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## Geography Education, Spatial Thinking, and Geospatial Technologies: Introduction to the Special Issue

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# Geography Education, Spatial Thinking, and Geospatial Technologies: Introduction to the Special Issue

## **Abstract**

This special issue contains six papers on the development of students' knowledge, skills, and practice of geospatial thinking in a variety of educational contexts. Each of the papers addresses an aspect of the research gap that deserves timely attention in the field, focusing on curriculum design, pedagogical approaches, exemplary resources or tools, and strategies to move forward for the promotion of geospatial teaching and learning. We encourage continued research efforts to accumulate knowledge about curriculum, instruction, and assessment, as well as teachers' professional development that can help students become 21st-century citizens equipped with geospatial literacy. Further research is recommended on the theories that can help explain and guide the development of students' geospatial knowledge and skills in both formal and informal education, and effective ways to incorporate geospatial thinking into teacher preparation programs.

## **Keywords**

geography education, spatial thinking, geospatial technologies

## 1. INTRODUCTION

This special issue focuses on the educational practice in geography of promoting students' spatial knowledge and thinking skills. Since publication of the National Research Council's report *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum* (National Research Council 2006), many educators and education researchers have examined ways to incorporate spatial thinking into classrooms at the various levels of the education system from early childhood to higher education (e.g., Verdine et al. 2017; Newcombe 2016; Uttal and Cohen 2012). It is axiomatic to claim the close relationship of geographic thinking to spatial thinking and reasoning (Sinton et al. 2013; Golledge 2002; Uttal 2000), and scholars have noted the potential of learning geography for the development of students' spatial thinking skills (Solem et al. 2008; Golledge 2002; Downs 1994). Researchers have also made efforts to identify domains of spatial thinking that are specific to geography. Conceptualizing geospatial thinking (e.g., Baker et al. 2015; Ishikawa 2013) can be considered the first step toward differentiating geography-unique spatial thinking from the spatial thinking practiced in other disciplines, such as medical science, engineering, and architecture. Much of the effort to incorporate spatial thinking into geography classrooms has been in accordance with finding ways to use geospatial technologies for teaching and learning (e.g., Metoyer and Bednarz 2017; Jo et al. 2016; Bodzin et al. 2014; Favier and van der Schee 2014). The increase in the number of journal article searches based on the keywords "spatial thinking" and "geospatial technologies" during the last decade reflects this trend.

This special issue contains six papers on the development of students' knowledge, skills, and practice of geospatial thinking in a variety of educational contexts. Each of the papers addresses an aspect of the research gap that deserves timely attention in the field, focusing on curriculum design, pedagogical approaches, exemplary resources or tools, and strategies to move forward for the promotion of geospatial teaching and learning.

## 2. GEOGRAPHY AND SPATIAL THINKING

The first three papers contribute to identifying specific areas of spatial thinking that can be effectively developed by learning geography. Verma and Estaville (2018) examined the relationship between undergraduate students' geography course experience and their geospatial thinking skills. The authors note that there is currently a lack of empirical research evidence showing that learning geography helps students develop spatial thinking skills. The paper aims to address the research gap by conducting and analyzing a national survey of over 1,000 undergraduate students in the U.S. Based on the findings, the authors advocate that it is critical to integrate geography into fundamental aspects of university education. Collins (2018) compared traditional paper maps and digital maps to determine whether different media have different effects on improving students' awareness and certain types of spatial thinking skills. Based on the analysis of in-depth interviews with middle school students and teachers after implementing a series of geospatial learning activities, the authors conclude that increased exposure to maps and spatial thinking activities can improve students' spatial thinking skills regardless of media. The conclusion of Flynn's (2018) paper is similar to that of the two papers above. He investigated the effect of an experiential-based geocaching activity on strengthening

spatial thinking skills of non-geography majors in the U.S. and Ethiopia. Improvement in students' performance was observed in several areas of spatial thinking. Flynn argues that an introductory geography course incorporating such a geospatial activity would benefit general higher education around the world.

All three papers indicate a positive relationship between explicit learning of geographic concepts and skills and students' performance in certain types of spatial thinking. For example, in Verma and Estaville's (2018) study, undergraduate students who had taken five or more geography courses demonstrated a better understanding of geospatial pattern and transition, geospatial profile and transition, geospatial association, geospatial shapes, and geospatial overlay than students who had not had such course experience. In Collins's (2018) study, geographic learning activities to find spatial correlation and choose the best location helped students learn spatial overlay and dissolving. Flynn (2018) also reports that, as a result of experiential geocaching activities, improvement was observed in certain areas of students' spatial thinking, including orientation and directional abilities, spatial overlay and dissolving, and recognizing spatial patterns.

It is noteworthy that either the original version or a slightly modified version of the Spatial Thinking Ability Test (Lee and Bednarz 2012) was the instrument used in all three studies to assess students' spatial thinking skills. This made comparing the results among the three studies easy and straightforward. Developing and using a valid and reliable instrument for research should be encouraged for collecting meaningful knowledge for geography education.

### **3. CONCEPT KNOWLEDGE AS A FOUNDATION**

The next two papers focus on the acquisition and uses of spatial concepts as students engage in various types of geographic learning experiences. Through classroom observations and in-depth interviews, Moorman and Crichton (2018) examined the necessary knowledge that middle school students should possess to be able to interpret Google Earth imagery. Ghaffari et al. (2018) explored the potential of astronaut photographs to facilitate students' uses of various spatial concepts in an introductory remote sensing course. In both studies, students were asked to identify and describe geographic features shown in the given images and to explain the strategies they used.

According to Moorman and Crichton (2018), the students who participated in their study used seven interpretation elements (tone, texture, pattern, shape, size, shadow, and association) to identify Google Earth imagery. Specifically, the students mainly used tone and shape, and secondarily used size, shadow, and association for image interpretation. However, they rarely used texture and pattern. The authors recommend temporal change as an additional interpretation element because of its helpfulness in students' image interpretation. Ghaffari et al. (2018) showed that students used some of the primitive concepts (i.e., magnitude, color, geographical feature, and name) more frequently than other simple (e.g., enclosure, direction, and distance) or complex (e.g., scale, distribution, and diffusion) spatial concepts to interpret the six given astronaut photographs. This latter study also showed improvement in students' use of those spatial concepts over the course of the semester.

Moorman and Crichton (2018) argue that basic knowledge about technology and satellite imagery is critical at an early stage of students' development of geospatial literacy. The benefit of an introductory remote sensing course to help students'

acquisition and uses of spatial concept knowledge is suggested by Ghaffari et al. (2018). In both studies, students employed a range of concepts and skills to interpret the given images but also encountered various challenges. Further research is desirable to provide insights into the specific curriculum and pedagogical strategies that can help students overcome these challenges.

#### **4. CITIZENSHIP EDUCATION AND GEOGRAPHY**

Geography has played an important role in citizenship education for a long time (Stoltman 1990). Through geography education, students can understand various civic issues, including social, environmental, political, and economic issues, at local to global scales (Bednarz and Bednarz 2015). However, not many geography educators have vibrantly discussed the future potential of geography learning to develop citizenship in young people, particularly in the U.S. (Bednarz and Bednarz 2015). To make matters worse, some people impute American youth's lack of civic involvement in global issues to insufficient geography education (Davis 2002).

Nevertheless, the National Geography Standards, *Geography for Life*, are aiming at preparing young people to be actively responsible and engaged citizens (Heffron and Downs 2012). A Road Map for Geography Education in the 21st Century also emphasizes geography education's contribution to and its vital role in citizenship education (Bednarz et al. 2013). That is, through geospatial knowledge, skills, and practices, students can develop problem-solving skills as well as critical and analytical thinking skills and furthermore, can make the informed decisions required for citizens in the 21st century (Hong and Melville 2018; Bednarz et al. 2013). Recently, several geography researchers and educators in various countries have conducted projects using geospatial technologies (e.g., CityLab using interactive maps; SeeClickFix using volunteered geographic information; and FieldScope in citizen science projects) and spatial thinking (e.g., Spacit for spatial citizenship) to improve students' civic engagement (Bednarz and Bednarz 2015).

In the final paper in this issue, Hong (2018) explores ways to enhance critical citizenship through the teaching and learning of geography. The author's main intention is to attract geography education researchers' interest in and attention to critical citizenship education. She also urges coordinated efforts among researchers, professionals, and teachers to ensure our students become critical citizens through geography education.

#### **5. MOVING FORWARD**

This collection of papers illustrates the increased attention to and keen interest in the practice of geospatial teaching and learning in geography. We encourage continued research efforts to accumulate knowledge about curriculum, instruction, and assessment, as well as teachers' professional development that can help students become 21st-century citizens equipped with geospatial literacy. Further research is recommended on the theories that can help explain and guide the development of students' geospatial knowledge and skills in both formal and informal education, and effective ways to incorporate geospatial thinking into teacher preparation programs.

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