant differences in the results.

Diagnostic Testing

In most Peruvian universities, teachers typically administer an entrance examination, also referred to as a diagnostic test, at the beginning of courses to assess students' skills and knowledge relevant to the course requirements. To achieve the objective of measuring the procedural and problem-solving skills of first-year students, the diagnostic test applied in the mathematics subject consisted of the instrument developed by Faulkner et al. (2020), which aims to measure the aforementioned skills, and the only modification made for its application in this study was a translation into Spanish.

The applied test has undergone rigorous quality controls to ensure its suitability and has demonstrated strong reliability and validity on a global scale (Faulkner et al., 2020). The test is divided into two sections: A, which assesses procedural skills, and B, which evaluates problem-solving skills, and every question from section A is paired with a question from section B. These paired questions require the same procedural skills for successful completion, with section B questions presenting real-world contexts.

For instance, a question in section A consists of calculating combinatorics and probabilities without context; in other words, it is just an exercise. However, in its paired question in Section B, a contextualization is provided to assess their problem-solving ability in applied situations. Although procedural skills are part of problem-solving skills (Nasir & Syartina, 2021), the test has been designed such that if a student has the ability to apply his or her knowledge of mathematics to solve problems, then the scores on both questions, problem-solving and procedural, would be identical.

Alongside the comparison of procedural and problem-solving skills, the study also incorporated variables related to gender and school type. The rationale behind including these variables is twofold. Firstly, in Peru, there are persistent issues related to gender inequality, which are influenced by social and cultural factors and have been exacerbated by the pandemic (Maraví Zavaleta, 2021). Furthermore, it has been proved that gender is related to mathematical achievement (Brezavšček et al., 2020; Gilmore et al., 2017). Secondly, in Peru, although it has not been proven yet, there is a prevailing belief that private schools provide a higher quality of education compared to state schools (Cámere, 2019).

Consequently, the structure of the diagnostic test applied to measure the procedural and problem-solving skills of first-year university students was, as follows:

- **Identification:** Student's name, field of study, gender, and type of school, where he/she studied.
- **Section A:** Nine questions that measure procedural skills.
- **Section B:** Nine questions that measure problem-solving skills.

In Peruvian universities, the assessment follows a zero-20 scale. Therefore, each section A and section B was evaluated on a scale of zero-10, for a maximum score of 20. It is worth mentioning that some of the questions included mathematical graphs, which were elaborated with GeoGebra, given its usefulness for the illustration of mathematical problems (Wassie & Zergaw, 2019).

Table 1. Distribution of surveyed students by degree & gender

Degree	Gender		Total
	Male	Female	
Pharmacy & biochemistry	40	129	169
Accounting	21	29	50
Industrial engineering	91	64	155
Total	152	222	374

Study Group & Data Collection

In March 2023, during the first session of the mathematics virtual subject, a total of 374 first-year students from three distinct degree programs at a Peruvian university underwent in the test. They were selected through the non-probabilistic "convenience sampling" method, and details regarding the distribution of participants can be found in **Table 1**. The examination was administered on the Blackboard virtual platform, with Microsoft Teams serving as an e-proctoring tool. Each participant was explicitly informed that their results would contribute to this study's objectives. With the application of the diagnostic test explained in the previous subsection, it was possible to obtain information on the field of study, gender, type of secondary school, and scores for section A and section B, for each of the 374 students. This information was analyzed as explained in the following subsection.

Data Analysis

The data collected was analyzed using the statistical package for the social sciences (version 27) for both sections A and B of the test. A paired-samples t-test was employed to assess statistically significant differences between the scores in section A and section B, while independent-samples t-tests were conducted to compare the mean performances of participants with different demographic backgrounds. All tests utilized a significance level of 5%.

RESULTS

The results unveiled a subpar level of mathematical knowledge, as the average score was 5.75 on a scale of zero-20 for the entire test. Additionally, these findings highlight the participants' challenges in applying the necessary skills for the procedural section and, consequently, their problem-solving abilities, including logical thinking and information interpretation. Many students struggled with using incorrect mathematical terminology and encountered difficulties in representing statements presented in proposed problems, particularly in section B, which focused on problem-solving. For instance, in **Figure 2**, two questions from the test are shown: part a from section A and part b from section B, along with the responses of a student (part c and part d in **Figure 2**). These two questions require the same knowledge of geometry for a correct solution, specifically, the student needs to be familiar with the Pythagorean theorem. Although student demonstrated knowledge of the theorem by answering the question correctly in part a, he or she struggled to apply it to a practical problem, selecting the wrong option in the applied question (part b in **Figure 2**). This observation indicates that this particular student possesses a lower level of problem-solving skills in comparison to their procedural skills. Similar situations were noted for the majority of the 374 surveyed students.

On a scale of zero to 20, encompassing both section A and section B of the complete diagnostic test, the mean test score for all 374 students was $\bar{x} = 5.75$, with only a minority of students achieving scores exceeding 10. However, the mean score in section A ($\bar{x} = 4.12$), which pertains to the procedural section, is statistically higher than the mean score in section B ($\bar{x} = 1.63$), corresponding to the problem-solving section ($p < 0.05$). The results in section B indicated a deficiency in problem comprehension. In summary, these findings underscore the students' struggles in applying fundamental mathematical concepts in practical contexts. While it's important to note that this result cannot be generalized to all first-year university students due to the small sample size, it aligns with expectations, given the prevailing highly procedural approach in current mathematics education (Garcés-Córdova & Font-Moll, 2022; Maraví Zavaleta, 2021). This underscores the need for a revamped mathematics curriculum in basic education that incorporates a problem-posing and problem-solving approach (Maraví Zavaleta, 2021).

Table 2 presents the results by degree. A comparative analysis of overall performance, encompassing both sections A and B, was conducted to identify potential significant differences using the ANOVA process. The HSD Tukey post hoc test was applied to discern, which means exhibited significant disparities. The results indicate that students in the field of industrial engineering ($\bar{x} = 7.14$) achieved higher scores than their peers in pharmacy and biochemistry ($\bar{x} = 4.69$) and accounting ($\bar{x} = 5.06$) ($p < 0.05$). This outcome, illustrated in **Figure 3**, was anticipated, as engineering students typically require a more advanced level of mathematics knowledge for university admission compared to other degree programs.

Figure 3 also illustrates that industrial engineering students demonstrated greater success in both problem-solving and procedural sections of the test than students from other degree programs. But it's noteworthy that the mean test scores for all students, encompassing section A and section B, on a scale of zero-20, fell below expectations. Especially, although engineering students possess a robust mathematical foundation, they face challenges when it comes to applying their knowledge in real-world scenarios, as can be seen in **Table 2**. This suggests the need to reinforce several mathematics topics during initial mathematics courses.

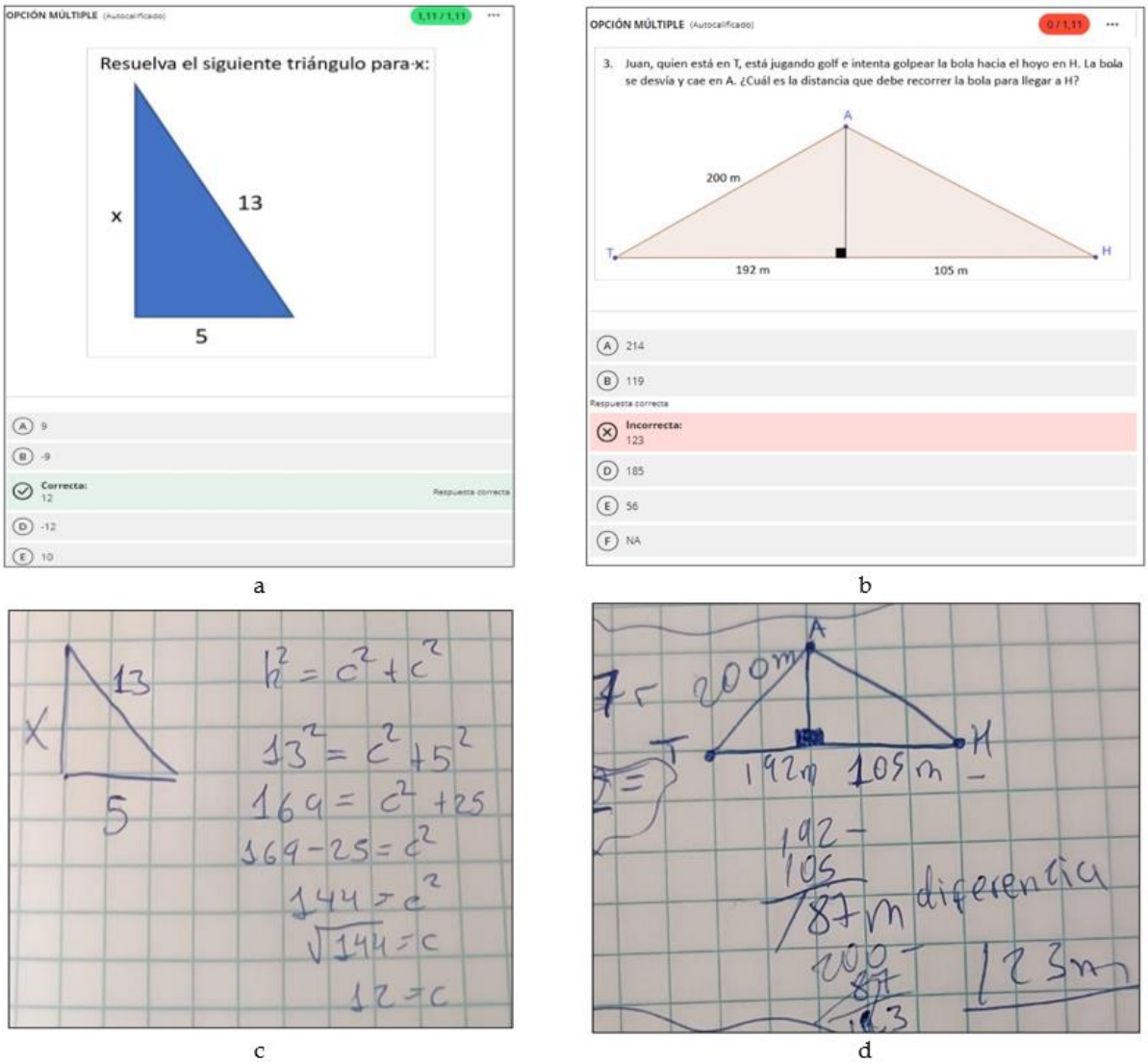

Figure 2. Example of a student's responses & resolution (c & d) in two questions of same topic (a & b) (Source: Authors' own elaboration)

Table 2. Mean & standard deviation of section A & section B scores, by degree

Degree	n	Section A: Procedural skill		Section B: Problem-solving skill	
		Mean	Standard deviation	Mean	Standard deviation
Pharmacy & biochemistry	169	3.34	2.06	1.35	1.55
Accounting	50	3.64	2.22	1.42	1.44
Industrial engineering	155	5.13	2.39	2.01	1.92

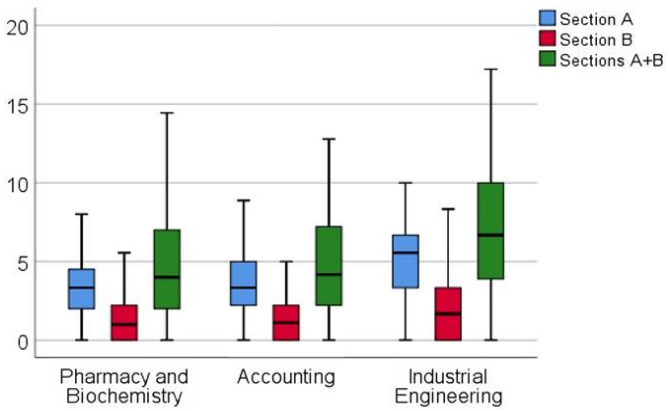

Figure 3. Results of 374 surveyed students (Source: Authors' own elaboration)

Comparison by Gender

It has been proved that gender is related to mathematical achievement (Brezavšček et al., 2020; Gilmore et al., 2017).

According to PISA 2018 Peru country report (OECD, 2019a), boys outperformed girls in mathematics by 16 score points, whereas across OECD countries, boys outperformed girls by five score points. This outcome in PISA 2018, along with the assertion that gender is deemed one of the most influential factors in mathematics achievement (Brezavšček et al., 2020), prompted a comparison of performance by gender among the 374 students, as shown in **Table 3**.

Table 3. Mean & standard deviation of section A & section B scores, by gender

Gender	n	Section A: Procedural skill		Section B: Problem-solving skill	
		Mean	Standard deviation	Mean	Standard deviation
Male	152	4.50	2.42	1.88	1.84
Female	222	3.86	2.32	1.46	1.63

A t-test for independent samples indicated that male students achieved higher scores than female students in the overall evaluation, including sections A and B ($p < 0.05$). However, Cohen's d for the effect size comparison, with a value of 0.285, suggests that this difference between means is relatively small. When comparing results by sections, male students also attained higher scores in both sections A and B of the test: $\bar{x}_M = 4.50$, $\bar{x}_F = 3.86$ in section A, and $\bar{x}_M = 1.88$, $\bar{x}_F = 1.46$ in section B. The t-test for independent samples indicated that these differences were statistically significant ($p < 0.05$), as depicted in **Figure 4**. However, the effect sizes, according to Cohen's d, were relatively modest: 0.269 in section A and 0.245 in section B.

Nonetheless, these results highlight a well-known issue: the gender gap in education. According to the global gender gap report 2022, educational parity in Peru stands at 0.749, one of the highest in South America, and one of the countries worldwide that has made the most progress in improving gender parity scores (World Economic Forum, 2022). Nevertheless, concerted efforts should be made to narrow this educational gender gap, particularly in mathematics. Multiple studies have revealed that male students tend to exhibit higher confidence in their mathematical abilities and a more positive attitude, while female students often experience higher levels of anxiety (Mozahem et al., 2021).

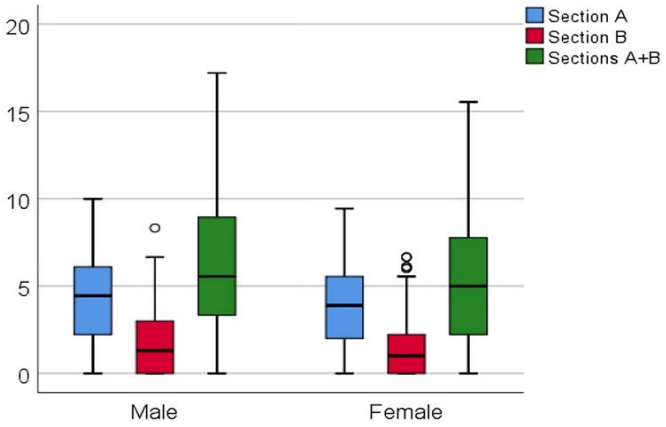

Figure 4. Results of 374 surveyed students by gender (Source: Authors' own elaboration)

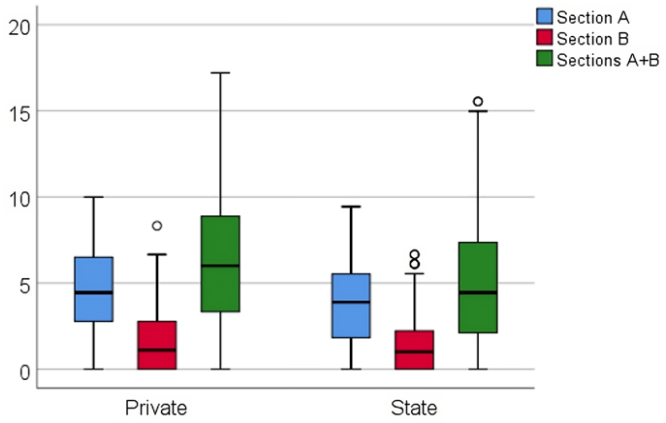

Figure 5. Results of 374 surveyed students by type of school (Source: Authors' own elaboration)

Comparison of Results by Type of School: State vs. Private

In Peru, there are essentially two types of schools: private and state schools (Cámere, 2019). PISA 2018 Peru report indicated that socio-economically advantaged students, who typically attend private schools, outperformed disadvantaged students in mathematics (OECD, 2019b). This discrepancy may imply differences in mathematical achievement between private and state school students, specifically in procedural and problem-solving skills. Consequently, **Table 4** presents a comparison of the results.

A t-test for independent samples revealed that the difference in means was statistically significant ($p < 0.05$), which is depicted in **Figure 5**. However, according to Cohen's d, the average score of private school students is only 0.302 standard deviations higher than that of state school students, indicating a relatively small difference between the means. Nonetheless, it suggests a higher level of mathematical skills in private school students when compared to their state school counterparts, which aligns with expectations given the educational disparity between state and private education in Peru. The possible reasons for this disparity are further explained in the discussion. Despite efforts to enhance the quality of state education, these endeavors are still insufficient (Cámere, 2019).

DISCUSSION

The results, obtained through the application of the test designed by Faulkner et al. (2020), which has undergone rigorous quality controls to ensure its

Table 4. Mean & standard deviation of section A & section B scores, by type of school

Type of school	n	Section A: Procedural skill		Section B: Problem-solving skill	
		Mean	Standard deviation	Mean	Standard deviation
State	186	4.51	2.38	1.80	1.76
Private	188	3.73	2.32	1.47	1.68

suitability and demonstrated strong reliability and validity on a global scale, indicate that students commence their professional education with a low level of mathematical knowledge, as evidenced by their notably low scores, challenges in representing problem statements, and the use of incorrect terminology, among other shortcomings. Moreover, the findings align with previous research, highlighting students' deficient problem-solving abilities and relatively average procedural skills scores (Barham, 2020; Faulkner et al., 2020; Khalid et al., 2020). This is concerning as these students are future professionals who will need to apply their mathematical skills in various contexts. These results provide further evidence of the educational crisis warned about by UNICEF (2022) due to the pandemic-induced closure of schools.

Additionally, an analysis based on demographic factors, including gender and type of school, reveals disparities in mathematical skills between male and female students and between private and state school students.

When analyzing the comparison of results by gender, it became apparent that male students outperformed their female counterparts in both the procedural and problem-solving sections. This finding is in line with previous research that has highlighted a disparity in mathematical abilities between men and women, with men generally performing better (Muelle, 2020). However, it is important to acknowledge that this performance gap could be attributed to various factors, including societal and cultural biases that influence the teaching and perception of mathematics.

Interestingly, the COVID-19 pandemic has exacerbated gender inequality issues in Peru, as highlighted by Maraví (2021). The pandemic has underscored pre-existing disparities and drawn attention to the deeply ingrained social and cultural factors that contribute to gender inequality. Furthermore, gender stereotypes have been identified in Peruvian school mathematics textbooks (Guerrero & Rojas, 2020; Maraví Zavaleta, 2021), which may, in part, account for the observed performance differences between male and female students.

Despite efforts to close the gender gap in education, inequalities persist in Peru, particularly affecting rural women who often encounter additional challenges, such as domestic responsibilities and work obligations (Guerrero & Rojas, 2020). It's noteworthy that some of the students in the sample mentioned that they completed their secondary education in rural schools, which could partially account for this outcome. While progress has been made, as indicated by the global gender gap report (World Economic Forum, 2022), there is still significant work ahead to ensure equal opportunities for all students, regardless of their gender or background.

On the other hand, although the effectiveness of private education compared to public education in Peru remains a topic of debate, as noted by several authors (Cuenca et al., 2019), it is crucial to delve into the nuanced factors that may influence the observed differences in problem-solving and procedural skills between students from private and state schools. This study highlights that students from private schools exhibited slightly better performance in both procedural and problem-solving sections, a result consistent with previous research. For instance, Eigbiremolen et al. (2020) argue that in Peru, students in private schools achieve higher test scores in math than students from public schools. Furthermore, Meneses et al. (2022), by applying survival methods to predict higher education entry rates for recent high school graduates in Peru, found that private education offers a greater probability of transitioning to higher education. Nevertheless, it is essential to acknowledge the complexity of the educational landscape in Peru.

It's noteworthy that students from state schools often come from provinces or rural areas, where educational resources and infrastructure can be significantly limited (Montero Checa & Uccelli Labarthe, 2020). The disparity in infrastructure and access to quality educational materials may contribute to challenges in developing strong problem-solving skills and procedural knowledge. Furthermore, socio-economic conditions may also shape students' learning environments. The public and private educational offerings have followed a residential pattern of spatial segregation, with individuals with fewer resources residing in peripheral areas, in contrast to those with greater resources primarily located in high-income areas (Carrillo & Murillo, 2023).

Additionally, cultural factors and societal perceptions regarding private and public education may impact students' motivation and level of engagement. These factors could indirectly influence their willingness to participate in problem-solving tasks and the extent to which they perceive these skills as valuable for their future pursuits. Considering that public education in Peru is striving to attain parity with, or even exceed, the quality of private education (Cámere, 2019), it is crucial to comprehensively examine these dynamics.

Finally, the highly procedural approach to mathematics teaching in schools is substantiated by the obtained results, which align with expectations based on previous research, such as the study conducted by Faulkner et al. (2020), where all categories of students performed significantly worse in section B, corresponding to problem-solving skills. The results of this study revealed a significant deficiency in students' mathematical proficiency, as indicated by their low average score of 5.75 out of 20 on the comprehensive test.

This underscores their difficulties in applying procedural skills, which in turn impairs their problem-solving abilities, logical reasoning, and effective interpretation of information. Notably, students faced challenges with mathematical terminology and articulating problem statements, particularly evident in the problem-solving segment.

Importantly, section A ($\bar{x} = 4.12$), which focuses on procedural aspects, exhibited a significantly higher mean compared to section B ($\bar{x} = 1.63$), dedicated to problem-solving ($p < 0.05$). The outcomes of Section B highlighted participants' difficulties in understanding problems, indicating a lack of clarity in their approach. While the findings cannot be universally generalized due to the sample size, the study underscores the need for an educational overhaul to emphasize problem-solving in mathematics curricula (Maraví Zavaleta, 2021).

The teaching of mathematics in Peru follows a competency-based model in which it is expected that students can 'utilize mathematical knowledge in diverse situations, construct arguments, and communicate their ideas using mathematical language, as well as various representations and resources' (MINEDU, 2016). However, the results indicate that students have not yet achieved this competency. As noted by Barham (2020), it is crucial for schoolteachers to foster the development of competencies such as abstracting and generalizing and to include carefully designed problems that encourage students to devise novel approaches, a concept known as creative problem-solving. This model offers students an effective means to develop mental discipline and logical reasoning.

Moreover, it can contribute to the enhancement of problem-solving skills and creativity (Khalid et al., 2020). Several authors suggest that one approach to improve problem-solving skills and foster critical thinking and creativity is the STEM approach, especially in mathematics. However, its implementation has been limited in scope (Maraví Zavaleta, 2021).

CONCLUSIONS

This study highlights the deficient problem-solving and procedural skills among first-year students in a Peruvian higher education institution. The observed disparity between mathematics knowledge, represented by procedural scores and problem-solving scores underscores the necessity of strengthening practical application abilities. While the diagnostic test administered to first-semester students in March 2023 provides valuable insights, caution is warranted when generalizing results due to limited mathematics education research in the context of Peru, sample size, and restricted diversity, as the surveyed students come from only one university.

Furthermore, gender and school-type comparisons reveal skill gaps between male and female students, as well as between private and state students, with males outperforming females in both procedural and problem-solving sections, and private school students outperforming their state school counterparts. However, further exploration is necessary to understand these nuances fully. Future research should expand the sample to include students from both state and private universities, enabling broader insights into students' capabilities.

Enhancing problem-solving skills among university entrants is crucial. By addressing the identified deficiencies, educational institutions can bridge gaps and promote comprehensive mathematical competencies. These findings provide valuable insights for educational decision-makers and contribute to the advancement of mathematics education in Peru's higher institutions.

Recommendations

- The teaching of mathematics requires teachers to introduce students to real-world thinking, where they can contextualize and apply what they are learning. This justifies the urgent introduction of an approach focused on problems as key elements in the mathematics curriculum, in schools as well as in higher education institutes. The authors suggest the incorporation of the problem-solving theory developed by George Pólya, which is little known in the Peruvian educational community but could contribute to improving students' ability to use their mathematical knowledge and skills in applied situations.
- A great deal of degrees' curricular plans in Peruvian universities are structured around a preliminary phase known as basic or general studies, which was created to give students the fundamental skills they would subsequently use in other degree-related courses as well as in their professional jobs. This approach supposes that students would be able to apply their knowledge from their general studies courses in any situation, including their professional activity (Garcés-Córdova & Font-Moll, 2022); however, this leads to a studies plan that is general to most of the degrees, which gives space to the teaching of content that will not subsequently be used and should be avoided. Therefore, in order to give an applied approach to the teaching of sciences, particularly mathematics, the authors suggest the addition of career-related topics, where students can apply what they learn in real situations. For instance, this can be achieved by coordinating the elaboration of mathematics subjects' content with teachers of careers subjects.

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