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Stochastic sense in the primary education curriculum system in Peru

Sentido estocástico en el sistema curricular de educación primaria en el Perú

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Marisol Edith Zelarayan Adauto
https://orcid.org/0000-0002-6086-9491
mzelarayan@une.edu.pe
Universidad Nacional de Educación Enrique Guzmán y Valle. Lima, Peru

Daniel Marcos Chirinos Maldonado
https://orcid.org/0000-0002-1673-5509
dchirinos@une.edu.pe
Universidad Nacional de Educación Enrique Guzmán y Valle. Lima, Peru

Lourdes Gálvez Morales
https://orcid.org/0000-0001-7279-4370
lgalvez@une.edu.pe
Universidad Nacional de Educación Enrique Guzmán y Valle. Lima, Peru

Abstract
Stochastic reasoning, defined as the ability to reason in the face of uncertainty and variability, is a key component of current mathematics education, especially in primary education. Its incorporation into the Peruvian curriculum responds to the need to prepare students for decision-making in everyday situations involving uncertainty. This study aimed to analyze the mathematical and didactic organization of stochastic reasoning in fifth- and sixth-grade primary education textbooks, as well as to identify the transformations of stochastic knowledge in didactic transposition. A mixed approach, predominantly qualitative, was employed, using the praxeological model to identify the tasks, techniques, technologies, and theories present in official textbooks. Additionally, a descriptive quantitative analysis was conducted on the distribution and complexity of the tasks. The sample included 28 probability-related tasks, mostly focused on qualitative comparisons and of low cognitive demand. The results showed a fragmentation of the stochastic meaning, with a predominance of structured tasks and little theoretical foundation to support teaching practices. Furthermore, limitations in authenticity, contextual diversity, and conceptual development were evident, as the tasks focused on personal contexts without addressing advanced concepts such as statistical inference or stochastic modeling. In conclusion, the didactic organization of the stochastic meaning is partial and insufficient. Therefore, its revision is recommended to include authentic tasks, a greater diversity of contexts, and theoretical coherence that favor a more comprehensive development of probabilistic thinking in primary education.

Keywords: primary education, mathematical praxeology, stochastic meaning, didactic transposition.

Resumen
El sentido estocástico, definido como la capacidad para razonar frente a la incertidumbre y la variabilidad, es un componente clave en la educación matemática actual, especialmente en la formación primaria. Su incorporación en el currículo peruano responde a la necesidad de preparar a los estudiantes para tomar decisiones en situaciones cotidianas con incertidumbre. Este estudio tuvo como objetivo analizar la organización matemática y didáctica del sentido estocástico en los textos escolares de 5º y 6º grado de educación primaria, así como identificar las transformaciones del conocimiento estocástico en la transposición didáctica. Se empleó un enfoque mixto, con predominancia cualitativa, utilizando el modelo praxeológico para identificar las tareas, técnicas, tecnologías y teorías presentes en los textos oficiales. Complementariamente, se realizó un análisis cuantitativo descriptivo sobre la distribución y complejidad de las tareas. La muestra incluyó 28 tareas relacionadas con probabilidad, mayormente enfocadas en comparaciones cualitativas y de baja exigencia cognitiva. Los resultados

mostraron una fragmentación del sentido estocástico, con predominancia de tareas estructuradas y escasa fundamentación teórica que apoye las prácticas docentes. Además, se evidenciaron limitaciones en la autenticidad, diversidad contextual y desarrollo conceptual, ya que las tareas se concentraron en contextos personales sin abordar nociones avanzadas como inferencia estadística o modelización estocástica. En conclusión, la organización didáctica del sentido estocástico es parcial e insuficiente, por lo que se recomienda su revisión para incluir tareas auténticas, mayor diversidad de contextos y coherencia teórica que favorezcan un desarrollo más integral del pensamiento probabilístico en la educación primaria.

Palabras clave: educación primaria, praxeología matemática, sentido estocástico, transposición didáctica.

Introduction

Stochastic sense can be defined as the human capacity to reason in the face of uncertainty, establish connections, and understand variability. This ability reflects an individual's readiness to navigate a world characterized by randomness and unpredictability. Its significance in education lies in facilitating students' development of competencies to analyze phenomena related to risk, variation, and probability—elements that are increasingly relevant in daily life and decision-making.

In this context, it is essential for the primary education curriculum in Peruvian public schools to explicitly incorporate the development of stochastic sense. Its inclusion not only promotes the understanding of probability as a mathematical tool but also fosters critical thinking and the ability to argue based on evidence. Thus, educators have an appropriate space to conduct a teaching-learning process that enhances reflection and prepares students to confront situations of uncertainty.

Although this proposal differs from traditional mathematical teaching, which historically starts from certainties to advance toward the uncertain, the early incorporation of stochastic sense constitutes a necessary innovation. Implementing it from the earliest educational stages provides the opportunity to build solid foundations in probabilistic reasoning, thereby better preparing students to understand the complexity of their environment.

Therefore, stochastic sense is a fundamental component of contemporary mathematics education, integrating notions of statistics and probability to address uncertain situations (Rico & Moreno, 2016). This approach combines complex cognitive processes, such as formulating questions, collecting and organizing data, selecting and validating analytical methods, as well as evaluating inferences and predictions.

In this way, stochastic sense occupies a central place not only because it is essential for conceptually building probability but also due to its multiple benefits in the teaching and learning process. Bayés & Vargas (2025) highlight that this sense promotes the development of structured reasoning for problem-solving through generalization, coherent justification, and argumentation. Furthermore, it enriches the understanding of the sample space and events through representations that facilitate the identification of possible and favorable outcomes. It also aids in grasping the inverse concept in probability, expands specialized vocabulary, and strengthens the link between probability and statistics through the use of modal expressions.

Today, the development of stochastic sense in childhood is particularly relevant due to advancements in mathematics education. Revisiting the definition of numerical sense proposed by Sowder (1992), Alsina & Bosch (2023) argue that stochastic sense corresponds to the set of numerical skills associated with understanding probability. These include interpreting probabilistic statements, recognizing possible and favorable cases, estimating and comparing probabilities, and forming associations that facilitate deep and meaningful learning.

The development of this sense is closely related to the logical and mathematical competencies that everyone should attain throughout life. According to Piaget (1951), these competencies are structured in three cognitive levels—sensorimotor, preoperational, and concrete operational—that support the capacity to interact reflectively with the environment. In this regard, Ureña-Villamizar et al. (2024) emphasize that, although stochastic sense still requires further definition, it is a key component for individuals to play, make decisions, and undertake actions that yield consequences. This potential is dynamic, develops over time, and can be strengthened both through formal study of probability and everyday experience.

Regarding the primary education curriculum in Peru, it is designed to guide basic training in the first six grades, aimed at students aged 6 to 11. Marion Montoya (2024) notes that this curriculum offers comprehensive training in various areas and exposes students to problems that involve decision-making. This approach fosters habits and skills of critical thinking and autonomy, allowing for the resolution of everyday problems without anxiety and strengthening competencies such as analysis and reflection. In this framework, the National Curriculum organizes its guidelines into sections such as section 3.1, which relates to its general structure, and section 3.2, where the objectives of primary education are established.

In this context, practical work with stochastic concepts aims to formalize skills for daily life, particularly in identifying, analyzing, and solving problems through hypothesis formulation and risk evaluation. Torres-Roberto (2024) argues that this perspective leads directly to the notion of decision-making under uncertainty or risk, an aspect not limited to childhood, as it also affects adolescents, young adults, and adults who face vulnerabilities that economic support cannot always resolve. Thus, education must fulfill a fundamental role: to promote in students the understanding and evaluation of risk, both in the present and future, so they can make informed decisions and minimize negative consequences. This requires going beyond the teaching of basic statistical concepts and prioritizing practical applications of statistics in everyday life.

In the Peruvian educational system, the development of stochastic sense is articulated through the competency "Solves problems of data management and uncertainty," present in the National Basic Education Curriculum (CNEB) and the Primary Education Curriculum Program (MINEDU, 2016). This competency requires students to integrate specific skills such as representing data with graphs and statistical or probabilistic measures, communicating the understanding of statistical and probabilistic concepts, applying strategies to collect and process data, and supporting conclusions based on the information obtained.

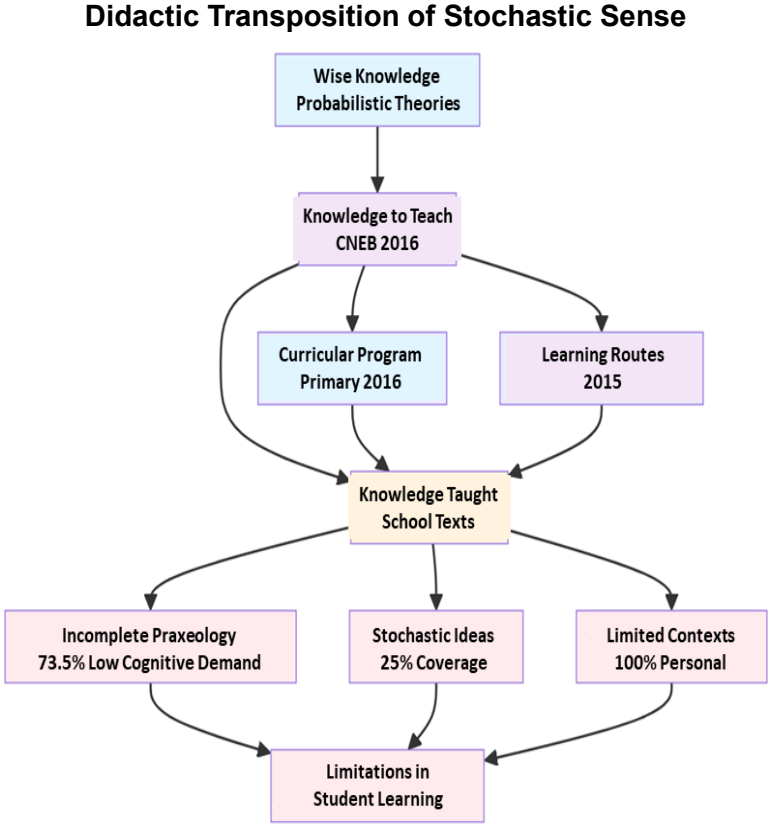
However, the curricular implementation of stochastic sense faces particular challenges in didactic transposition, a concept developed by Chevallard (1998) that describes the transformation of expert knowledge into taught knowledge. In this sense, the analysis of textbooks is fundamental to understanding how this transposition materializes and what mathematical organization is proposed for learning stochastic sense.

In this framework, the Anthropological Theory of Didactics (Chevallard, 1985) provides conceptual tools to study the mathematical organization through the praxeological model [T/τ/θ/Θ], where T represents tasks, τ techniques, θ technologies, and Θ theories. This model enables the identification of the structuring of stochastic knowledge in educational materials and the evaluation of its coherence with curricular objectives.

To illustrate the process of didactic transposition of stochastic sense, Figure 1 presents a diagram that synthesizes how expert knowledge transforms into taught knowledge and highlights the limitations evidenced in student learning.

Figure 1

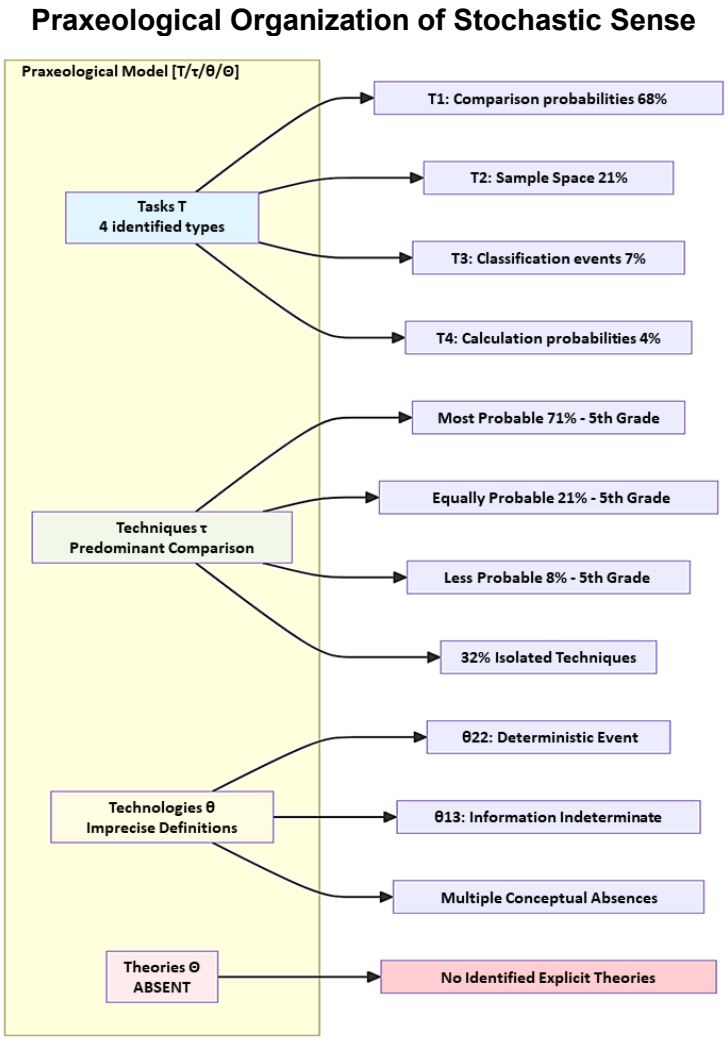
Process of didactic transposition of stochastic sense from expert knowledge to limitations in student learning



In continuity with this conceptual analysis, Figure 2 presents the praxeological organization of stochastic sense as identified in the curriculum texts, clearly illustrating the structure of tasks, techniques, technologies, and theories utilized in educational materials.

Figure 2

Praxeological organization of stochastic sense identified in the texts of the V cycle



Thus, school mathematical tasks become fundamental elements of analysis, as they establish the connection between what is taught and what is learned (Bosch & Gascón, 2009). Their characterization, based on cognitive demand, allows for the evaluation of their formative potential, encompassing levels ranging from memorization to the execution of complex procedures with connections and mathematical creation (Stein et al., 2000).

In this context, the present study aims to analyze and describe the mathematical and didactic organization of stochastic sense in the school texts of the V cycle of Peruvian primary education. The objective is to identify the transformations that stochastic knowledge undergoes during didactic transposition, from the curriculum to educational materials. This research is grounded in the necessity to ensure that students develop solid competencies in probability and statistics, in alignment with the requirements of the National Curriculum and international recommendations, such as the Guidelines for Assessment and Instruction in Statistics Education (GAISE) and the Programme for International Student Assessment (PISA). Moreover, the study significantly contributes to improving the design and review processes of school texts by highlighting gaps and limitations that may affect the learning of stochastic sense. Therefore, it provides a solid foundation to guide both educational policies and teaching practices toward more relevant, rigorous, and contextualized instruction.

Methodology

The study adopted a mixed design that combined document review with content analysis, prioritizing a qualitative-interpretive approach supported by descriptive quantitative analysis. This qualitative perspective allowed for an in-depth examination of the didactic transposition of stochastic sense in school texts, while the quantitative analysis, through counting and calculating frequencies and percentages, facilitated an objective characterization of the distribution of tasks, techniques, and levels of cognitive demand. This methodological integration provides greater consistency and robustness in interpreting the results.

The study population consisted of official mathematics texts for primary education distributed by the Ministry of Education of Peru (MINEDU). The sample, which was intentionally non-probabilistic, included texts for 5th and 6th grades of the V cycle, as this level formally introduces the work with probability according to the National Basic Education Curriculum (MINEDU, 2016). All tasks related to probability present in the texts were included, without applying exclusion criteria, thereby ensuring representativeness based on the most recent editions available on the official MINEDU portal, ensuring that the analysis reflects the current educational material.

A total of 28 tasks related to probability were identified and analyzed, distributed as 7 tasks in the 5th-grade texts (25%) and 21 in the 6th-grade texts (75%). Each task was considered a complete unit of analysis, encompassing the statement, the proposed technique, graphical resources, context, and methodological development.

Table 1

Distribution of tasks by type and grade

Type of Task	5th Grade	6th Grade	Total	Percentage
T1: Comparison of Probabilities	5	14	19	68 %
T2: Identification of the Sample Space	1	5	6	21 %
T3: Classification of Events	1	1	2	7 %
T4: Calculation of Probabilities	0	1	1	4 %
Total	**7**	**21**	**28**	**100 %**

Each task constitutes a complete unit of analysis that includes the statement, methodological development, graphical resources, and complementary activities.

The following analytical instruments were applied:

- **Praxeological Model** [T/τ/θ/Θ] from the Anthropological Theory of Didactics (Chevallard, 1999) to identify tasks (T), techniques (τ), technologies (θ), and theories (Θ) in the treatment of stochastic sense.
- **Multidimensional Analysis Matrices**, based on:
    - Wiggins' (2012) criteria for authenticity to characterize the relevance of tasks.
    - PISA Framework (OECD, 2018) to classify application contexts (personal, educational, public, and scientific).
    - GAISE Guidelines (Franklin et al., 2007) to contrast components of stochastic education (formulation of questions, collection, analysis, and interpretation of data).
    - Fundamental stochastic ideas proposed by Batanero (2001) to evaluate the conceptual coverage in the texts.

Validity was ensured through methodological triangulation by employing different instruments on the same units of analysis, and researcher triangulation, with independent review of categorizations by specialists in mathematics didactics. Reliability was secured through the systematic application of the same criteria across all tasks. Additionally, an editorial quality analysis was incorporated to detect terminological inconsistencies and conceptual gaps that could affect students' understanding.

The procedure was developed in four phases:

1. Identification and transcription of all probability tasks in the 5th and 6th-grade texts.

2. Praxeological categorization, identifying tasks (T), techniques (τ), technologies (θ), and presence/absence of theories (Θ).
3. Descriptive quantitative analysis, through counting and calculating percentages of frequencies in task types, techniques used, addressed stochastic ideas, application contexts, and levels of cognitive demand.
4. Comparison with international standards, contrasting findings with GAISE guidelines, the PISA framework, and Wiggins' authenticity criteria.

Results

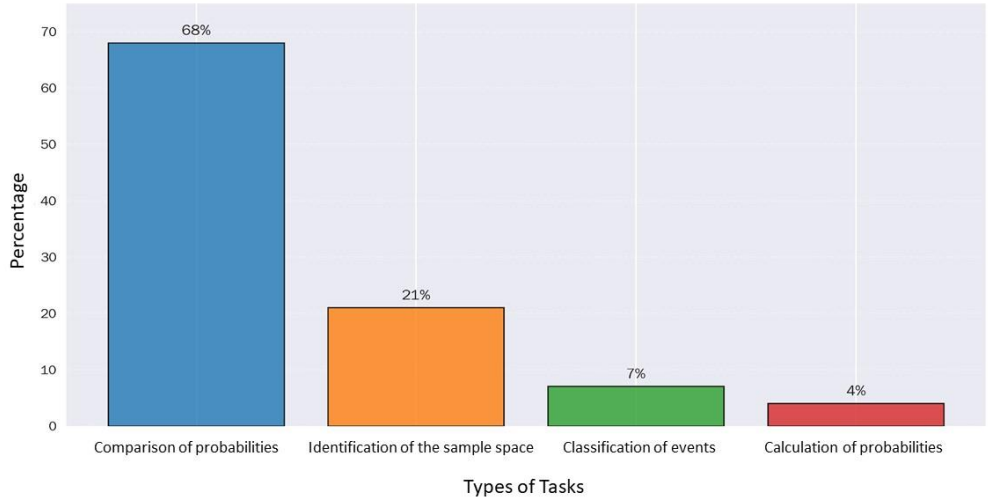
Praxeological organization of stochastic sense

Analysis of task types (T)

The praxeological analysis allowed for the identification of four main types of tasks related to the development of stochastic sense: Distribution of task types

Figure 3

Percentage distribution of identified task types in the V cycle texts (N = 28)



T1 - Comparison of probabilities: Accounts for 68% of the analyzed tasks (19/28). These tasks require students to determine which of several events is more probable, less probable, or equally probable.

T2 - Identification of the sample space: Represents 21% of the tasks (6/28). This involves enumerating all possible outcomes of a random experiment.

T3 - Classification of events: Comprises 7% of the tasks (2/28). It requires distinguishing between deterministic and random events.

T4 - Calculation of probabilities: Only 4% of the tasks (1/28). This involves the numerical calculation of probabilities using Laplace's rule.

Analysis of techniques (τ)

The distribution of techniques shows a significant concentration in qualitative comparisons.

Table 2
Praxeological techniques identified by grade

Type of Technique	Code	Description	Grade	Frequency
More Probable	τ31, τ24, τ75, τ85, τ46	Qualitative comparison of higher probability	5th	5 (71 %)
More Probable	τ16, τ37, τ57, τ58, τ19, τ110, τ310	Qualitative comparison of higher probability	6th	7 (52 %)
Equally Probable	τ34, τ65, τ66	Identification of equiprobability	5th	3 (21 %)
Equally Probable	τ71, τ16, τ108, τ29, τ111, τ211, τ311, τ116, τ420, τ221	Identification of equiprobability	6th	10 (38 %)
Less Probable	τ57	Comparison of lower probability	5th	1 (8 %)
Less Probable	τ59, τ410, τ213, τ216	Comparison of lower probability	6th	4 (10 %)

The isolated techniques identified represent 32% of the total, indicating a lack of articulation in mathematical organization.

Analysis of technologies (θ) and theories (Θ)

Table 3
Evaluation of identified technologies (θ)

Code	Textual Definition	Grade	Critical Evaluation	Recommendation
θ22	"A deterministic event is an experiment or phenomenon that results in a certain outcome"	5th	Conceptual ambiguity between event/experiment/phenomenon	Clarify conceptual distinctions
θ13	"In daily life, information is presented in an indeterminate manner"	5th	Imprecise terminology for the educational level	Use "uncertain" instead of "indeterminate"
θx	Absence of definitions for "equally probable," "less probable," "unlikely"	6th	Critical conceptual gap	Include precise definitions

Theoretical absence: No explicit theories (Θ) were identified that underpin the technologies, evidencing an incomplete mathematical organization according to the praxeological model.

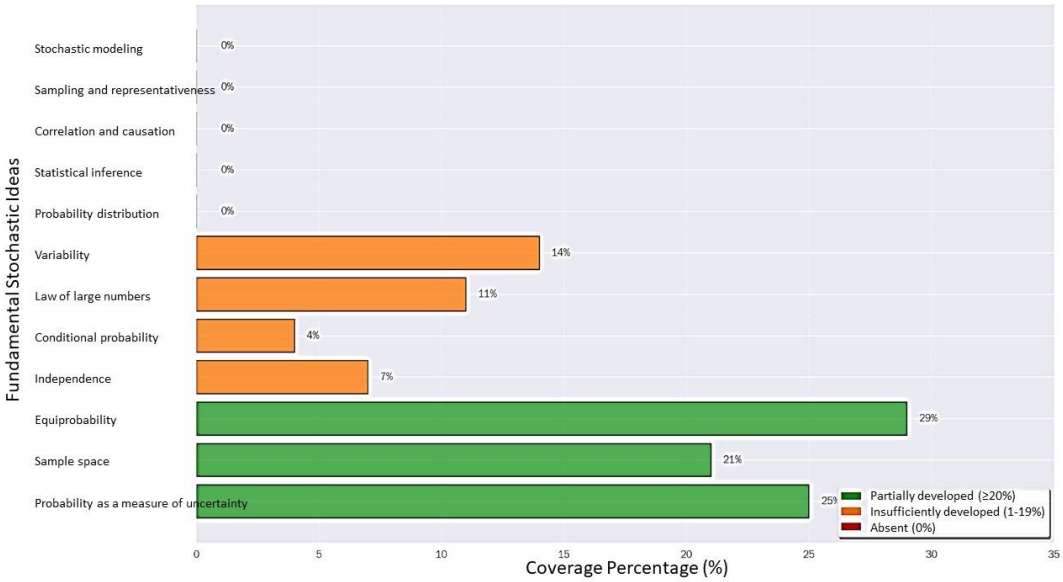
Fundamental stochastic ideas: Detailed analysis

Quantitative evaluation

Fundamental stochastic ideas

Figure 4

Coverage of fundamental stochastic ideas in the V cycle texts



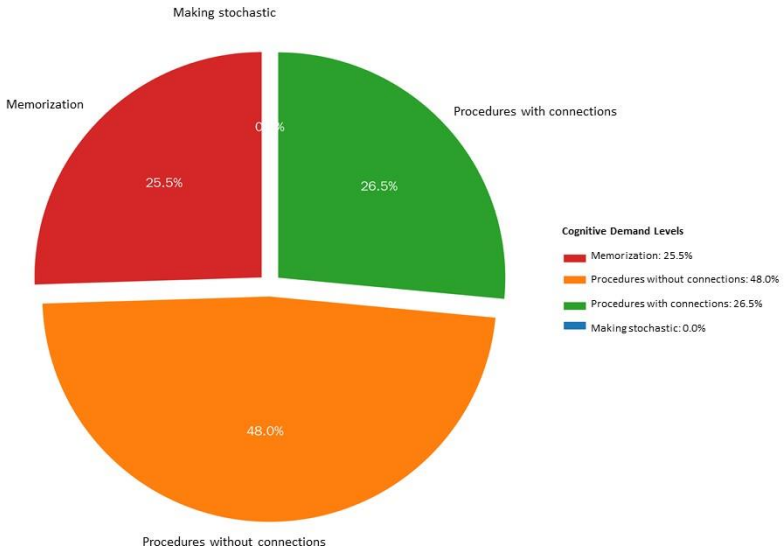
The analysis of fundamental stochastic ideas reveals an unequal treatment in the evaluated tasks. For instance, probability as a measure of uncertainty is presented in 7 out of the 28 tasks (25%), although with partial and limited development mainly focused on simple comparisons. Conversely, the sample space is addressed in 6 tasks (21%), also in a partial manner and without the support of technologies that facilitate its comprehension. Equiprobability emerges as the most frequent idea, appearing in 8 tasks (29%), but similarly suffers from incomplete treatment, as it is not linked to the notion of symmetry.

Regarding independence, it appears only in 2 tasks (7%), with insufficient and superficial development. Conditional probability is mentioned in just 1 task (4%), without conceptual development. Likewise, the law of large numbers is identified in 3 tasks (11%), but without adequate depth. Variability is present in 4 tasks (14%), although its treatment is limited due to its presentation in very restricted contexts. Finally, fundamental concepts such as probability distribution, statistical inference, correlation and causation, sampling and representativeness, as well as stochastic modeling, do not appear in any of the analyzed tasks (0%), highlighting a total absence of these topics in the curricular design.

Cognitive demand: Detailed analysis by levels

Cognitive demand

Figure 5
Distribution of cognitive demand in stochastic sense tasks



The analysis of the cognitive demand level of tasks in the school texts reveals that 25.5% correspond to memorization tasks, with a total of 7 activities distributed between fifth grade (2 tasks) and sixth grade (5 tasks). Meanwhile, the majority of tasks, at 48%, fall within the level of procedures without connections, encompassing 13 tasks, of which 3 correspond to fifth grade and 10 to sixth grade. Additionally, 26.5% of the tasks involve procedures with connections, distributed evenly between fifth grade (2 tasks) and sixth grade (6 tasks).

It is important to note that no tasks were identified that correspond to the "doing stochastic" level, which requires more advanced critical and creative thinking. This absence evidences the current limitations in teaching stochastic sense during primary education. Overall, the 28 analyzed tasks are predominantly concentrated at basic and intermediate levels of cognitive demand, posing a challenge for promoting more complex cognitive developments in this area.

Authenticity characteristics: Systematic evaluation

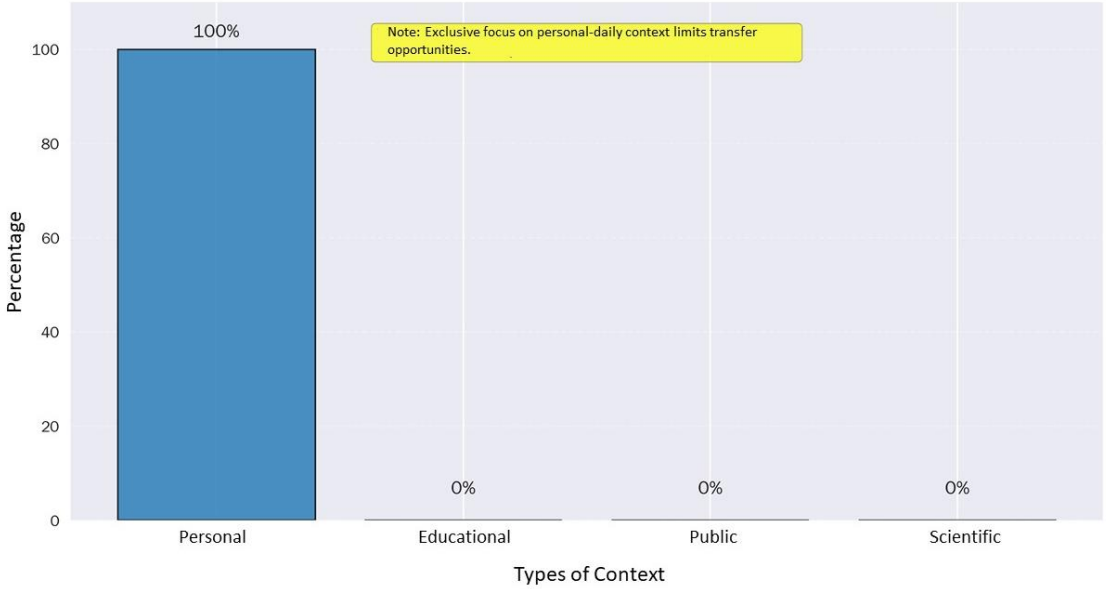
Table 4
Characterization of tasks according to authenticity criteria (Wiggins)

Authenticity Criterion	Compliance	Observations
Real Recipients	0/28 (0%)	Total absence of specific interlocutors
Appropriate Structure	6/28 (21.5%)	Predominance of highly structured tasks
Opportunities for Practice	4/28 (14%)	Limited opportunities for feedback
Broad Cognitive Repertoire	9/28 (33.5%)	Majority requires immediate resolution

Application contexts: Analysis by PISA framework

Figure 6

Distribution of contexts in stochastic sense tasks according to PISA framework



The tasks identified in the school texts focus exclusively on a single type of context: the personal context, encompassing everyday situations of the student, representing 100% of the 28 analyzed tasks. Examples of these situations include activities like rolling dice, tossing coins, and family raffles. In contrast, no tasks related to educational (school and academic), public (community and social), or scientific (applications in research) contexts were found, leaving these areas completely absent in the reviewed sample.

This contextual concentration significantly limits opportunities for learning transfer and reduces the perception of the relevance of stochastic sense in various fields where it could be applied.

Identified problematic tasks

In task 5 of fifth grade, a terminological inconsistency was detected between the terms "possibilities" and "probability," which generates conceptual confusion. Additionally, in this same task, the inclusion of compound events without equiprobability introduces an inappropriate complexity for the corresponding educational level. In sixth grade, task 9A presents ambiguity by requesting the "most probable event" without providing clearly distinguishable options, thus complicating the selection of the correct response. Furthermore, task 10B mentions "3 events" when in reality 4 are shown, constituting a correspondence error. Finally, task 14B formulates an imprecise question by referring to "one letter" when in fact two letters have a higher probability, generating ambiguity in the statement.

Discussion

The purpose of this study was to analyze the didactic transposition of stochastic sense in Peruvian school texts. The findings reveal significant gaps in this transposition, limiting the consolidation of a solid and effective stochastic reasoning. Unlike international standards, which promote the resolution of open problems and the transfer of learning to diverse contexts (Wild & Pfannkuch, 1999), the analyzed texts restrict work to personal situations and games of chance. This contextual limitation, as highlighted by the OECD in PISA (2018), reduces the perception of stochastic sense as a relevant tool for making informed decisions in public, academic, and scientific domains.

Moreover, the fragmentation of content and the scarce presence of explicit theories that underpin practices, in contrast with the recommendations of Franklin et al. (2007), reveal a disconnection between didactic proposals and conceptual frameworks. This situation can be attributed to various factors, such as unclear curricular guidelines that do not specify the depth with which contexts should be addressed, an editorial tradition focused on decontextualized exercises, and a possible lack of teacher training in the didactics of stochastic concepts. Additionally, the low coverage of fundamental stochastic ideas (25%) and the absence of tasks with high cognitive

demand, such as those involving "doing stochastic" (Stein et al., 2000), limit the development of critical thinking. The lack of authenticity in tasks, which do not consider real recipients or diverse contexts, contravenes Wiggins' (2012) proposals.

For instance, an authentic task could involve students analyzing local climate data to predict the probability of rain in the upcoming week and thus making decisions about agricultural planning—an issue of great relevance for many Peruvian communities. The absence of such activities prevents students from establishing deep connections between variability and uncertainty, as warned by Batanero (2001).

Finally, these results underscore the urgent need to review the didactic transposition of stochastic sense in the Peruvian curriculum. There is a need for greater diversity of contexts, an increase in tasks with high cognitive demand, and the incorporation of clear theoretical frameworks that serve as a foundation for the techniques employed. Furthermore, teacher training should be strengthened by incorporating competencies in probability and statistics, so that teachers have the necessary tools to mediate these learnings in the classroom, following curricular innovation proposals as suggested by Rico et al. (2013).

Conclusions

The analysis revealed that the mathematical organization of stochastic sense in the V cycle texts presents incomplete complexity, manifested in the lack of progression, coherence, and precision in relation to the standards of previous and subsequent cycles. Although probabilistic comparison techniques predominate, they align with the expected competencies for this level.

Nevertheless, the proposed tasks lack authenticity characteristics and show a high concentration in low levels of cognitive demand (73.5%), which limits the development of complex stochastic competencies. The total absence of tasks oriented toward "doing stochastic" hinders the promotion of critical and creative thinking among students.

The treatment of fundamental stochastic ideas is minimal (25%) and presents difficulties, especially in characterizing random situations and understanding uncertainty. The exclusive concentration on personal contexts restricts the transfer of learning to various situations. Additionally, technological inconsistencies and the presence of isolated techniques affect the coherence of mathematical organization, while theoretical absences prevent adequate justification of procedures and concepts.

Therefore, the mathematical and didactic praxeology of stochastic sense in these texts is incomplete, highlighting the urgent need for a thorough review. The transformations of stochastic knowledge during didactic transposition present gaps, breaks, and inconsistencies that hinder effective curricular implementation.

These findings suggest an urgent need to reformulate educational materials, incorporating authentic tasks with high cognitive demand, broadening application contexts, and strengthening coherence in didactic transposition. Regarding practical implications, the study indicates the necessity for a curricular reform that more effectively integrates stochastic sense into primary education. Furthermore, future research could focus on designing and validating didactic sequences that address the identified limitations, as well as analyzing teaching practices and their impact on the development of probabilistic reasoning in students.

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