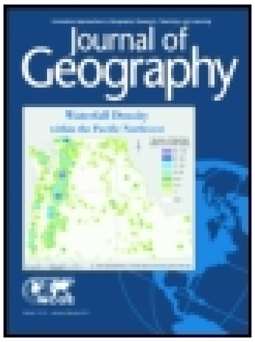

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Evaluating Geography Textbook Questions from a Spatial Perspective: Using Concepts of Space, Tools of Representation, and Cognitive Processes to Evaluate Spatiality

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ABSTRACT

This article examines whether questions embedded in geography textbooks address three components of spatial thinking: concepts of space, tools of representation, and processes of reasoning. A three-dimensional taxonomy of spatial thinking was developed and used to evaluate questions in four high school level geography textbooks. The results indicate that textbook questions focus on low-level spatial concepts more frequently than high-level spatial concepts; few questions require students to create various kinds of spatial representations; and textbook questions only rarely encourage higher-order cognitive skills. The study provides insights on the design and use of textbook questions to foster learning to think spatially.

Key Words: *spatial thinking, geography textbooks, concepts of space, tools of representation, processes of reasoning*

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INTRODUCTION

Spatial thinking is defined as "a collection of cognitive skills comprised of knowing concepts of space, using tools of representation, and reasoning processes" (National Research Council 2006, 12). Enhancing spatial thinking is one of the key goals of geography education (Geography Education Standards Project 1994), but whether school geography is able to achieve this goal depends on the degree to which students' practice to learn spatial thinking is supported by the education system (i.e., teacher practices, curricula, textbooks, and assessments).

Particular attention needs to be paid to the role geography textbooks play in developing this important skill. Textbooks play critical roles in most school subjects, acting as the curriculum (Apple 1986; Posner 1992; Stodolsky 1989; Venezky 1992); the primary source of the content knowledge for teachers (Chambliss and Calfee 1998; Garner 1992; Herlihy 1992; McMurray and Cronbach 1955); and the dominant instructional tool (Chambliss and Calfee 1998; Finkelstein, Nielson, and Switzer 1993; Herlihy 1992; Posner 1992; Venezky 1992). This is especially true in social studies education, of which geography is a component (Chall and Conard 1991; Davis *et al.* 1986; Hill 1994; Marran 1994; Myers and Savage 2005; White 1985). It has been noted that "[geography] textbooks set the parameters for knowledge and serve as the source of facts, concepts, and generalizations to be learned by students at each grade level in all parts of the nation" (Bednarz 2004b, 223).

Little is known, however, about whether current geography textbooks function as a vehicle for student acquisition of knowledge and skills supporting spatial thinking. Only a few studies have examined geography textbooks from a spatial perspective (e.g., Bednarz 2004b; Martin 1996). The diagnoses of these studies on geography textbooks are informative, but several limitations are also detected. First, the scope of spatial thinking evaluated in the studies is confined to map skills. These studies evaluate whether geography textbooks help students develop map skills effectively but not whether they support the acquisition of conceptual knowledge associated with spatial thinking. Second, the evaluations rely largely on the researcher's qualitative insights and scrutiny rather than on a more quantitative and systematic methodology, so the result is hardly replicable and comparable across studies. Another limitation is the lack of hands-on guidelines that can help teachers wisely use materials provided in textbooks to teach spatial thinking. This article addresses these limitations by proposing a taxonomy of spatial thinking that encompasses its three key components: concepts of space, tools of representation, and processes of reasoning (National Research Council 2006). Our ultimate purpose is to provide textbook publishers and teachers with a means to develop questions, one of textbooks' most prevalent features, to facilitate students' spatial thinking skills. This article consists of two parts. In the first part we explain the structure of our spatial thinking taxonomy and how it was developed. In the second part we examine questions in geography textbooks, evaluating their "spatiality," using the taxonomy to illustrate its practical use to geography educators.

CONSTRUCTION OF A TAXONOMY OF SPATIAL THINKING

An educational taxonomy is defined as "a classification of educational outcome" (Bloom *et al.* 1956, 1) and conceptualized as "a framework for classifying statements of what we expect or intend students to learn as a result of instruction" (Krathwohl 2002, 212). Numerous taxonomies have been developed for

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educational purposes. Traditionally these have been used to evaluate instructional activities and materials in terms of where the relative emphases are, how the curriculum is aligned, and what educational opportunities are missing (Anderson and Krathwohl 2001; Bloom *et al.* 1956). There are a dozen taxonomies of thinking skills (e.g., Anderson and Krathwohl 2001; Bloom *et al.* 1956; Costa 2001; Gouge and Yates 2002; Marzano 2001; Moseley *et al.* 2005; Presseisen 2001; Quellmalz 1987; Stahl and Murphy 1981), but no one taxonomy wholly developed for spatial thinking skills exists.

To design a taxonomy is to construct categories of phenomena, then to arrange the categories by a consistent set of principles (Krathwohl, Bloom, and Masia 1964). To establish a taxonomy of spatial thinking, therefore, is to identify categories of key aspects of spatial thinking and to order them according to a consistent rule. Three primary categories of this taxonomy can be derived from the definition of spatial thinking as "a collection of cognitive skills comprised of knowing concepts of space, using tools of representation, and reasoning processes" (National Research Council 2006, 12). The subcategories for each primary category are then derived from a review of the relevant literature.

Classification of the First Primary Category: Concepts of Space

Spatial concepts are building blocks for spatial thinking (National Research Council 2006). In geography, concepts such as location, distribution, region, pattern, distance decay, and spatial association have been considered essential to spatial thinking (see Bednarz 2004a; Gersmehl 2005, 2006; Golledge 1995, 2002). A taxonomy of spatial thinking, therefore, should enable one to distinguish spatial concepts from nonspatial concepts and to classify these spatial concepts in a reasonable way. Four subcategories for the first primary category were proposed: nonspatial concepts, spatial primitives, simple-spatial concepts, and complex-spatial concepts.

Golledge's (1995, 2002) scheme of spatial concepts and classifications form the basis of this categorization. Spatial primitives represent basic and fundamental characteristics of an existence in space, such as place-specific identity, location, or magnitude. Simple-spatial concepts are concepts established by sets of spatial primitives (e.g., distance is the interval between locations); complex-spatial concepts are those derived by assemblies of sets of simple-spatial concepts (e.g., network is expressed as sets of connected locations) or from combinations of spatial primitives and simple-spatial concepts. For example, the concept of hierarchy can be derived by combining location and magnitude with connectivity. A total of thirty-one concepts were identified as essential in spatial thinking and categorized into the three subcategories of spatial concepts, each assumed to represent a distinct level of abstractness and complexity (Fig. 1).

Classification of the Second Primary Category: Using Tools of Representation

The second component of spatial thinking is the use of tools of representation. Representations, such as maps, diagrams, and graphs, are a powerful tool to organize, understand, and communicate information. A taxonomy of spatial thinking must acknowledge that the ability to effectively use and create spatial representations is pivotal in spatial thinking. Two subcategories were thus proposed for the second primary category: nonuse of representations and use of representations (Fig. 1). While spatial concepts could theoretically be classified in more detail by complexity and abstractness, this was not the case with tools of representation. No framework to classify representations in terms of complexity has been developed, nor does it seem either possible or meaningful to do so because the difficulty and complexity of a learning activity using representations draws on the learning context rather than the type or characteristic of the representations used.

Classification of the Third Primary Category: Processes of Reasoning

Spatial thinking is a cognitive skill necessitating complex reasoning. The core of reasoning is "going beyond" the given information (Bruner 1973, 219); it requires high level cognitive processes as differentiated from merely retrieving factual information (Costa 2001; Gouge and Yates 2002; Holyoak and Morrison 2005; Moseley *et al.* 2005; Quellmalz 1987). A taxonomy of spatial thinking, therefore, should be able to help distinguish high-level cognitive processes from low-level ones. Three levels of thinking proposed by Costa (2001) were selected to constitute the subcategories of the third primary category, cognitive processes (Fig. 1): the input level of thinking, the processing level of thinking, and the output level of thinking. Costa's classification was chosen not only because this comprehensively covers cognitive domains identified in other taxonomies (e.g., Anderson and Krathwohl 2001; Bloom *et al.* 1956; Gouge and Yates 2002; Marzano 2001; Moseley *et al.* 2005; Presseisen 2001; Quellmalz 1987; Stahl and Murphy 1981) but because it is intuitive and easily applicable to question analysis.

The first level of thinking, the input level, represents cognitive processes engaged to gather information from the senses or to recall information from memories, such as recognizing, defining, identifying, recalling and listing. Cognitive processes at this level may not account for reasoning but they do provide the basis to acquire the knowledge necessary for reasoning to occur. At the second level, the processing level, learners analyze, classify, explain, or compare information acquired at the input level. This type of cognition is associated with reasoning because it requires making sense of collected information, and, therefore, going beyond the information. The third level of thinking, the output level, refers to generating new knowledge or products from the information obtained from

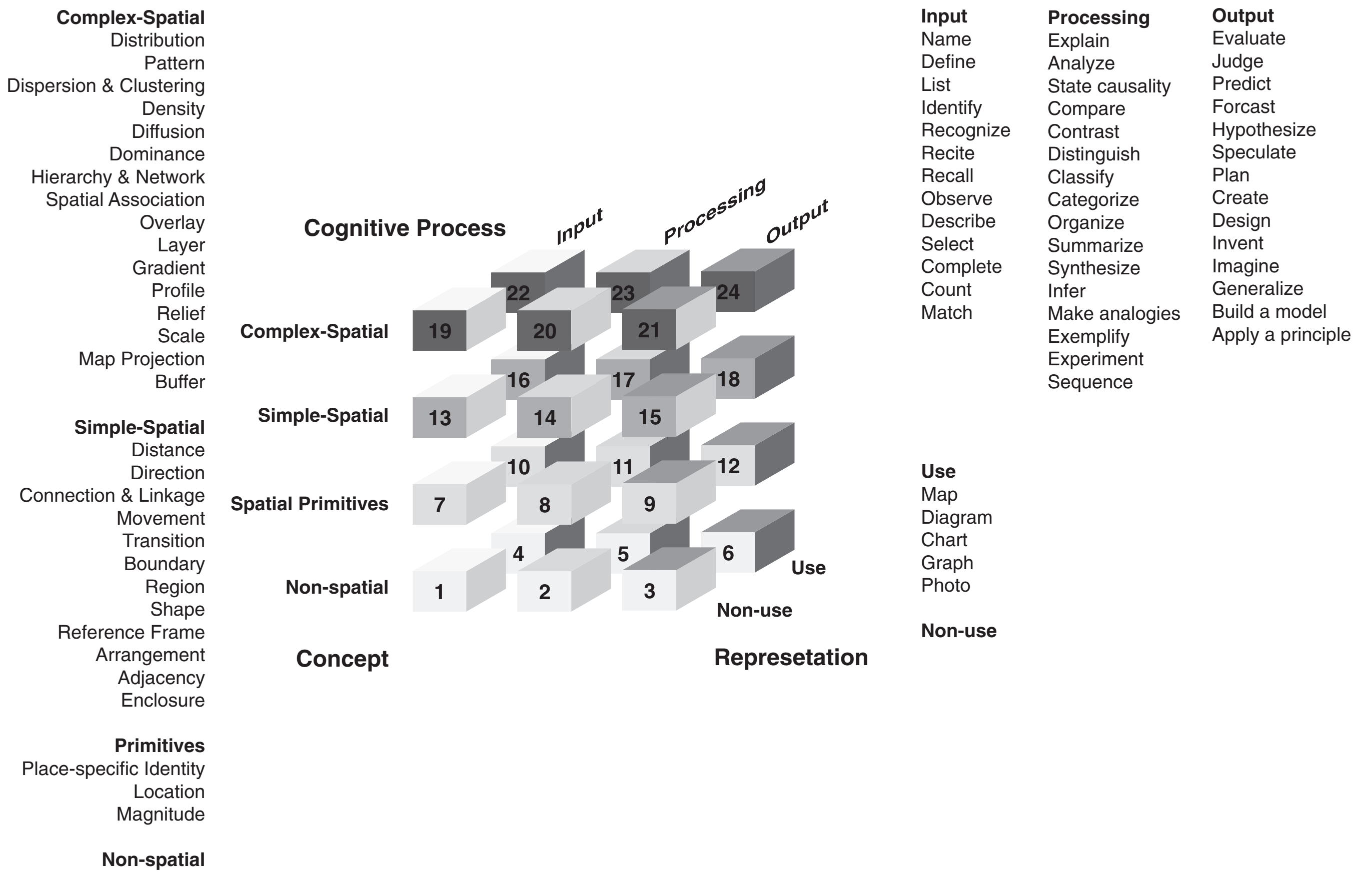

Figure 1. A taxonomy of spatial thinking: Each of the twenty-four cells represents a unique characteristic in terms of three components of spatial thinking involved. For example, Cell 24 stands for a complex-spatial concept, use of a representation, and the output level cognitive process. Numbers were assigned for referential convenience.

the first two levels through the processes of evaluation, generalization, and creation. Such processes necessitate reasoning and are considered the highest level in difficulty as well as in complexity.

A Taxonomy of Spatial Thinking

The three primary categories (concepts of space, using tools of representation, and processes of reasoning) and the subcategories (nonspatial, spatial primitives, simple-spatial, and complex-spatial for the category of concepts; nonuse and use of representation for the category of using tools of representation; input, processing, and output level for the category of cognitive processes) were visualized as a 4 × 3 × 2 cube in which each axis stands for one of the three primary categories of the taxonomy (see Fig. 1). Each of the twenty-four cells constituting the taxonomy is unique in terms of the three components of spatial thinking involved. For example, Cell 1 represents a nonspatial concept, nonuse of a representation, and the input level of cognitive processing; thus it has nothing to do with spatial thinking. Cell 24, on the other hand, represents a complex-spatial concept, the use of a representation, and an output level cognitive process; it definitely is associated with higher level spatial thinking.

The validity of the taxonomy was assessed through a ten-question survey regarding its face and content validity (Appendix). Face validity was defined as the extent to which the taxonomy of spatial thinking appears to measure the three components of spatial thinking. Content validity referred to the degree to which the taxonomy represents aspects of spatial thinking identified in the definition. Five experts in spatial thinking (three geography professors and two geography graduate students) rated the taxonomy on a 1 to 5 scale (1 = strongly disagree; 5 = strongly agree) for each question. Overall, the taxonomy was judged highly valid (face validity = 4.3 out of 5; content validity = 4.6 out of 5).

Evaluation of Geography Textbook Questions

Textbook Questions and Learning

Questions constitute a critical part of a textbook. The most typical social studies textbooks, including geography textbooks, consist of narrative text and sets of questions

(Kragler, Walker, and Martin 2005; Stodolsky 1989). Many questions are to be answered by students as a means of assessing their knowledge about the textual content. Such review questions are interspersed within the text, at the end of sections and chapters, and sometimes at the end of each unit. Some questions are designed for skill development such as map-reading skills. These questions almost always appear in the margin of pages or in supplemental sections.

The educational effects of textbook questions may vary, depending on how much and in which way they are used by individual teachers. It is well known, however, that textbook questions improve students' comprehension of content (Peverly and Wood 2001); assist students in identifying critical information in the textbook (Holliday 1981); help build strategies for processing given information (Leonard 1987; Wixson 1983); and stimulate students' problem solving skills (Myers and Savage 2005; Wilen 2001). In addition, research has found that there is a considerable relationship between the cognitive level of questions and the level of student thinking (Cole and Williams 1973; Craig *et al.* 2006; Measel and Mood 1972; Newton 1978; Redfield and Rousseau 1981; Yip 2004). That is, questions that require students to synthesize, evaluate, and analyze information or to generate a meaningful relation between phenomena will better facilitate thinking skills than recall questions. As Costa (2001) points out, carefully designed questions are expected to cause students to think. Despite the considerable number of questions found in geography textbooks and the significant roles questions play in learning, research that analyzes the nature of such questions and, more specifically, the degree of spatiality of questions is nonexistent.

Questions to Facilitate Spatial Thinking

Spatial thinking requires knowing spatial concepts to structure knowledge of space; utilizing tools of representations to understand, remember, and communicate it effectively; and complex reasoning that enables knowledge about space and representations to be combined for problem solving and decision making .(National Research Council 2006). Thus, if facilitating spatial thinking is an important objective in geography education and if textbook questions are to contribute to accomplishing the objective, the questions must ask students to understand critical spatial concepts and to carry out high-level cognitive processes relevant to spatial thinking. Using and creating a variety of spatial representations should also be encouraged by and through these questions.

Method

Sample. The four textbooks adopted by the Texas Education Agency in 2003 for use in the high school course World Geography Studies were selected for analysis. The books have almost the same organization and structure, which adopts a systematic approach introducing geographic perspectives, methodologies, and general concepts in the first unit, followed by an examination of world regions for the remaining units. Questions are interspersed throughout the textbooks but largely in five distinct locations: in the text; in page margins; in supplemental sections; in the end of sections; and at the end of chapters. All questions posed in these five locations within the first and second unit of the four textbooks, a total of 3,010 questions, were examined in this study (Table 1).

Question Coding. The spatiality of each question was measured:

1. by classifying the concepts that the question required students to know (i.e., nonspatial, spatial primitives, simple-spatial, complex-spatial concepts);
2. by determining the nature of the tools of representation that the question asked students to use (i.e., nonuse, use); and
3. by classifying the cognitive processes that each question expected to address (i.e., input, processing, output level).

An example of question coding is shown in Table 2. The question is a typical textbook entry; in order to answer the question, the student must know a specific term. The term "fisheries" in this case is nonspatial. Students were neither provided with a representation nor directed to use one from the textbook, so this question was categorized as an example of nonuse of representation. It was coded at

Table 1. Number of questions examined, by textbook and by question location.

	Textbook A		Textbook B		Textbook C		Textbook D		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
In Text	0	0.0	109	11.6	61	7.6	15	2.3	185	6.1
Page Margin	90	14.6	96	10.2	98	12.3	91	13.8	375	12.5
Supplemental Section	34	5.5	58	6.2	41	5.1	110	16.7	243	8.1
End of Section	261	42.4	352	37.5	280	35.0	238	36.2	1131	37.6
End of Chapter	230	37.5	323	34.4	319	39.9	204	31.0	1076	35.7
Total	615	100.0	938	100.0	799	100.0	658	100.0	3010	100.0

Table 2. An example of question coding (question from Boehm 2003, 128).

Question: ____ supply great quantities of fish and other sea animals to North America.
Answer: Fisheries

Concept	Representation	Cognitive Process
Nonspatial	Nonuse	Input

the input level of cognitive processes because the processes required to answer this question were only to recall the definition and the meaning of the term and to complete the given sentence.

Scheme of the Analysis. Data were analyzed in terms of:

1. the degree to which each individual component of spatial thinking is addressed in each question; and
2. the degree to which the questions integrate the three components of spatial thinking.

Whether a question integrates the three components was measured by its location in the twenty-four cells of the taxonomy (Fig. 1). The questions categorized into nine cells, 10, 11, 12, 16, 17, 18, 22, 23, and 24, were viewed as integrating all three components of spatial thinking. Among these, questions classified in Cells 10, 11, and 16 are at the simplest level of spatial thinking, involving low-level spatial concepts and cognitive processes. A question asking students to identify a location on a map would be an example. Questions falling into Cells 12, 17, and 22 are at a higher level of spatial thinking than Cells 10, 11, and 16. An example is a question that requires students to compare two regions using a map. Questions categorized into Cells 18, 23, and 24 are viewed as representing spatial thinking at its highest complexity and abstractness, requiring knowledge about complex-spatial concepts, use of representations, and the highest level of cognitive processes. Questions asking students to make generalizations about a pattern featured on a map is an example of spatial thinking at this level.

Results

In this article, spatial thinking was defined as "a collection of cognitive skills comprised of knowing concepts of space, using tools of representation, and reasoning processes" (National Research Council 2006, 12). The spatiality of examined textbook questions is reported in terms of:

1. the degree to which each component of spatial thinking, concepts of space, tools of representation, and processes of reasoning, is addressed; and
2. how well all three components are integrated.

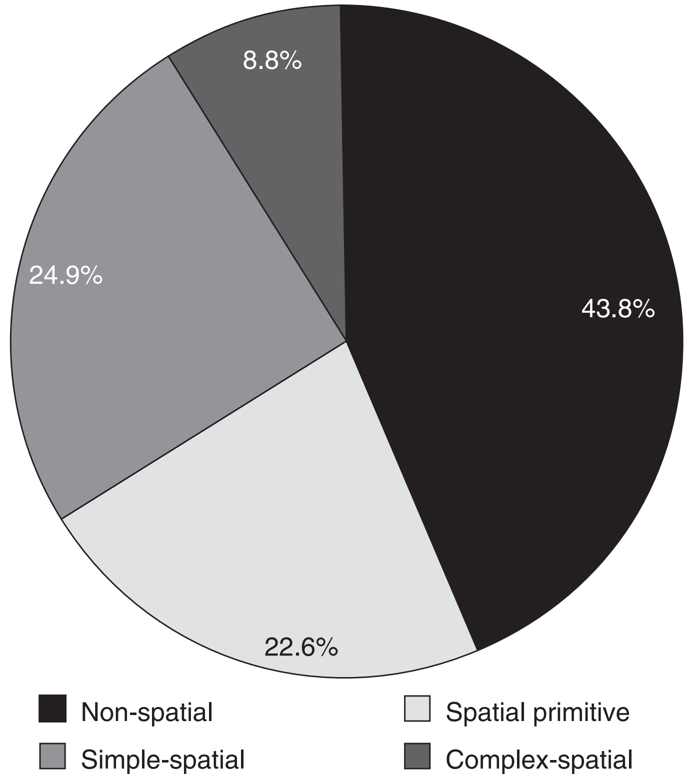

Figure 2. Concepts required, overall (n = 3,010).

Concepts of Space. What kinds of spatial concepts are featured in the textbook questions? As shown in Figure 2, about 44 percent of the 3,010 questions focus on nonspatial concepts. Questions focusing on spatial primitives, such as location and place-specific identity, are about 22 percent of the total; and questions engaging simple-spatial concepts, including direction and region, constitute about 25 percent. Only about 9 percent of the questions dealt with complex-spatial concepts, such as pattern and diffusion. All the textbooks are similar in that most of the questions are aspatial, that is, they do not ask about spatial concepts at any level, and questions requiring students to use complex-spatial concepts are featured least.

Tools of Representation. In order to develop student ability to think spatially, questions need to not only use concepts of space but to visualize them with representations. Do the questions examined require students to use and create spatial representations? About 70 percent of the 3,010 questions ask students neither to use nor to create representations to answer the questions (Fig. 3). Little difference is observed among the four textbooks in that there are more questions not requiring use of representations than those requiring it.

Processes of Reasoning. Spatial thinking is a cognitive skill necessitating complex reasoning, and the core of reasoning

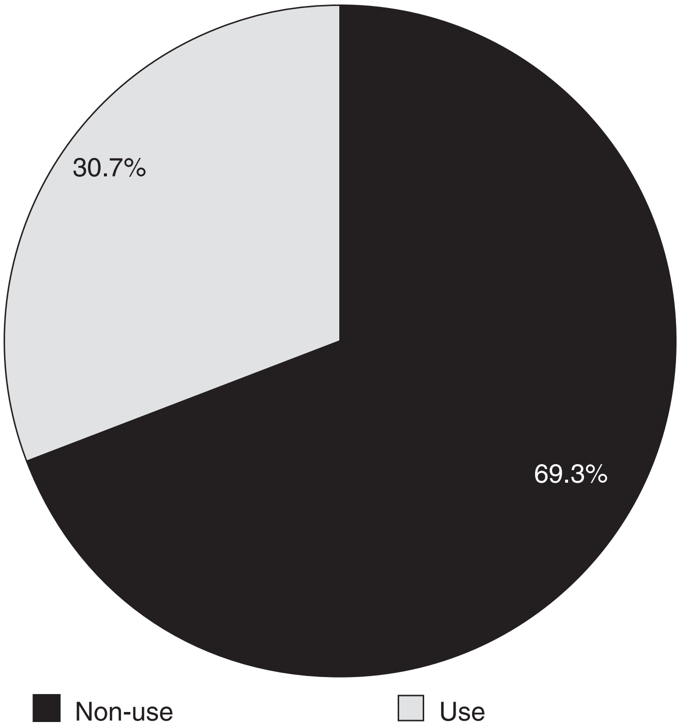

Figure 3. Representations required, overall (n = 3,010).

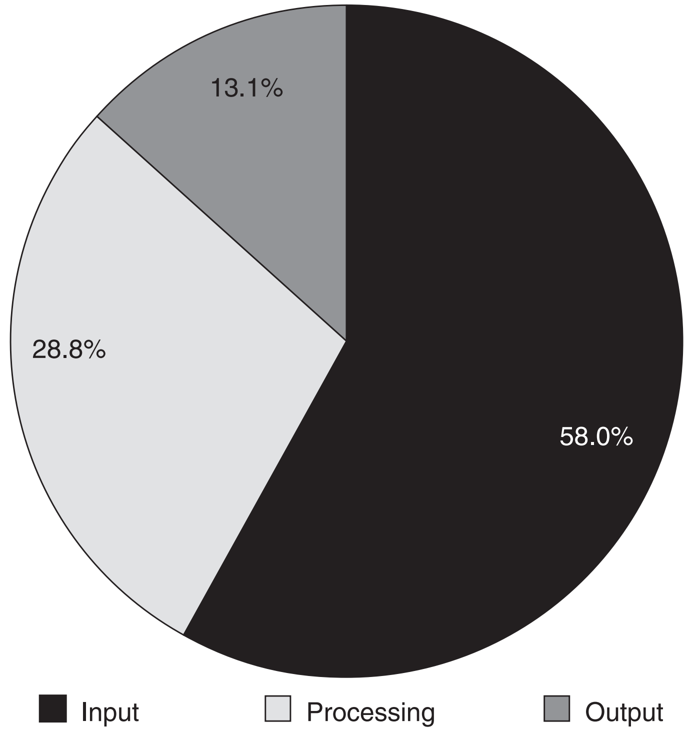

Figure 4. Cognitive processes required, overall (n = 3,010).

is "going beyond" (Bruner 1973, 219) the given information through high level cognitive processes. What kinds of cognitive processes are drawn upon in answering the questions? The results show that over half the questions are at the input level, which requires students to gather information from the senses or to recall information from memory. Slightly less than one-third of the questions demand processing level thinking, such as explaining, comparing, and classifying. Only about 13 percent out of the 3,010 questions are associated with output level thinking including the processes of evaluation, generalization, and creation (Fig. 4).

Integration of the Three Components. Spatial thinking is a complex form of thinking in which a person should integrate knowledge about spatial concepts, abilities to use spatial representations in appropriate and effective ways, and reasoning skills. Therefore, if a question is to support spatial thinking it would be desirable to ask students to integrate all three components rather than to ask about only one or two components. By looking at the degree to which the three components of spatial thinking are integrated, this section examines how the questions support the comprehensive development of spatial thinking.

Each question was characterized in relation to the twenty-four cells that constitute the taxonomy. Questions categorized into Cells 1, 2, 3, 4, 5, 6, 7, 8, 9, 13, 14, 15, 19, 20, and 21 represent those that do not integrate the three components, while questions classified into Cells 10, 11, 12, 16, 17, 18, 22, 23, and 24 represent those incorporating all three components: concepts of space, tools of representation, and processes of reasoning. Those representing integration of the three components differ in the complexity of concepts and cognitive processes involved: Cells 10, 11, and 16; Cells 12, 17, and 22; and Cells 18, 23, and 24, therefore represent three different levels of spatial thinking (Fig. 1).

Overall, about 76 percent of the 3,010 questions do not feature all three components. Of the other 24 percent in which all three components are incorporated, 62 percent require the simplest level spatial thinking, focusing on low level spatial concepts at low level of thinking. Only about 18 percent of the questions demand complex level spatial thinking involving complex-spatial concepts or output level cognitive processes (Fig. 5).

Discussion

The Design of Textbook Questions

This study provides evidence that several key spatial concepts, such as pattern, diffusion, hierarchy, and network, are rarely featured in textbook questions. Understanding such concepts is critical in our daily lives as well as in the workplace, but students are neither provided with sufficient opportunities to learn these important spatial

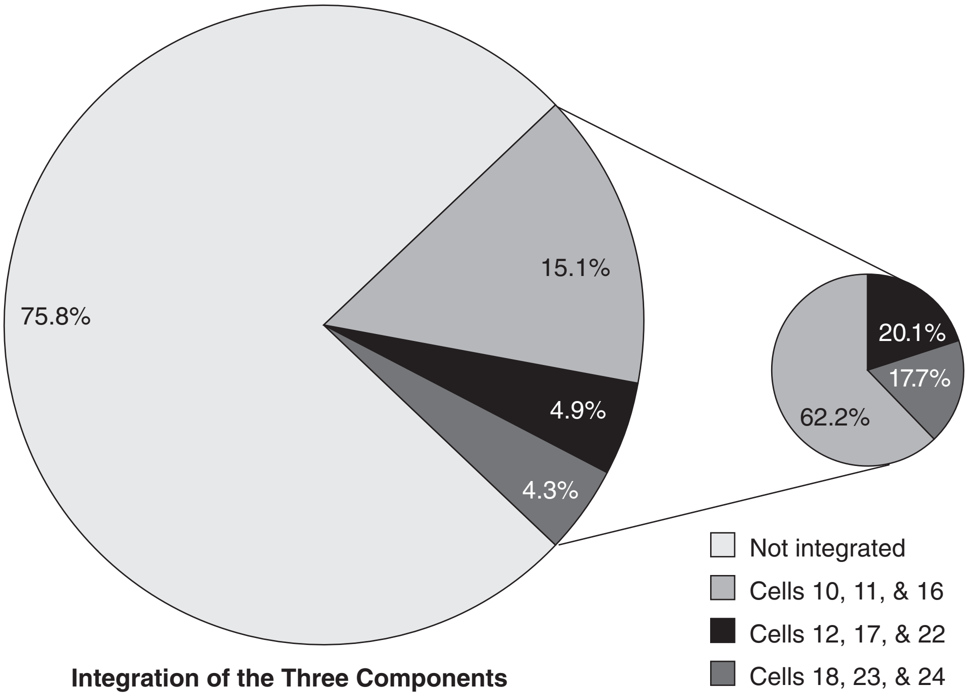

Figure 5. Integration of the three components, overall (n = 3,010).

concepts nor asked to monitor their knowledge about such concepts through answering questions. Textbook publishers need to ensure these concepts are included in their question sets.

The geography textbooks under this study feature a number of graphics and spatial representations. However, as shown in the study results, students are not directed to actively use these representations to answer textbook questions. In other words, questions do not fully utilize the rich array of graphics provided in the textbooks to support spatial thinking. Questions to support spatial thinking are those that guide students to learn how to use a variety of representations to obtain, transform, and communicate information more effectively. Questions that only ask a student to fill in a blank map may not play such a role. Textbook designers must be aware that representations are a powerful tool of thinking, not just a graphic displaying information.

It seems evident that the higher order thinking skills emphasized in the National Geography Standards (Geography Education Standards Project 1994), such as analyzing, explaining, and evaluating, have not been implemented into textbook questions. Question designers should make efforts to infuse the spirit and expectations of the Standards, especially in regard to spatial thinking skills, into textbook questions more explicitly so that students can practice higher levels of thinking through answering the questions.

Spatial thinking is a complex form of thinking. To be a competent spatial thinker a person should be equipped with knowledge about a variety of spatial concepts, the abilities to use spatial representations in appropriate and effective ways, and reasoning skills. Therefore, questions that require students to incorporate all three of the components would be desirable to develop spatial thinking skills more than those related to only one component. This study reveals that the three components of spatial thinking are rarely integrated in the majority of textbook questions. There is a need for the development of more questions that guide students to synthesize the three components.

The Use of Textbook Questions

This article demonstrates the degree to which the questions posed in high school geography textbooks incorporate aspects of spatial thinking. Many questions focus on nonspatial concepts and relatively simple spatial concepts rather than complex and high-level spatial concepts. Not many questions require students to use and create spatial representations. Most questions demand low level cognitive processes, such as defining, recalling, and recognizing. The results suggest that to facilitate students' spatial thinking skills, teachers need to use textbook questions selectively and cautiously. It is also important for educators to be able to distinguish questions that effectively integrate the three components of spatial thinking from those that do not.

The results of this research also indicate that textbook questions hardly contribute to students' learning of complex-spatial concepts; to the practice of producing spatial representations; or to the development of higher order thinking skills. Therefore, in addition to selectively using the questions presented in the textbook, it would be better for teachers to design questions of their own, through which students can learn a variety of complex-spatial concepts, skills to create spatial representations, as well as higher level cognitive processes. The taxonomy developed in this study may function as a guide to design such questions.

The Evaluation of Educational Materials

Research can help teachers effectively use textbooks by providing them with information about their nature and quality. This study provides in-depth analyses of the spatiality of questions posed in high school world geography textbooks. To teachers who value textbook questions, such information will be useful to compare the characteristics of questions in different textbooks and to select the book whose questions most satisfy their educational goals. In addition, teachers can evaluate the strengths and weaknesses of the questions posed in the textbook that they currently are using by applying the taxonomy of spatial thinking proposed in this article. The taxonomy is not an absolute, but it may offer a sound framework for such evaluation purposes. The use of the taxonomy can also be extended to systematically assess the degree to which other educational materials such as lesson plans, curricula, and assessments incorporate aspects of spatial thinking.

CONCLUSIONS

Spatial thinking is considered an essential skill to be developed in schools, and more attention is now being paid to how spatial thinking skills can be developed. The tradition of geography emphasizing spatial perspectives (Geography Education Standards Project 1994; Golledge 2002) demonstrates its potential as a central subject to foster this important thinking skill. To support spatial thinking in classrooms, however, curriculum support materials such as textbooks should incorporate aspects of spatial thinking. The present study examined whether current geography textbooks serve as an effective means to acquire the knowledge and skills to support students' spatial thinking through an evaluation of embedded questions.

A valid taxonomy of spatial thinking that reflects its three key components in a three-dimensional structure was developed. The taxonomy can guide textbook publishers in incorporating the three components of spatial thinking into their textbook features in more explicit and systematic ways. The taxonomy also can serve as a framework upon which teachers can diagnose and improve their lessons and instructional materials, as well as evaluate textbook questions in terms of aspects of spatial thinking.

Overall, the textbook questions deal with spatial concepts at a relatively low level. The diversity of concepts, including complex-spatial concepts, taught in geography classes should be ensured both by individual teachers as well as textbook designers. Spatial representations provided in the textbooks are rarely combined with activities to elicit higher level cognitive processes. It should be noted that questions asking students only to recognize and memorize information presented in representations are insufficient to facilitate spatial thinking skills. More questions that feature all three components of spatial thinking need to be developed.

APPENDIX: TAXONOMY VALIDATION SURVEY

This survey asks your opinion on the appearance and content of a spatial thinking taxonomy. The purpose of the survey is to achieve face validity and content validity for the taxonomy from expert judges.

Terms:

- Face validity: The extent to which the taxonomy looks like a measure of aspects of spatial thinking
- Content validity: The degree to which the categories of the taxonomy represent aspects of spatial thinking identified in the definition

Definition of Taxonomy:
A system of classification and the concepts underlying it (Good 1973)

Definition of Spatial Thinking:
A collection of cognitive skills consisting of knowing concepts of space, using tools of representation, and reasoning processes (National Research Council 2006)

Directions:
Please examine Taxonomy of Spatial Thinking and answer the following ten questions. Rate aspects of the taxonomy on a 1 to 5 scale and then circle your response to the items.
(1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree)

1.	Does the taxonomy seem to be measuring aspects of spatial thinking?	1	2	3	4	5
2.	Does the taxonomy seem like a reasonable way to gain the information about whether geographic instructional materials incorporate three components of spatial thinking?	1	2	3	4	5
3.	Does the taxonomy seem as though it will work reliably?	1	2	3	4	5
4.	Does the taxonomy reflect the definition of spatial thinking?	1	2	3	4	5
5.	Does the taxonomy reflect three key components of spatial thinking?	1	2	3	4	5
6.	Are the concepts of space representative?	1	2	3	4	5
7.	Are the cognitive processes representative?	1	2	3	4	5
8.	Is the classification of concepts appropriate?	1	2	3	4	5
9.	Is the classification of representation appropriate?	1	2	3	4	5
10.	Is the classification of cognitive processes appropriate?	1	2	3	4	5

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