

Epistemic suitability of the stochastic sense in the secondary education virtual module for adults in Andalusia

Idoneidad epistémica del sentido estocástico en el recurso virtual de educación secundaria para adultos en Andalucía

Adéquation épistémique du sens stochastique dans la ressource virtuelle de l'enseignement secondaire pour adultes en Andalousie

Idoneidade epistêmica do sentido estocástico no recurso virtual do ensino secundário para adultos na Andaluzia

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Abstract

This study analyses the stochastic sense promoted in the virtual resource offered by the Regional Government of Andalusia to support adult secondary education within compulsory secondary education. The epistemic suitability tool described in the theoretical framework of the Onto-Semiotic Approach was applied, and content analysis was used to identify the representativeness of meaning along with the connections and relationships between processes presented to the student. The results reveal limitations regarding the fundamental ideas of stochastic understanding, primarily concerning uncertainty, which extends to the representativeness of connections established in terms of recognizing variability and identifying models. The recommendations and

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conclusions based on the results provide valuable information for managing curriculum design in this educational setting, as well as for designing new resources for the different units where stochastic understanding is promoted.

Keywords: Secondary Education, Adults, Stochastic Sense, Virtual Training, Didactic Suitability.

Resumen

Este trabajo analiza el sentido estocástico que se promueve en el recurso virtual de enseñanza que ofrece la Comunidad Autónoma de Andalucía como apoyo al estudio de la Educación Secundaria para Personas Adultas en la Educación Secundaria Obligatoria. Se aplica la herramienta de idoneidad epistémica descrita en el marco teórico del Enfoque Ontosemiótico y mediante el método de análisis de contenido se identifica la representatividad del significado junto a las conexiones y relaciones entre procesos que se presentan al estudiante. Los resultados informan de limitaciones en torno a las ideas fundamentales del sentido estocástico, principalmente, en cuanto a la incertidumbre, que trasciende a la representatividad de conexiones que se establecen en cuanto al reconocimiento de la variabilidad y la identificación de modelos. Las recomendaciones y conclusiones sobre los resultados obtenidos ofrecen información valiosa para gestionar diseños curriculares en esta enseñanza, así como para diseñar nuevos recursos para los distintos bloques donde se promueve el sentido estocástico.

Palabras clave: Educación Secundaria, Adultos, Sentido Estocástico, Enseñanza Virtual, Idoneidad Didáctica.

Résumé

Cet article analyse le sens du stochastique promu dans la ressource virtuelle proposée par le gouvernement régional d'Andalousie pour soutenir la formation continue des adultes au sein de l'enseignement secondaire obligatoire. L'outil d'évaluation de la pertinence épistémique décrit dans le cadre théorique de l'approche onto-sémiotique a été appliqué, et une analyse de contenu a permis d'identifier la représentativité du sens ainsi que les liens et les relations entre les processus présentés à l'apprenant. Les résultats révèlent des limites concernant les concepts fondamentaux de la compréhension de la stochastique, principalement liées à l'incertitude, ce qui affecte la représentativité des liens établis en termes de reconnaissance de la variabilité et d'identification des modèles. Les recommandations et conclusions basées sur les résultats obtenus offrent des informations précieuses pour la conception des

programmes d'études dans ce contexte éducatif, ainsi que pour la conception de nouvelles ressources pour les différentes unités où la compréhension de la stochastique est promue.

Mots-clés : Enseignement Secondaire, Adultes, Sens du Stochastique, Formation Virtuelle, Pertinence Didactique.

Resumo

Este artigo analisa o sentido estocástico promovido no recurso virtual oferecido pelo governo regional da Andaluzia para apoiar a educação contínua de adultos no ensino secundário obrigatório. Foi aplicada a ferramenta de avaliação da idoneidade epistémica descrita no quadro teórico do Enfoque Ontosemiótico, e realizou-se uma análise de conteúdo para identificar a representatividade do significado, junto das conexões e relações entre os processos apresentados ao aluno. Os resultados revelam limitações relativas aos conceitos fundamentais do sentido estocástico, principalmente relacionadas com a incerteza, o que afeta a representatividade das ligações estabelecidas em termos de reconhecimento da variabilidade e identificação de modelos. As recomendações e conclusões baseadas nos resultados oferecem informações valiosas para o planeamento curricular neste contexto educativo, bem como para o desenvolvimento de novos recursos para as diversas unidades onde se promove o sentido estocástico.

Palavras-chave: Ensino Secundário, Educação de Adultos, Sentido estocástico, Aprendizagem Virtual, Idoneidade Epistémica.

Epistemic suitability of the stochastic sense in the secondary education virtual module for adults in andalusia

Adult Education is considered the main resource for individuals who have discontinued their studies or who have not had access to formal education (Contreras-Villalobos et al., 2023). Since the 19th century, particularly in the post-war context, it has become a governmental challenge (Cruz y Castorini, 2018; de Oña Cots et al., 2018; Rumbos, 2006), driven by the need to support citizens' critical thinking in response to problematic situations in the world, their involvement in social progress, and their ability to acquire knowledge, competencies and attitudes (Martínez de Morentin de Goñi, 2016; OCDE, 2024).

In Spain, Adult Secondary Education (Educación Secundaria para Personas Adultas – ESPA) is regulated by Organic Law 3/2020 on Education (Jefatura del Estado, 2020). It is intended for individuals who are at least eighteen years old at the beginning of the academic year, with exceptions for sixteen-year-old students who hold an employment contract and are unable to attend conventional educational institutions regularly; high-performance athletes; individuals who have not previously registered in the Spanish Education System; and persons deprived of liberty. Our study focuses on individuals studying basic education within ESPA programs with the purpose of obtaining the Secondary Education Certificate (Educación Secundaria Obligatoria – ESO) for adults.

Fombona et al. (2019) emphasize the importance of adapting this type of education to individual needs by promoting self-learning and a responsible attitude towards the educational process, while also encouraging student motivation. However, limited research has been conducted in the field of mathematics education within this context (Gal, 2024). Most existing studies focus on participation in these educational processes (Pérez, 2008), lifelong learning and continuing education perspectives (Martí, 2007), as a model that promotes inclusion and civic participation (Cabello, 2002), or the different socio-professional opportunities that this education provides (Salas et al, 2013).

Furthermore, the standardized international assessments of adult competencies conducted through the Programme for the International Assessment of Adult Competencies (PIAAC), organized by the Organization for Economic Co-operation and Development (OECD) among populations aged 16 to 65 in participating countries, report notable and statistically significant differences in Spain's low performance

compared with other countries in mathematics and adaptive problem solving (OECD, 2024).

This study focuses on stochastic sense, which is the only component that complements the deterministic approach to mathematics (Bargagliotti et al., 2020; Batanero et al., 2013) by addressing random situations. For its interpretation, we adopt the model of components proposed by Batanero et al. (2013), assuming that the definition of stochastic sense admits different interpretations (Contreras & Molina-Portillo, 2019), although all of them share the same foundation: "Statistical literacy may have lost a battle as a phrase, but it may be winning the war as an idea. It all depends on how one defines statistical literacy." (Schield, 2017, p. 59).

Specifically, we aim to describe the epistemic suitability of stochastic sense in the context of virtual education provided by the Autonomous Community of Andalusia as support for the development of the contents related to this topic, which is included in Blocks 7 and 8 of the Scientific-Technological Area of Level II, entitled "We are what we eat. People and Health: Conducting Statistical Studies" (Junta de Andalucía, 2025a) and "Mens sana in corpore sano" (Junta de Andalucía, 2025b), respectively. The contents of these units are also available in downloadable and printable formats.

Theoretical framework

Components of stochastic sense

Various studies underscore and conceptualize the term of "statistical literacy" (Contreras & Molina-Portillo, 2019). All of them emphasize its relevance in contemporary society, which Wild (2017) extols through the dichotomy: producing (cooking) and consuming statistics. As explained Castañeda et al. (2024): "[...] our relationship with data is not merely passive, since we also consume large amounts of information that shape our worldview and influence our decisions" (Castañeda et al., 2024, p. 290).

In this study, we adopt the characterization proposed by Batanero et al. (2013), who relate literacy to culture and identify a model based on the components of knowledge, reasoning and disposition. Regarding knowledge, they identify the following fundamental ideas:

- *Data and the information they provide*, are the essence of statistics. This idea involves understanding the typology of variables, distinguishing categories and frequencies within a variable, as well as identifying which data should be collected and how they should be obtained.

- *Data representations*, which organize and synthesize information and facilitate its interpretation. Particular emphasis is placed on the study of statistical tables and graphics, since each representation requires understanding its structure and construction conventions.
- *Variability*, since data emerge from a context and measuring differences among them is an essential activity in statistics for making appropriate decisions; for example, when making predictions through a fitted model.
- *Data distribution*, which represents the potential of statistical analysis, given that isolated data are not interpreted independently but rather through their trends and joint variation. Therefore, it is necessary to connect measures across the dataset. Moreover, this idea is fundamental for understanding the concepts of random variable and statistic.
- *Association and correlation*, which refer to the study of dependence between variables and constitute fundamental ideas when establishing inferences or predictions while analyzing the effect of one variable on another. Their study also involves becoming aware of the use of beliefs, conception and heuristics.
- *Probability*, since we manage uncertainty to inform decision-making and measuring risk in situations approached from different perspectives (Batanero, 2005). The ESPA identifies the intuitive, classical, and frequentist approaches, along with an implicit subjective approach (see Table 1).
- *Sampling and inference*, since the purpose of answering questions and testing hypotheses refers to data obtained from population samples or repeated experiences. Although inference is not explicitly included as a concept within ESPA (see Table 1), it is implicitly addressed through the processes of study design and data collection.

Regarding the relationships between ideas and the processes involved in stochastic sense, are considered the four dimensions of statistical thinking identified by Wild y Pfannkuch (1999), and the following types of reasoning are distinguished (Batanero et al., 2013):

- *Recognizing the need for data*, since any reasoning process must be grounded in an appropriate sampling design and involves analyzing both the type of data to be collected and the procedures for collecting and refining them.

- *Transnumeration*, since each statistical representation provides specific information, making it necessary to understand how to integrate the information conveyed by different representations.
- *Recognition of variability*, through the identification of properties of a dataset such as its distribution, while considering variability, representativeness, and size.
- *Reasoning with statistical models* in order to explain the characteristics of a situation, as well as applying a variety of strategies when responding to research questions.
- *Integrating the context of the data* when interpreting a situation and drawing conclusions based on the results of a study.

Finally, the attitudes and emotions that every citizen should develop as part of a critical disposition towards statistical information are identified. This component, together with knowledge of the fundamental ideas, is understood as statistical culture.

Meaning of a mathematical object and epistemic suitability

The Onto-Semiotic Approach (Enfoque Ontosemiótico – EOS) constitutes an inclusive and theoretical models used in Mathematics Education research (Godino, 2024). It is grounded in anthropological and semiotic perspectives to provide analytical tools for both mathematical practices and the didactic aspects associated with such practices.

Within the EOS, the notions of problem-situation and practice are understood as fundamental principles of mathematical knowledge, considering a mathematical object as the emergent outcome of a mathematical practice. Consequently, for a mathematical object to acquire meaning, it is necessary to consider any element involved in such practice, which is referred to as a primary element.

The EOS identifies the following primary elements, which together constitute an onto-semiotic configuration when they provide meaning to the object: the problem-situation, as a primary element, due to the diversity of application that confer meaning upon an object; language, which is use to formulate a problem-situation, solve it, or explain its solution, and which operates through different registers (words, symbols, graphs, etc.); definitions or concepts involved, either implicitly or explicitly, in solving a problem-situation; properties or propositions that regulate the resolution of a problem-situation; the typology of procedures (operations or algorithms) employed in solving a problem-situation; and the typology of arguments used to validate procedures

or the application of definitions and propositions in the resolution of a problem-situation.

Finally, we consider the tool of didactic suitability, through which the EOS provides criteria for analyzing the factors involved in the design, development, and evaluation of an instructional process. Didactic suitability is divided into six facets: epistemic, cognitive, mediational, affective, interactional and ecological. Our study focuses on the first of these, which comprises (Godino, 2024): (1) *representativeness*, considering the diversity of primary elements involved in the acquisition of the meaning of the mathematical object according to the educational level at which the instructional process is implemented; and (2) *the relationships and processes* from which the meaning of the mathematical object emerges.

Background

The analysis of didactic suitability has received considerable attention in several studies in Statistics Education (Beltrán-Pellicer et al., 2018; 2020; Gea, 2022; Hernández-Solís & Batanero, 2023) and across a wide range of mathematical contents (Alsina & Domingo, 2010; Arguedas et al., 2017; Aroza et al., 2016; Castillo et al., 2022a, 2022b; Cruz et al., 2017; Esqué & Breda, 2021; Parra & Ávila, 2015). It has also been considered an appropriate tool for validating the selection of educational resources (Orcos Palma et al., 2022).

In contrast, research in Mathematics Education within ESPA remains very limited, and none of the existing studies addresses the analysis of didactic suitability in this educational context. Among the few available studies, Donvito et al. (2017), reporting student dissatisfaction in Argentina, who attribute limited usefulness to the mathematical knowledge studied, as well as a substantial gap between mathematics teaching in ESPA and its usefulness in providing learning for life. Delprato (2013) identifies the importance of promoting students as social agents of their own learning process, which entails improving the transmission of knowledge and the recontextualisation of mathematical objects.

Focusing specifically on stochastic sense, we highlight the study conducted by Eudave (2009), who interviewed 28 students enrolled in adult education in Mexico regarding tasks involving the interpretation of statistical tables and graphs. Concerning tasks related to information and graphical representations, the author considered the reading levels proposed by Curcio (1987) in order to establish four categories of participant performance: (1) no statistical knowledge, when participants were unable

to answer the questions; (2) literal, when they performed some appropriate but limited reading of tables and graphs; (3) relational, when they interpreted information and made certain comparisons, although without substantial depth; and (4) statistically literate, when they answered all questions appropriately, providing reasoned answers supported by data. The results revealed that students experienced difficulties in reading data within context, since only five participants correctly interpreted both the frequency table and the line graph (highest level: statistically literate). Only three students established relationships between pieces of information, whereas nine demonstrated no statistical knowledge. The remaining participants showed difficulties in their interpretations or produced responses that were almost literal.

Method

This study is framed within the qualitative research paradigm and follows a descriptive and exploratory approach, given the absence of prior research on this topic (Hernández & Carpio, 2019). The study analyses the epistemic suitability of the virtual teaching resource provided by the Autonomous Community of Andalusia to support learners to obtain the official Secondary Education Certificate for Adults. Consequently, this research is understood as a case of study, since it provides a detailed examination of the reality under analysis (Yin, 2018). To this end, content analysis (Neuendorf, 2018) was chosen as the methodological approach, understood as an inductive and systematic method of analysis of a documentary (Díaz-Barriga & Luna-Miranda, 2014), making use of the theoretical framework described below. The reliability of the coding process was ensured through the joint review of the codifications carried out by the authors of this study, appropriately resolving the few discrepancies identified during the process.

Our research is grounded both in the curricular framework established by the Autonomous Community of Andalusia, described below together with the educational resource under analysis, and in the components of stochastic sense described by Batanero et al. (2013), as well as in the theoretical framework of the Onto-Semiotic Approach (EOS) to mathematical knowledge and instruction (Godino, 2024), from which we adopt the tool of didactic suitability.

Curricular framework

In the current curricular regulations ESPA to the ESO, in the Autonomous Community of Andalusia, the stochastic sense is described as follows:

Stochastic sense comprises the analysis and interpretation of data, the formulation of conjectures, and decision-making based on statistical information, together with its critical evaluation and the understanding and communication of random phenomena in a wide variety of everyday situations (MEFP, 2022, p. 41726).

The basic knowledge established for the development of stochastic sense on ESPA to the ESO in the Autonomous Community of Andalusia is presented below. The abbreviations refer to the Scientific-Technological Area (Ámbito Científico Tecnológico – ACT), depending on whether the focus concerns the organization and analysis of data (ACT.2.E.1) or uncertainly (ACT.2.E.2).

ACT.2.E.1.1. Strategies for collecting and organizing data from everyday situations involving a single variable. Distinction between variables and individuals values.

ACT.2.E.1.2. Analysis and interpretation of statistical tables and graphs involving qualitative variables, discrete quantitative variables and continuous quantitative variables in real contexts.

ACT.2.E.1.3. Interpretation of measures of location and dispersion. Selection and calculation of the most appropriate measure of central tendency according to de situation under study.

ACT.2.E.1.4. Recognition that measures of dispersion describe the variability of data.

ACT.2.E.1.5. Manual and technological calculation and interpretation of measures of location and dispersion in real situations.

ACT.2.E.1.6. Statistical graphs: representation through different technologies (calculator, spreadsheet, applications, etc.) and selection of the most appropriate representation.

ACT.2.E.2.1. Deterministic and random phenomena: definition.

ACT.2.E.2.2. Assignment of probability through experimentation and the concept of relative frequency, Laplace rule and simple counting techniques. (Junta de Andalucía, 2025c, p. 6245/33).

Table 1

Specific competencies, evaluation criteria, and basic knowledge related to stochastic sense in ESPA leading to the ESO in the Autonomous Community of Andalusia (Junta de Andalucía, 2025c)

Specific Competencies in Mathematics	Evaluation Criteria	Basic Knowledge
4. Identify the sciences and mathematics involved in diverse contexts, interrelating concepts and procedures in order to apply them to everyday situations.	4.1. Identify and apply procedures specific to the sciences and mathematics, establishing connections between different areas of	ACT.2.E.1.2 ACT.2.E.2.2

	knowledge in social and professional contexts.	
7. Interpret and model scientific problems and everyday and professional situations by applying different strategies, forms of reasoning, technological tools and computational thinking in order to find and analyze solutions while ensuring their validity.	7.1. Develop representations that support the search for strategies to solve a problem situation by organizing the given data and understanding the questions posed.	ACT.2.E.1.1 ACT.2.E.1.3 ACT.2.E.1.4 ACT.2.E.1.5 ACT.2.E.1.6 ACT.2.E.2.1 ACT.2.E.2.2

As shown in Table 1, the analysis and interpretation of tables and graphs (ACT.2.E.1.2), together with probability calculation from both the frequentist and classical approaches (ACT.2.E.2.2), are applied to the identification of contexts in which scientific procedures can be implemented and concepts interconnected. However, it is noteworthy that only graphs are explicitly considered for modelling and for the search for strategies to solve a problem situation within evaluation criteria 7.1, despite the fact that statistical tables are essential for the organization and representation of data.

Virtual teaching resources

ESPA is delivered in schools authorized by the educational administrations, managed by the different Autonomous Communities, and offered through three modalities: In-person instruction; distance learning (where students attend the reference educational center occasionally while teaching and learning activities are carried out virtually); and fully virtual distance learning (where all activities are conducted online). The virtual resources used in the latter two teaching modalities are also employed in face-to-face instruction, since students are enrolled in a Moodle platform managed by the Autonomous Community of Andalusia, and teachers have access to these resources to support their practices.

Stochastic sense is present in three of the six learning blocks (Blocks 7 to 12) corresponding to the Scientific-Technological Area of Level II. Block 7 addresses the concepts of population and sample, statistical variables and their types, the organization and interpretation of data through statistical tables and graphs, the calculation and interpretation of measures of central tendency, the use of basic statistical techniques, and critical thinking for questioning and evaluating information presented in the media. Furthermore, special emphasis is placed on the contextualized use of teaching and learning.

Blocks 8 and 9 continue to develop contents introduced in Block 7, although the presence of stochastic sense is less explicit in Block 9 than in Block 8. In Block 8, data related to healthy lifestyle habits and sports are collected and interpreted, tables and graphs are used within health-related contexts, and the functional relationship between variables (dependent and independent) is distinguished through tables, graphs, or verbal descriptions. Evaluation focuses on the construction and interpretation of tables and graphs. In Block 9, functional dependence between variables is analyzed in relation to physical phenomena (force and motion) using both tables and graphs.

Results

The results of the study are organized according to the components that explain the epistemic suitability of the virtual teaching resource analyzed (Godino, 2024). The first section describes the representativeness of the meaning promoted by the resource regarding stochastic sense, through the diversity of primary objects involved in the proposed mathematical activity. Each elementary object is characterized according to the fundamental ideas constituting stochastic sense identified by Batanero et al. (2013).

The second section describes the relationships established between the primary objects promoted within the resource together with the processes from which stochastic sense emerges. In order to characterize these two components of epistemic suitability, it explains how each type of thinking identified in the model proposed by Batanero et al. (2013).

The reader is referred, in each section, to synthesis studies of research lines developed within the theoretical framework of the EOS, in which the reference meaning of the mathematical objects characterising the fundamental ideas is established.

Promoted meaning of stochastic sense

The results of the analysis of this component of epistemic suitability are described through the typology of elementary objects included in the virtual teaching resource. These are characterized according to the fundamental ideas that constitute stochastic sense (Batanero et al., 2013).

Problem-situations and contexts used: The results of the analysis within the virtual resource for the development of stochastic sense were organized according to the fundamental ideas upon which the mathematical activity was based.

- *Situations involving data.* A frequent type of activity consists of identifying and describing the type of variable (qualitative and quantitative, discrete or continuous) within a dataset in a study, as well as distinguishing the categories of a variable according to their corresponding frequencies.
- *Situations involving statistical representations.* Most of the situations involving statistical representations require translating information between graphs and statistical tables. Therefore, we distinguish between situations specifically designed for one representation or the other in order to highlight their limited variety, according to the classifications identified by Díaz-Levicoy (2018) and Pallauta (2022) regarding statistical graphs and tables, respectively.

We identified more instances of table construction than of graphs, whereas tasks focused on regarding representations were only proposed for statistical graphs. However, the reading levels required in these situations are very elementary (levels 1 and 2, according to Curcio's classification, 1987), since they involve the direct reading of individual data values for identification purposes, performing calculations, or comparing certain trends. Only three situations required organizing information presented in a text through the construction of either a graph (two situations) or a table (one situation).

- *Situations involving data distribution.* We distinguish between situations involving the mean, mode, and median in order to highlight their limited variety compared with the classifications identified by Cobo (2003) and Mayén (2009), since most activities focus on calculating the arithmetic mean, and only one situation requires comparing two arithmetic means from two data distributions to determine whether they are equally representative.

Although the situations involving the calculation of the mode are representative, the most frequent activities focus on calculating the mean either to obtain an equitable quantity (as in distribution) or to obtain a representative value for a set of approximately symmetrically distributed data. Only two situations involve calculating the mean as a measure representing the best estimator derived from several measurements affected by error.

- *Situations involving variability.* We identified two types of situations within this category, although none required identifying variability through graphical representations. Although the representativeness of the meaning associated with this fundamental idea may appear limited, according to the classification of situations proposed by Del Pino (2019), it is noteworthy that the same number of situations was found involving comparisons between two or more datasets in order to analyze their differences (expressed using the same unit or measurement scale) as situations requiring the calculation of variance, mean deviation, or standard deviation.
- *Situations involving sampling and inference.* These situations are included within the teaching resource despite the fact that these fundamental ideas are not identified in the curricular regulations of this educational level (see Table 1). We found situations requiring the distinction between a sample and the population from which it is drawn, together with the use of properties such as representativeness.
- No situations involving association and correlation or probability are proposed.

As shown in Table 2, most situations involve the construction and reading of representations, followed by the analysis of data distribution through the calculation of the mean and variability, although no situations involving the median are proposed. Situations requiring the identification of data are also particularly prominent. However, special attention should be drawn to the absence of situations involving uncertainty, despite probability being a content area included in this educational level (Junta de Andalucía, 2025c). At the same time, it is unsurprising that situations involving sampling and inference are proposed, given that these constitute fundamental ideas within stochastic sense (Batanero et al., 2013), even though they are not identified as basic knowledge within the curricular regulations (Junta de Andalucía, 2025c).

Table 2

Types of problem-situations proposed in the virtual resource according to the fundamental ideas.

Fundamental Idea		Frequency (%)
Data		28 (19,0)
Statistical tables	Construction	17 (11,6)
Statistical graphs	Construction	2 (1,4)
	Reading	8 (5,4)

Statistical tables and graphs	Transnumeration	21 (14,3)
Variability		28 (19,0)
Distribution	Mean	24 (16,3)
	Mode	9 (6,1)
Sampling and inference		10 (6,8)
Total		147 (100)

We complete the analysis of the problem-situations by identifying the contexts in which they are presented. Their importance lies in the influence they exert on both the comprehension of a problem-situation and the selection of the most appropriate procedure for solving it (Font, 2007). The categories employed coincide with those established in the PISA, organized by the OECD (2022): personal context (related to everyday life, oneself or groups); occupational context (focused on the world of work or economics, for example, quality control); social context (situations involving the local, national, or global community); and scientific context (applications involving mathematics itself -intramathematics-, science or technology)

Table 3

Frequency (percentage) of contexts proposed in the problem-situations included in the virtual resource

Context	Frequency (%)
Scientific	22 (15,0)
Occupational	28 (19,0)
Personal	39 (26,5)
Social	58 (39,5)
Total	147 (100)

Table 3 shows that the virtual teaching resource focuses primarily on social and personal contexts (39.5% and 26.5%, respectively), generally through situations related to the local environment, including statistical representations concerning voting processes, public transportation, demographics, among others. No decontextualized situations are presented, despite this being a prominent trend identified in the research literature on textbooks (for example, Pallauta, 2022).

Procedures: The procedures described in the analyzed virtual teaching resource mainly involve the organization of data through statistical representations and the calculation of measures related to data distribution. Procedures are also included for identifying the type of variable and the data sample under analysis according to the population from which it originates.

Language: The type of language used in the virtual teaching resource is generally verbal and colloquial. Definitions and properties are usually expressed without rigorous notation, while symbolic language is employed only for representing frequencies and the formulas used to calculate measures of central tendency and dispersion. Table 4 summarizes the most frequently used specific terms associated with the fundamental ideas related to stochastic sense.

Table 4

Specific terms related to Stochastic Sense in the Virtual Teaching Resource

Fundamental ideas	Terms
Data	Data, statistical variable (qualitative, quantitative: continuous, discrete).
Statistical representations	Type of graph, pictogram, histogram, pie chart, bubble chart. Elements of a graph: coordinate axis, circle, circle sector, angle ("pie slices", amplitude) Frequency (absolute, cumulative, relative, cumulative relative), data base frequency distribution table for a variable, summation (total) or sum of frequencies, row (column), class interval, class mark.
Distribution	Arithmetic mean, mode, unimode, bimodal, polymodal, modal interval, measures of position, central and non-central position measures, geometric mean, median.
Variability	Variance, standard deviation, coefficient of variation.
Sampling and inference	Population, sample, sample size, representativeness.

We highlight that graphical and numerical language are widely employed throughout the resource, although there is limited use of percentage and decimal numerical representations. Regarding tabular language, the resource primarily employs one-dimensional frequency distribution tables and, to a lesser extent, lists of data (Pallauta, 2022). Recommendations are also provided concerning their use, particularly in procedures involving the completion or construction of tables, where the use of headings (rows and columns), titles, and the interpretation of class interval for grouped data are considered fundamental.

Definitions: The results of the analysis of the typology of concepts defined within the virtual teaching resource, according to the fundamental ideas, are presented below:

- Definitions related to data. The resource begins by addressing the concept of variable, the distinction between qualitative and quantitative variables, and the definitions of discrete and continuous quantitative variables. It

subsequently introduces problem-situations intended to contextualize their use and promote their identifications.

- Definitions related to statistical representations. Definitions concerning representations refer only to tables and simple bar charts, pictograms, and histograms. Although bubble charts are mentioned, they are not used to represent a two-dimensional variable. These definitions explain both the coordinate axes and class intervals in order to specify the procedures for constructing each type of graph. The concepts of frequency (absolute, relative, and cumulative) and category or value of the variable are distinguished.
- Definitions related to data distribution. Both the arithmetic mean and the mode are defined and accompanied by supporting material for their calculation; however, the median is not defined, despite its usefulness in the study of asymmetric distributions (Cobo, 2003; Mayén, 2009). The mean is defined as an average obtained by multiplying each value of the variable by its frequency and dividing the resulting sum by the total number of data values.
- Definitions related to variability. We identified three definitions corresponding to the concept of variance, standard deviation, and coefficient of variation. The virtual resource includes a specific section devoted to this fundamental idea entitled "Not all data are the same: Data dispersion", in which variance is defined as the average of the squared distances of the data values from the mean, together with its calculation formula; standard deviation is defined as the positive square root of the variance, also accompanied by its formula; and the coefficient of variation is defined as the ratio between the standard deviation and the mean, together with its formula, although its usefulness for comparing the dispersion of heterogeneous datasets is not specified.
- Definitions related to sampling and inference. Although the curricular regulations governing ESPA for the ESO in Andalusia do not explicitly establish the concepts of sample, population, and inference as a core knowledge (Junta de Andalucía, 2025c), these concepts are nevertheless defined in the virtual resource. Although the concept of sample is correctly defined, the definition of population is introduced alongside the concepts of population size, sample size, and sample representativeness. However,

population is described as the set of elements studied with respect to the statistical variable in a study. Therefore, we note the potential difficulty this may pose for students, since the absence of a precise definition of population may hinder the formulation of appropriate inferences from the study results to the population.

- No concepts related to association and correlation, or to probability, are defined.

Properties: The properties addressed in the virtual teaching resource express particular characteristics of the different concepts previously defined, thereby contributing to the enrichment of their meaning (Godino, 2024).

- Properties related to variables. Regarding this fundamental idea, the properties addressed refer to the class mark as the representative midpoint value of an interval when the variable is continuous or when the data are grouped.
- Properties related to representations. The properties associated with statistical tables refer to the frequencies represented, including their totals, whereas the properties related to statistical graphs concern the correspondence between the values and frequencies of the represented variable according to their structure and construction conventions. For example, in pie charts, numerical and geometric proportionality are associated. We note the need for greater attention to properties related to proportional reasoning, which are fundamental when dealing with pictograms or histograms, among others. For instance, in the latter case, the properties are presented together with those of the bar chart, and it is stated that the height of the rectangle is determined by the absolute or relative frequency, without mentioning the width of the class interval.
- Properties related to data distribution. The properties are presented in relation to the arithmetic mean and the mode, emphasizing the usefulness of the mode as a representative value in the study of qualitative variables. Regarding the mean, attention is drawn to its sensitivity to extreme values. Therefore, we consider it important to include the definition of the median and its associated properties in order to strengthen the understanding and use of these measures in the context of asymmetric distributions.

- Properties related to variability. The properties associated to variability concern the calculation of variance and standard deviation, emphasizing their non-negative values. In the case of the coefficient of variation, properties are presented implicitly by relating dispersion to standard deviation.
- Properties related to sampling and inference. Only one property related to representativeness is presented implicitly, without specifying properties associated with sampling variability. Responsibility is therefore placed on the student to understand the usefulness of inference for extending the conclusions obtained from the sample to the population.

Arguments: Argumentation within the virtual resource refers both to the interpretation of statistical representations and to the calculation of statistical measures.

The types of arguments used in relation to representations differ depending on the representation considered, which deductive, argumentation employed for tabular representation and example-based argumentation for graphical representation. With respect to graphical representation, particular situations involving errors in interpretations are presented, mainly due to issues related to graph construction and the coordinate axes. In addition, examples are provided to justify which type of graphs is most appropriate for representing a given situation.

Argumentation concerning statistical measures is primarily algebraic and deductive, relying mainly on verbal language rather than symbolic or algebraic language.

Relationships between objects and processes involved in stochastic sense

The results of the analysis of these components of epistemic suitability are described jointly, since they are explained in terms of the type of reasoning promoted through the virtual teaching resource, according to the typology described by Batanero et al. (2013).

- *Recognizing the need for data.* The resource promotes the identification of variables and defines related concepts; however, the sampling design of a statistical study is not problematized through the formulation of research questions and hypotheses, nor through reflection on what type of data should be collected, how such data should be gathered and measured, or

how they should be cleaned in order to obtain high-quality data capable of addressing the proposed research questions.

- *Transnumeration*. The resource promotes this type of reasoning through a high number of situations involving the translation between graphical and tabular representations, as well as decisions regarding which type of graph is most appropriate for interpreting data distributions.
- *Recognition of variability*. Although the resource promotes problematization and argumentation through the calculation of measures of dispersion within a data set, we identified limitations regarding the treatment of uncertainly-related content that should be addressed in this type of instruction. Since relationships between statistical and random variability are not considered, we note the difficulty involved in managing processes that connect the different approaches to probability. This issue is linked to the fundamental ideas of sampling and inference, which are not included as core knowledge in the curricular regulations governing this level of education (Junta de Andalucía, 2025c), despite being essential for achieving different levels of distributional understanding of data (Batanero et al., 2019).
- *Reasoning with statistical models*. Inquiry-based approaches are not promoted, nor are technological resources used to model structures and trends in the data of a statistical study. This type of reasoning is fundamental for explaining the characteristics of a situation while considering error and uncertainly. Furthermore, Table 1 includes this type of reasoning as an assessment criterion for most of the core knowledge related to stochastic sense in this educational stage.
- *Integrating the data context* when interpreting real situations is a fundamental principle underlying the virtual teaching resource. We found that all the situations presented involve real-world contexts, generally within the personal or social sphere, and require the interpretation of data representations in order to draw conclusions.

Discussion and conclusions

This study addresses the analysis of the stochastic sense promoted through the virtual teaching resource provided by the Autonomous Community of Andalusia as support for ESPA within ESO. The meaning conveyed to students is described, as well as the connections and relationships among the processes promoted throughout the

development of the topic, using the epistemic suitability tool described within the theoretical framework of the EOS (Godino, 2024). To this end, the model that determines the components of stochastic sense described by Batanero et al. (2013) is employed.

The results of the analysis reveal limitations in the meaning constructed around the fundamental ideas of stochastic sense, since representativeness among the assessed contents was not observed. This is particularly evident with regard to probability, as no definitions, properties, or problem-situations related to this concept are presented. This limitation extends to the representativeness of the connections established among the processes involved in stochastic sense, mainly due to the lack of integration of digital competence for reasoning about data modeling, despite the wide range of available tools and resources for this purpose (Batanero et al., 2013; Marín Suelves et al. 2021). Furthermore, we found that most of the proposed situations focus on statistical representations, especially graphs, where students are mainly asked to read or calculate from the data without being required to engage in critical interpretations of such representations.

Our findings provide valuable information for the management of curricular designs in this field of instruction, as well as for the development of new resources for the different content blocks through which stochastic sense is promoted for ESPA within ESO. This is relevant not only for the Autonomous Community of Andalusia, but also for any educational administration responsible for managing this type of instruction. To this end, a comparative study could be conducted across educational administrations regarding the core knowledge and specific competencies related to stochastic sense established for this educational stage. Likewise, this study opens a line of research aimed at comparing the content assessed in the examinations leading to the Secondary Education Certificate for Adult Education in Andalusia with the findings obtained in the present study.

We emphasize that this constitutes a novel and relevant line of research (Batanero & Álvarez-Arroyo, 2024; Burrill & Pfannkuch, 2024; Gal, 2024); particularly due to the recognition that civic statistic has gained within society (Ridway, 2022). Consequently, another possible line of research related to the above would involve examining this context in other countries.

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