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Thematic Dossier
TEACHING GEOGRAPHY: GEOGRAPHICAL THINKING AND THE VISIBILITY OF LEARNING

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SPATIAL THINKING TAXONOMIC ANALYSIS OF SCHOOL GEOGRAPHY TEXTBOOKS IN COSTA RICAN SECONDARY EDUCATION

ANÁLISIS TAXONÓMICO DEL PENSAMIENTO ESPACIAL EN LIBROS DE TEXTO DE GEOGRAFÍA ESCOLAR EN LA EDUCACIÓN SECUNDARIA COSTARRICENSE

ANÁLISE TAXONÔMICA DO PENSAMENTO ESPACIAL NOS LIVROS DE GEOGRAFIA DO ENSINO MEDIO NA COSTA RICA

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Abstract
Spatial thinking is a fundamental skill of geographic thinking that allows a well-thought reasoning of space through representation tools. This type of thinking is subject to be gradually developed by students in the context of formal education, who can develop a better understanding of spatial processes of social and environmental issues of our world. International studies suggest that the development of spatial thinking skills is absent, reduced, or limited in student's textbooks. The current study addresses through the use of a spatial thinking taxonomy, the situation in which these skills are present in geographic exercises on the most important school geography textbooks used in Costa Rica by seventh grade students in high school. The analysis of 690 exercises showed that only 12% of the questions are associated to learning processes involving some level of spatial thinking development from students. This is mainly associated to spatial primitive concepts, input reasoning processes and a low use of spatial representation tools. The findings aligned with the global trends on the topic related to the low interest on fostering spatial thinking skills on textbooks. This is a call for improving the ways in which this type of skills is being presented, develop and promoted in Geography textbooks.

Keywords: Spatial thinking; Textbooks; School geography; Geographic exercises; Secondary education.

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Resumen
El pensamiento espacial es una habilidad fundamental del pensamiento geográfico, que permite el razonamiento fundamentado del espacio a través de herramientas de representación. Este tipo de pensamiento es susceptible de ser desarrollado gradualmente por parte del estudiante en el contexto de educación formal, accediendo así a una mejor comprensión de procesos espaciales de diferentes temas sociales y ambientales de nuestro mundo. Estudios internacionales sugieren que el desarrollo de habilidades de pensamiento espacial está ampliamente ausente, reducido o bien limitado en los libros de texto utilizados por estudiantes. El presente estudio identifica, a través del uso de una taxonomía de pensamiento espacial, el estado en el que se presenta esta habilidad en los ejercicios geográficos de los principales libros de texto de Geografía escolar utilizados en Costa Rica por estudiantes de educación secundaria en sétimo año. A partir del análisis de 690 ejercicios geográficos, la investigación encontró que tan sólo un 12% de las preguntas se asocian a procesos de aprendizaje que involucran algún desarrollo de pensamiento espacial de los estudiantes. Estos se relacionan principalmente a conceptos espaciales primitivos, procesos de razonamiento de entrada y escaso uso de herramientas de representación espacial. Además, el nivel de pensamiento espacial no varía significativamente entre temáticas geográficas. Los resultados encontrados se alinean a los resultados del contexto internacional, de escaso fomento al pensamiento espacial en libros de texto, lo cual implica un llamado a mejorar las formas en que este tipo de habilidad se presenta, fomenta y desarrolla en textos escolares de Geografía.

Palabras clave: Pensamiento espacial; Libros de texto; Geografía escolar; Ejercicios geográficos; Educación secundaria.

Resumo
O pensamento espacial é uma habilidade fundamental do pensamento geográfico, permitindo o raciocínio informado sobre o espaço por meio de ferramentas representacionais. Esse tipo de pensamento tende a ser desenvolvido gradativamente pelo aluno no contexto da educação formal, possibilitando assim uma melhor compreensão dos processos espaciais das diferentes questões sociais e ambientais do nosso mundo. Estudos internacionais sugerem que o desenvolvimento de habilidades do pensamento espacial está em grande parte ausente, reduzido ou limitado nos livros didáticos utilizados pelos alunos. O presente estudo identifica, através do uso de uma taxonomia do pensamento espacial, o estado em que essa habilidade é apresentada nos exercícios geográficos dos principais livros didáticos de Geografia utilizados na Costa Rica por estudantes do ensino médio no sétimo ano. A partir da análise de 690 exercícios geográficos, a pesquisa constatou que apenas 12% das questões estão associadas a processos de aprendizagem que envolvem algum desenvolvimento do pensamento espacial nos alunos. Estes estão relacionados principalmente a conceitos espaciais primitivos, processos de raciocínio de entrada e pouco uso de ferramentas de representação espacial. Além disso, o nível de pensamento espacial não varia significativamente entre os temas geográficos. Os resultados encontrados estão de acordo com os resultados do contexto internacional, com pouca promoção do pensamento espacial nos livros didáticos, o que implica um apelo para melhorar as formas como esse tipo de habilidade é apresentada, promovida e desenvolvida nos livros didáticos de Geografia.

Palavras-chave: Pensamento espacial; Livros didáticos; Geografia escolar; Exercícios geográficos; Ensino médio.

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Introduction

The textbook represents one of the preferred instructional materials for teachers, serving as an academic link between the participants of the educational process (JO; BEDNARZ, 2009), as well as between the curriculum, the student, and their learning process (RODRÍGUEZ, 2013). Authors such as Lee and Catling (2017) propose that its dominance in the classroom is due to reasons of security and teaching experience, given the alignment of content and learning sequence. Not only do teachers seek support and data from them to improve the quality of their teaching and stimulate learning (CONCEIÇÃO et al., 2019), but at times they correspond to the source of facts, concepts, and generalizations of geographic themes that are developed from a study program (BEDNARZ, 2004), to which teachers resort in the context of their professional practice.

The textbooks stimulate curiosity and imagination, as well as the student's search for knowledge (KLEEMAN, 2011), given their function as a guide and orientation for teachers, who use them to develop ideas, exercises or even content related to the topics taught in the geography classroom (BOZKURT, 2019). Thus, textbooks have a dynamic role in didactic strategies that facilitate giving meaning to basic content explored in the classroom (ALZATE et al., 2005).

However, it has also been pointed out that the unrestricted use of textbooks, associating them as equivalent to the curriculum, can lead to undesirable learning situations (FERNÁNDEZ; CABALLERO, 2017). Likewise, Conceição et al. (2019) have suggested that the disproportionate use of textbooks can sometimes reduce the space for alternative learning methodologies. Even the use of outdated materials can have significant repercussions on teaching and student learning (FERREIRA; BARBOSA, 2016).

Both positions show that the textbook can be both a driving element of educational practice or, in certain contexts and situations, a factor that can lead to reductionist and monotonous views of learning. In any case, it is clear that the textbook plays an important role in the contemporary educational process.

e-ISSN: 2595-4881

One of the relevant elements of using textbooks lies in the presence of learning activities that provide students with opportunities to develop new levels of understanding and learning of geographic topics. Duarte (2016) states that the quality of the proposed exercises, taking into account theory, pedagogy, and methodology, is an aspect that should be present in these instructional materials. When these activities are not diverse and promote individualistic and somewhat monotonous exercises, they lead to a decrease in student interest and learning (GOUVEIA; MONTIEL; BEJAS, 2005; PICÓN; VARELA; BRAÑA, 2013). In other words, direct attention must be paid to the nature and meaning of the geographic practices or exercises presented to students in textbooks due to their implications for learning.

In the context of geographic education, the what, how, and why of pedagogical practices or exercises developed in textbooks are fundamental. Both Fachinello, Cândido, and Rossato (2000) and Jo and Bednarz (2009) argue that textbooks are key to the development of spatial notions in students, as they are a source of concepts, facts, and processes that need to be learned by the student. These instructional materials are a tool for stimulating the development of students' spatial thinking, a key skill for understanding and interpreting the world and how people inhabit the Earth (HEFFRON; DOWNS, 2012). Given that geographic textbooks should promote learning processes, cognitive stimulation, and a centralized geographic content associated with the objectives of geographic education (LEE et al., 2020), the proposed pedagogical activities should incentivize spatial thinking skills as an essential element in the development of transformative geographic thinking in students.

From this perspective, although there have been several approaches in the scientific literature for studying textbooks, addressing aspects such as the ways in which geographical themes and/or concepts are represented and analyzed (FACHINELLO; CÂNDIDO; ROSSATO, 2000; BARBOSA, 2017; DE OLIVEIRA; FERNANDES, 2019; DE VICENTE; MOREIRA, 2019; SANTOS; LUIZ, 2019) as well as the visual and cartographic elements present in them (KLEEMAN, 2011; RICHTER; BUENO, 2013; ALVES; KAWAKUBO; RUBIRA, 2016; NOGUEIRA; CLAUDINO, 2016), this research specifically focuses on a line of research directly associated with the theory of spatial

e-ISSN: 2595-4881

thinking, as a branch of geographical education, analyzing the connection between the textbook, pedagogical activities in this instructional material, and the development of students' spatial thinking.

The research aims to answer the question: To what extent is spatial thinking stimulated or developed in the pedagogical exercises proposed in textbooks for secondary education students? To achieve this, reference will be made to one of the theoretical and methodological proposals for the study of this topic at an international level, the spatial taxonomy, in order to identify the form, quantity, and characteristics of spatial thinking suggested to be developed in seventh-grade students in Costa Rican secondary education, through the resolution of questions presented in school texts.

Spatial thinking in geographic education and student training

Spatial thinking is defined as a set of cognitive skills that involve understanding concepts about space, using representation tools, and reasoning processes (NATIONAL RESEARCH COUNCIL, 2006). This approach implies understanding what space means in its different properties (e.g., dimensions, continuities, proximities, separations, among others), as a way of structuring problems, finding answers, and proposing solutions. On the other hand, Scholz et al. (2014) indicate that representation tools such as maps, graphs, videos, photographs, satellite images, geographic information systems, and others help improve the visualization of relationships between spatialized objects. Finally, reasoning processes, which involve different ways of thinking about space, refer to the capacity to project spatial relationships (JO; BEDNARZ, 2009).

Metoyer, Bednarz, and Bednarz (2015) suggest that spatial thinking is analyzed under an interactionist approach in geographic education, which implies that biological conditions existing at birth evolve as our cognitive abilities improve, considering also the effect of the sociocultural context of individuals. The most

e-ISSN: 2595-4881

relevant aspect of this approach is that it proposes that spatial thinking can and should be learned and developed in formal education at all levels (LEE et al., 2018).

Thinking spatially is not only essential for daily life and the study of other disciplines, which is why it should be part of the education system (SHIN; MILSON; SMITH, 2016), but it is also one of the structuring elements, according to Golledge (2002), of geographic thinking. If geographic education aims to provide students with the ability to address the social and environmental challenges they read and learn about, as well as to reason and propose solutions to them (FAVIER; VAN DER SCHEE, 2014), then spatial thinking constitutes a key cognitive skill to achieve this through learning.

In this perspective, there are studies that emphasize the importance of spatial thinking in student education. The development of this skill has been associated with better performance in STEM disciplines (ISHIKAWA, 2013; BEDNARZ; LEE, 2019) and is also considered fundamental in the social sciences and humanities (GOODCHILD; JANELLE, 2010). Spatial thinking has also been linked as fundamental to the development of students' critical thinking skills (KIM; BEDNARZ, 2013). All these factors refer to the relevance of incorporating spatial thinking as part of the skills to be developed in the formal education system.

Spatial thinking research approaches: the development of the spatial thinking taxonomy

As the development of spatial thinking is one of the central objectives of geographical education, Jo and Bednarz (2009) have pointed out the need for the education system to support student training in this direction, through curriculum planning, teaching practices, assessments, and the use of textbooks, as well as through the use of geospatial technologies (METOYER; BEDNARZ, 2017). This has resulted in four main streams of research on spatial thinking.

e-ISSN: 2595-4881

One line of research has focused on using tests to measure levels of spatial thinking in individuals. Studies such as those by Lee and Bednarz (2012), Huynh and Sharpe (2013), Tomaszewski et al. (2015), Cascante-Campos (2016), and Duarte, Teodoro, and Gonçalves (2022) have proposed the use of standardized assessment tools, finding a progression of spatial thinking as individuals age, advance in educational level and instruction, as well as differences between urban-rural contexts and academic disciplines. These results demonstrate the gradual evolution of spatial thinking in individuals, mediated by academic, personal, psychological, and geographic factors.

A second approach has focused on working with pre-service teachers, by incorporating spatial thinking into their professional training (JO; WHITHMAN, 2013) and their willingness to teach using this skill (JO; BEDNARZ, 2014; LEE et al., 2018). The emphasis is on understanding motivations and processes related to the acquisition of spatial thinking skills, within the framework of their preparation as future educators.

A third approach analyzes the development of spatial thinking through the use of geospatial technologies. Studies such as those by Lee and Bednarz (2009), Bodzin et al. (2015), Jo, Hong and Verma (2016), as well as Carbonell and Bermejo (2017) suggest that through geographic information systems and other emerging technologies, it is possible to improve spatial thinking abilities. However, research such as that by Metoyer and Bednarz (2017) has suggested that the use of geospatial technologies alone does not directly lead to improved spatial thinking. Nevertheless, individuals with higher levels of spatial thinking tend to make more effective use of geospatial technologies and achieve greater geographic learning.

The fourth approach is directly related to the present study, as it focuses on the use of spatial thinking taxonomies to analyze the ways and characteristics under which this ability is expressed. The taxonomy, understood as a framework for classifying statements about what is expected for a student to learn as a product of formal instruction (KRATHWOHL, 2002), has allowed for the creation of an evaluation system of how spatial thinking is developed by students, teachers or is manifested in curricula or textbooks.

Cenas Educacionais
e-ISSN: 2595-4881

Studies such as Anthamatten's (2010) have emphasized the use of spatial thinking taxonomies such as the one proposed by Gersmehl and Gersmehl (2006) related to neurological skills. In this case, it was identified that only four spatial concepts (location, condition, connection, and comparison) are present in the curriculum standards of early years students. However, this is the research that has analyzed the questions presented in exercises or pedagogical activities in textbooks, and also has made a more extensive use of spatial thinking taxonomies.

The study by Jo and Bednarz (2009), which proposed a systematic and well-grounded taxonomy of spatial thinking, has been widely used in various international studies analyzing textbooks. This taxonomy is based on a three-dimensional integration (Figure 1) of the three components of thinking: geographic spatial concepts, representation tools, and reasoning processes.

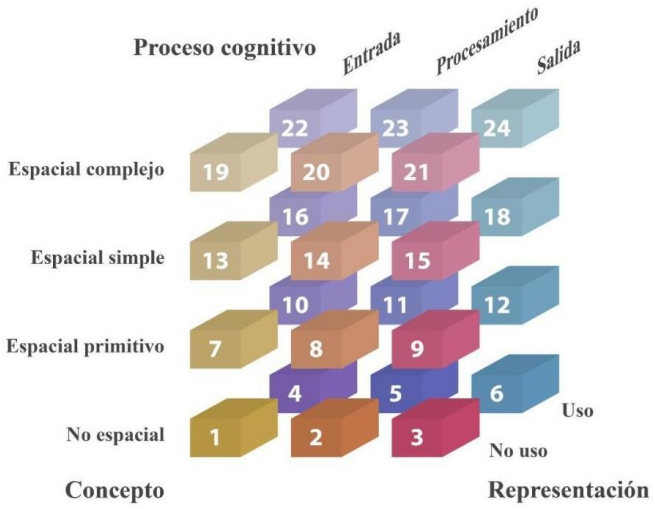

Figure 1. Spatial thinking taxonomy proposed by Jo and Bednarz (2009).

The authors suggest that, when analyzing geographic questions in textbooks, an ontological distinction must be made regarding the concepts associated with geographic space, in relation to the level of complexity that is being pursued. Although there are different classifications of spatial concepts (GERSMEHL; GERSMEHL, 2006; GOLLEDGE; MARSH; BATTERSBY, 2008), for this taxonomy, they used the classification proposed by Golledge (1995, 2002), establishing four levels of increasing complexity (Table 1).

e-ISSN: 2595-4881

In addition, the taxonomy distinguishes the need to use representation tools to address spatial concepts, such as maps, diagrams, graphs, photos, and videos, but it can be extended to other technologies such as online visualizers, digital globes, satellite images, or virtual or augmented reality devices. Finally, Jo and Bednarz (2009) propose that there is a gradient of reasoning about spatial concepts, through representation tools, based on the classification system of Costa (2001) that defines levels of input, processing, and output.

Table 1. Spatial concepts classification, based on Jo and Bednarz (2009).

Concept type	Definition
No spatial	The question does not have a spatial component, as the concept refers to non-spatial elements.
Spatial primitives	Concept of space at the lowest level, involves concepts of location, specific place identity, and magnitude.
Simple spatial	This is a higher-level space concept, based on derived concepts and distributions from primitive spatial concepts. These includes distance, direction, connection and linkage, movement, transition, boundary, region, shape, frame of reference, arrangement, adjacency, and enclosure.
Complex spatial	The highest-level concept of space is based on spatial distributions derived from primitive and simple concepts. These includes distribution, pattern, dispersion and clustering, density, diffusion, domain, hierarchy and network, spatial association, overlap, layer, gradient, profile, relief, scale, map projection, and buffer.

Jo and Bednarz (2009) propose that the input level is a reasoning process focused on receiving information, which is associated with verbs such as naming, defining, enumerating, identifying, recognizing, reciting, remembering, observing, describing, selecting, completing, counting, and combining. The second level of reasoning is processing, which involves analyzing the received information and is associated with verbs such as explaining, analyzing, establishing causality, comparing, contrasting, distinguishing, classifying, categorizing, organizing, summarizing, synthesizing, inferring, making analogies, exemplifying, experimenting, and sequencing. The last level is output, which involves using the analysis of received information to create, evaluate, judge, predict, forecast, formulate hypotheses, speculate, plan, design, invent, imagine, generalize, construct a model or apply a principle.

e-ISSN: 2595-4881

It is from the integration of these components that spatial thinking is formed. This means, according to Jo and Bednarz (2009), that in order for the ability to manifest, representation tools must be used to understand some spatial concept, according to a certain level of reasoning. In this way, they have established three levels of spatial thinking, taking into account the numerations of figure 1.

- Low complexity: corresponds to boxes 10, 11, and 16, that is, there is a use of representation tools to understand primitive concepts through input and processing reasoning, or simple spatial concepts but at the input reasoning level.
- Medium complexity: associated with boxes 12, 17, and 22, referring to the use of representation tools to analyze primitive spatial concepts but at an output reasoning level, simple spatial concepts at a processing level, or complex spatial concepts at an input reasoning level.
- High complexity: corresponds to cells 18, 23, and 24, in which thinking is identifiable through the use of representation tools to understand simple spatial concepts at a level of output reasoning, as well as complex spatial concepts at levels of processing and output reasoning.

Since the authors establish the need for the three components to be present in order to indicate the presence of spatial thinking in textbooks. In cases where spatial concepts are not addressed or no use of representational tools is made, it is not possible to associate questions with any level of spatial thinking development.

Studies such as Jo and Bednarz's (2009) have identified a large number of geography exercises where spatial thinking is not properly developed. In cases where it is visible, it is mainly associated with low complexity thinking, dominated by simple concepts and entry-level reasoning processes, with a clear absence of representation tools. Duarte (2016) has also used the same taxonomic analysis for Brazilian school geography textbooks in grades six through nine, finding similar results regarding the incorporation of spatial thinking in school textbooks. Similarly, Nguyen et al. (2019) also evidenced the limited presence of developed spatial thinking in geography exercises in textbooks for the same academic grades in Vietnam.

e-ISSN: 2595-4881

Scholz et al. (2014) found through the use of this spatial taxonomy that textbook exercises in Geography at the university level tend to develop a deeper spatial thinking, with more use of simple and complex concepts, as well as processing and output reasoning. However, Ridha et al. (2019) found a predominant absence of spatial thinking in the exercises proposed to students in geographic information systems textbooks in Indonesia. These initial studies show the possible differences between university educational materials regarding the development of this cognitive skill, which requires additional studies in different contexts.

The study by Jo and Bednarz (2011) also analyzed the questions in textbooks according to their location (margins of the page, end of section or chapter), and in relation to evidence of the development of spatial thinking. Their findings indicate that questions located in margins of the page tend to incorporate these skills more frequently in practice, compared to those arranged at the end of a topic or content.

In the context of using the spatial thinking taxonomy proposed by Jo and Bednarz (2009), several studies confirm a trend towards a limited presence of questions in geography textbooks that develop spatial thinking, with a dominance of low complexity levels, varying according to their location in the text and the academic level in which they are used. Under this scenario, this study addresses the analysis of how the level of spatial thinking is manifested in secondary education textbooks in Costa Rica.

Methodology

The research aimed to determine the level of spatial thinking present in school Geography textbooks used by secondary education students in Costa Rica. A case study was conducted on the materials used in the seventh grade during 2021. In this sense, the study required the definition of several methodological stages.

e-ISSN: 2595-4881

- Research context

Geography as a discipline in Costa Rican secondary education is developed together (not integrated) with History in the field called Social Studies. The curriculum has a national application, with the study plan for both the third cycle (7th, 8th, and 9th grades), as well as the diversified cycle (10th and 11th grades), addressing a series of separate topics for each discipline throughout the academic year. Around 50% of the expected learning outcomes for the student specifically relate to Geography.

The Ministry of Public Education (2016) emphasized a type of geographical curriculum associated with the sustainability paradigm, in line with the declaration of the Commission on Geographical Education of the International Geographical Union on geographic education for sustainable development (HAUBRICH; REINFRIED; SCHLEICHER, 2007). This curriculum proposes a series of topics associated with the sustainable development goals proposed by the United Nations (2015) for secondary education, which are analyzed through the use of geographical concepts, processes and skills, spatial, geospatial and geographical thinking, as well as the use of technological and geotechnological tools, based on case studies or illustrative examples. For seventh grade, there are three major sustainable geographical themes that should be developed for approximately five months:

1. The ecological footprint on our only home and common space, planet Earth.
2. Terrestrial ecosystems from a geographical perspective: between transformations and challenges.
3. The geography of food production: issues and challenges for planetary sustainability.

The textbooks used in secondary education propose an approach that addresses these contents in line with the national curriculum, so the geographic topics are seen as identifiable thematic units. Therefore, the selected textbooks for this study guarantee compliance with the provisions of the Ministry of Education. Their selection was also due to being the most widely circulated texts among Social Studies teachers and those that were available in educational centers in the country during the study period.

e-ISSN: 2595-4881

- Formulation, data collection, and analysis:

The research used Jo and Bednarz's spatial taxonomy (2009) in order to achieve the proposed purpose. The questions from the selected textbooks were analyzed, specifically those related to the geographic topics studied in seventh grade in Costa Rica. This process involved a gradual systematization of information regarding the following components:

1. Presence or absence of primitive, simple, and complex spatial concepts.
2. Use or non-use of representation tools.
3. Determination of the levels of reasoning, either input, processing, and output.
4. Definition of the levels of spatial thinking complexity present in the selected textbooks' questions.

A total of 690 questions were identified in the four selected textbooks for the analysis of spatial thinking components, distributed among the three geographic topics to be developed in seventh grade. Each question was analyzed, creating a database that recorded the type of spatial concept, representation tool, and level of reasoning. Based on these components, their integration and corresponding level of spatial thinking complexity were determined in each case. The questions were individually coded by each researcher for subsequent validation, following Creswell's criteria (2017), through cross-checking of the emerging categories, achieving a similarity between researchers of over 80%, which is a suggested parameter in these processes, ensuring greater certainty in the established classifications. In cases of disagreement, they were jointly analyzed to determine the best categorization of the components.

The results obtained from this process of systematization of the questions were analyzed through descriptive statistics with the support of graphs and tables, which aim to show the behavior of each component of spatial thinking individually, as well as its integration according to different levels of complexity (low, medium, and high).

Cenas Educacionais
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Once the level of spatial thinking developed in the geographic questions of textbooks was identified in a general way, we proceeded to investigate possible differences in relation to the geographic topics developed during seventh grade. Therefore, a chi-square test of independence was performed to determine the existence of a significant association between any geographic topic and the greater presence of questions that developed spatial thinking. The data for this analysis came from the same classification made earlier, broken down by geographic topic and were processed using the free software JAMOVI.

Results

The individual analysis on the first component, related to concepts of space (figure 2), shows that one out of two questions posed in the textbooks does not refer to any degree of spatiality. In particular, the distinction in quantity between primitive, simple and complex concepts can also be noted.

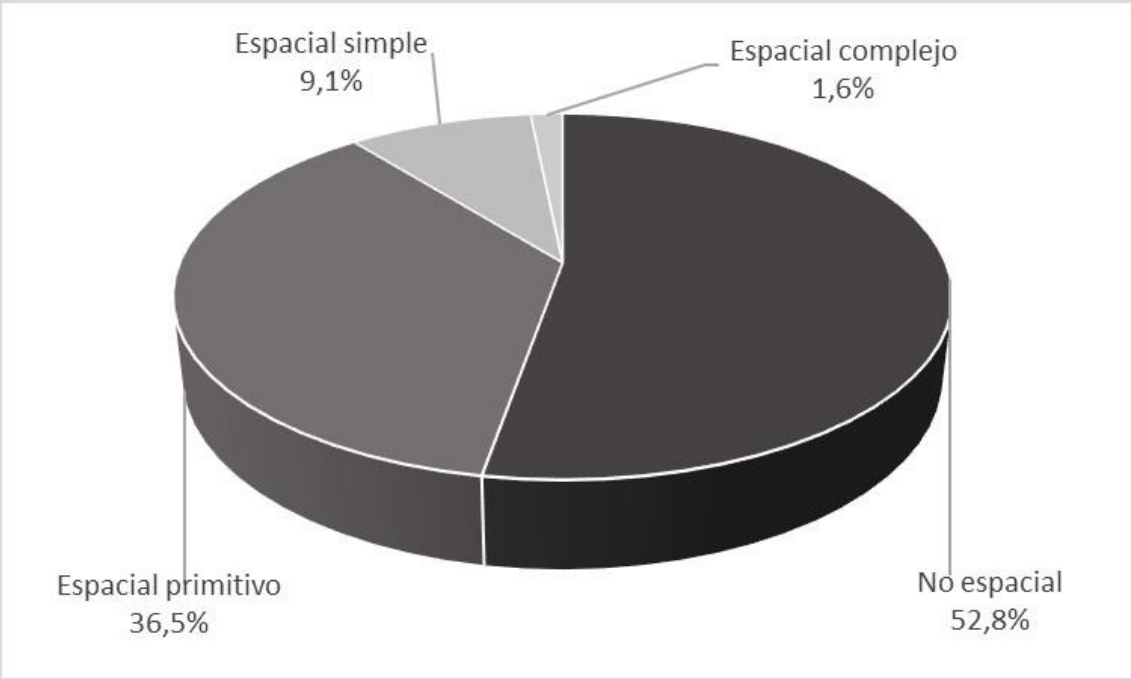

Figure 2. Classification of textbook questions according to concepts of space.

e-ISSN: 2595-4881

Of the concepts classified as primitive, it was found that the one related to specific identity of place is the most addressed with 87.7%, followed by the concept of location at 8.8%, and magnitude with 3.5%. This distribution is relatively similar when comparing textbooks. Regarding simple concepts, which represent a smaller proportion of textbook questions, they mainly focus on the approach of the concept of region with 81.5%, followed by concepts such as enclosure (9.3%) and adjacency (7.4%). In the very limited presence of complex spatial concepts, in most cases the concept of distribution was selected (70%) as part of the geographic exercises.

Considering all concepts used, without distinction of complexity, the concept of place-specific identity was the most used with 33%, followed by the concept of region (6.3%) and location (3.3%). Some examples of questions where these concepts were developed are the following:

- Place-specific identity concept: "Why is it said that the destruction of the Amazon is a serious risk to life on Earth?" (Selected book A)
- Proximity concept: "Determine which national park is closest to your educational institution" (Selected book B).
- Region concept: "Why have Central American countries historically had a strong participation of agriculture in the country's economy?" (Selected book A).
- Distribution concept: "What is the geographic distribution (observing a map) of the main ecosystems in the world?" (Selected book A)

Regarding the use of representation tools, the wide absence of this component in textbook questions is notable, as in 84.2% of cases it was not possible to determine that the exercises included them. Of the remaining 15.8%, maps were the most widely used (38.5%), followed by the use of images (21.1%), tables (15.6%), and graphs (12%). In this case, there were differences between publishers regarding the use of representation tools, as in two analyzed texts, maps are the most frequently used resource, while in the other two, the distribution is more balanced among maps, tables, and graphs.

Cenas Educacionais
e-ISSN: 2595-4881

The analysis of the questions allowed the identification of a greater number located at the input reasoning level. Comparatively, 65.5% of the exercises focused on the reception of information characteristic of the input level, compared to 33.8% that addressed the processing level and only 0.7% at the output level.

These results laid the groundwork for identifying the presence of spatial thinking in the questions of the analyzed school geography textbooks. Based on the criteria proposed by Jo and Bednarz (2009), it was possible to determine that 88% of the questions do not present an integration of the three components, thus not even determining some level of spatial thinking development. Of the remaining percentage, 10.8% refer to low complexity levels, 1% to medium complexity, and only 0.2% to high complexity spatial thinking. Figure 3 even shows that, regardless of the publishing house, the absence of spatial thinking integration in the textbook questions is very high.

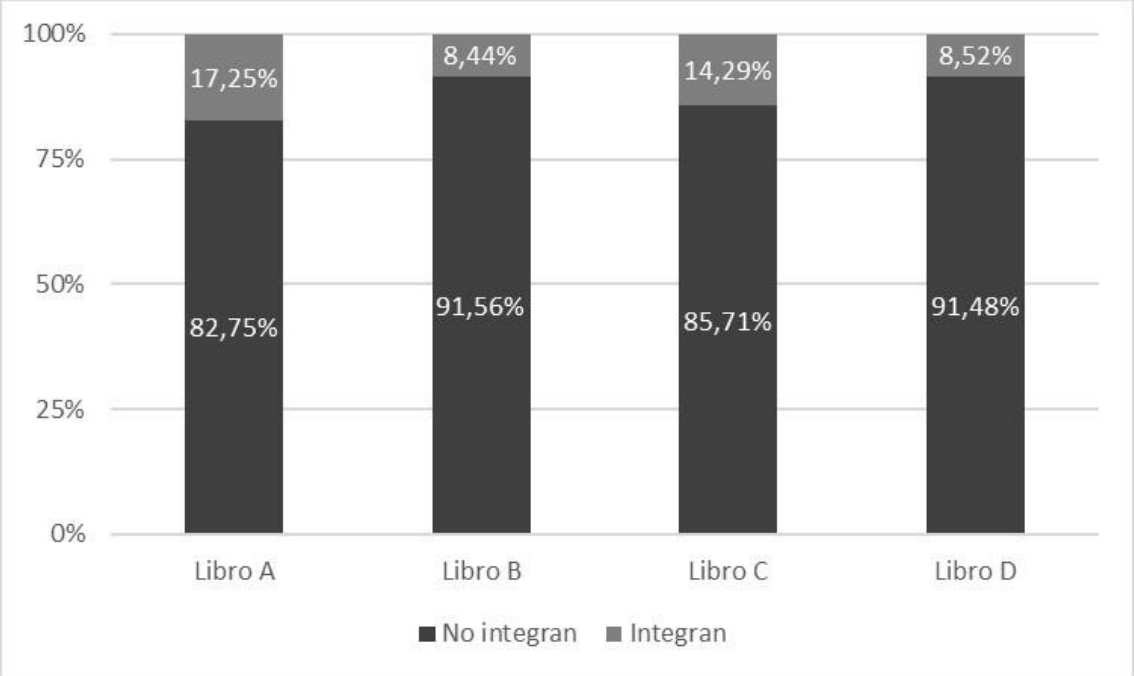

Figure 3. Spatial thinking integration in analyzed textbooks.

- Does spatial thinking vary depending on geographical topics?

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As a result of the research process, it was possible to identify the levels of integration of spatial thinking, based on the three major geographic themes studied in seventh grade, which are addressed by the four selected publishing houses. In general, Table 2 shows the distinction by theme in relation to the integration or non-integration of this cognitive skill, descriptively demonstrating a similar pattern to that described in general for all textbooks.

Table 2. Level of integration of spatial thinking according to geographic theme in the questions of seventh-grade textbooks.

Topic	No integration	Integration	Total
Ecological footprint	130 (90,3%)	14 (9,7%)	144
Terrestrial Ecosystems	233 (88,9%)	29 (11,1%)	262
Geography of food production	243 (85,6%)	41 (14,4%)	284
Total	606	75	690

The subsequent analysis using the chi-square test of independence aimed to demonstrate the existence of an association between the seventh-grade geographic themes and the level of integration of spatial thinking in the geographic questions of textbooks. The results of the test ($\chi 2(2) = 2.39$, $p = 0.303$) indicate that there is no statistically significant association, therefore it is not possible to determine whether the lack of integration of spatial thinking is greater or lesser in a specific theme or whether the presence of spatial thinking is more evident in any specific topic.

Discussion and conclusions

The results obtained indicate that, in the case study applied to the Costa Rican context, specifically seventh grade, textbooks present geographic questions or exercises with a very low level of integration of spatial thinking. It is revealing that although the findings align with the evidence found by Jo and Bednarz (2009), Scholz et al. (2014), Duarte (2016), Ridha et al. (2016), and Nguyen et al. (2019), the fact that almost 9 out of 10 questions do not integrate or develop spatial thinking skills raises

e-ISSN: 2595-4881

an urgent need for improvement in the design of these educational materials. In this sense, the evidence suggests that publishers have not adequately proposed processes for the preparation of classroom practices that are appropriate for adequate teaching of Geography, based on cognitive skills that are fundamental to proper training in geographic reasoning.

When assessing the individual components, it is important to consider that the emphasis on primitive spatial concepts and entry-level reasoning levels may be aligned with the fact that it is material prepared for seventh-grade students (students aged 13-14) and, therefore, the demand for higher levels of spatial understanding and reasoning should not be so high. However, the fact that their presence in the questions did not necessarily lead to the development of integrated spatial thinking, as well as the widespread presence of questions with non-spatial concepts and the lack of use of representation tools, leads to the assertion that there is no appropriate structure in the analyzed textbooks that allows students to advance in the learning of this cognitive skill, at least through the use of these educational materials in the classroom.

Similarly, given the marked absence of integration of spatial thinking in the questions of the geography textbooks, it was not surprising that there was no distinction between any of the three geographic themes represented in the study. That is to say, the consistent lack of this skill in the textbook seems to be a common denominator of the way in which this educational material represents the Geography that must be taught in the classroom, at least with respect to geographical exercises, questions or practices. Further analysis is needed on other elements such as the thematic content itself or similar analyses to those carried out by Jo and Bednarz (2011) on the positioning of geographical questions.

The findings of this research propose a series of elements to consider in the context of improving the teaching of school geography. First, the relevance that the adequate and explicit incorporation of academic exercises that stimulate the development of spatial thinking has for publishers of geography textbooks. A proper process of geographic learning and reasoning inevitably requires the stimulation of processes of understanding the spatial nature of geographic phenomena, which must undoubtedly be incorporated into textbooks.

e-ISSN: 2595-4881

In second place, the results should be a reason for reflection for those who teach geography in secondary education. These results should serve as a basis for teachers to consider the use of textbooks as a complementary material and not the only one to be used in the classroom. If scientific evidence shows a significant absence of spatial thinking in textbook questions, it will be necessary for teachers to create alternative scenarios through other instructional materials or resources that promote spatial thinking among students. Depending exclusively on educational texts, such as those analyzed in this study, may have an adverse effect on improving fundamental geographic skills to advance learning in the discipline in secondary education.

Lastly, and linked to the previous point, the teacher should pay particular attention to the incorporation of didactic exercises that gradually increase in complexity. The results show us that, in cases where there was an integration of spatial thinking in textbook questions, there is a marked tendency to promote low levels of spatial thinking. If we start from the principle exposed by Metoyer, Bednarz, and Bednarz (2015) that this ability can be fostered through formal education processes, in the face of the limited presence (or even absence) of an ordered sequence of growth in spatial reasoning in textbooks, it will be important for the teacher to adapt their professional practice to incite new stages of intellectual development in the student, a task that, at least in the Costa Rican context, cannot and should not be explicitly and solely delegated to textbooks, given the shortcomings reported in this study.

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