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Special Issue: Geospatial Technologies in Teacher Education

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For nearly 25 years, teachers, researchers, and curriculum developers have designed, tested, and evaluated teacher professional development with geospatial technologies in education. These innovators created a better practice in teaching with mapping and location-based technologies, using methods and principles that advanced inquiry in meaningful and authentic ways. That path, while challenging and often shifting, shows signs of success—in classrooms, preservice programs, summer professional development, and beyond.

Geospatial technologies typically include geographic information systems (GIS), global positioning systems (GPS), remote sensing, image analysis, and related location-based technologies. These tools and the understanding they can afford users is central to creating globally competent citizens. Information that is oriented to time and space provides opportunities to explore the complexity and interconnectedness of economic, political, social, or ecological relationships.

Geospatial technologies allow users to utilize critical thinking skills to locate, display, and analyze geographic information and make sense of the increasing amount of emerging place-based data. Engaging students in developing geospatial literacy helps them understand how location affects perspectives, power, and the environment. Visual representations of patterns require new visual and geospatial literacies to see interconnectivity and how actions in one area can impact another part of the globe.

Many in the geospatial education community regard the provenance of the field with the creation of Esri's education program for schools and the publication of an article by Robert Tinker (1992) calling for the use of electronic maps in science education. These watershed events were followed in 1994 by the first meeting on the educational applications of GIS (Barstow, Gerrard, Kapisovsky, Tinker, & Wojtkiewicz, 1994).

While the history of this subfield is reasonably well documented (e.g., Alibrandi & Baker, 2008), mainstream classroom adoption of geospatial technologies has been historically relatively isolated and inconsistent (Kerski, 2003). Moreover, the use of geospatial tools in teacher education has remained low in the United States (Alibrandi & Palmer-Moloney, 2001; Bednarz & Audet, 1999; Gatrell, 2004; Hammond, Langran, & Baker, 2014). These classroom adoption and teacher training patterns have been generally consistent globally (Milson, Demirci, & Kerski, 2012).

Context

Geospatial technologies in classrooms are at a watershed moment in the history of educational technology. In the last decade, the entry of large consumer-facing technology companies has helped to advance and democratize the state of easy-to-use geospatial tools in and out of the classroom. Most critically, over the past 3 years the ability to access the content and functionality of GIS tools through a browser has increased dramatically. Because in some cases students and teachers can now use these tools at a basic level without explicit training, instructional designers have begun to shift their focus from teaching *about* the technology to teaching *with* it in schools (as recommended two decades ago by Sui, 1995).

Some instructional designers are using as leverage the advanced state of GIS technology (e.g., web GIS) and its malleability in order to meet teachers where they are pedagogically (e.g., Baker, 2015; Bodzin, Peffer, & Kulo, 2012; Trautman & MaKinster, 2014). Designers are building instructional resources that target standards-based curricula, inquiry-based instructional models, and map concepts already found in the most widely used textbooks. These approaches are content-forward and use geospatial tools to help educators act as designers of engaging learning experiences. Instructional designers are also now using frameworks like technology, pedagogy, and content knowledge (TPACK) to support geospatial integration with great success (Doering, Koseoglu, Scharber, Henrickson, & Lanegran, 2014; Hong & Stonier, 2015).

Research

Research now exists in certain cases to support the use and best practice of geospatial tools in instruction. In the last special issue of a journal focusing on geospatial tools in precollegiate education, the editors, reflecting on process and author contributions, summarized the research into three basic categories (Baker & Bednarz, 2003):

- Student learning and outcomes.
- Teacher training.
- Technical development.

The categories still largely hold true, with the addition of the fast-growing subdiscipline of student learning literature on GIS in spatial thinking (e.g., *Learning to Think Spatially: GIS as a Support System in K-12 Curriculum*, National Research Council, 2006). The application of spatial thinking to learning (Gersmehl & Gersmehl, 2007; Lee & Bednarz, 2009; Metoyer & Bednarz, in press), spatial thinking in everyday life (Sinton, Bednarz, Gersmehl, Kolvoord, & Uttal, 2013), and the more focused geospatial thinking (Ishikawa, 2012; Bodzin et al., 2015) all have spun out significant lines of research in cognitive science, education, and geography.

The Research Agenda

In 2015, a long-awaited release of a research agenda for geospatial technologies and learning was realized (Baker et al., 2015). Four broad research areas were identified, including

- Connections between geospatial technologies and geospatial thinking.
- Learning geospatial technologies (especially in Career and Technical Education).
- Curriculum and student learning through geospatial technologies.
- Educators' professional development with geospatial technologies.

Research involving teacher education with geospatial technology has been conducted primarily in isolated, small-scale studies, conducted over extended periods of time with technological support, both in face-to-face and online learning (Moore, Haviland, Whitmer, & Brady, 2014; Trautmann & MaKinster, 2014). The agenda also identified several tactics to improve certain aspects of professional development with geospatial tools, including "peer coaching, practice teaching with students, and developing coherence with district educational goals and teachers' personal PD goals" (Baker et al., 2015, p. 123)

This current special issue attempts to highlight current, best-available research in the final category identified in the agenda, educator professional development. While the community producing the research is still growing, it has the potential to do to even more by involving many of the cognate fields, such as Earth systems science, computer science, and communications.

The CITE Special Issue

We are in the dawn of a new era of user-friendly, powerful, and free geospatial technologies in classrooms. Authors in this special issue identify strengths and weaknesses, pros and cons of varied approaches to preparing teachers for this new ubiquity of geospatial tools. For some, these educational approaches include preservice and in-service coursework, while for others the preparation may be online or even at off-campus and third party educational events (e.g., MOOCs or vendor workshops).

While the tools have become increasingly easier to use, Bodzin, Anastasio, Sahagian, and Henry (this issue) remind us that teachers need to use appropriate scaffolding to promote geospatial thinking and analysis skills with students. Effectively teaching about geospatial topics requires specific TPACK skill development and pedagogical design capacity that can be promoted through curriculum-linked professional development. Zalles and Manitakos (this issue) present another example of the training and support necessary for teachers to implement geospatial projects in their classrooms.

Teacher knowledge and skills in using geospatial technology are important, but Jo (this issue) documents the importance of teacher dispositions; preservice teachers need increased confidence, awareness of, and beliefs in the value of this type of technology. "This kind of learning will not occur incidentally," Jo asserted.

The goal, of course, is for teachers to be able to implement meaningful uses of geospatial tools beyond professional development sessions and teacher preparation programs. Rubino-Hare et al. (this issue) investigated teachers' use of these tools 1 to 2 years following professional development.

Geospatial technology represents an industry as well as a field of education, and there is a history and community of practice to draw upon. Nevertheless, Kerr (this issue) points to the dearth of published educational research in geospatial technology in the classroom. While the authors within this special issue (e.g., Baker & Langran, 2016) have contributed to what we know about supporting pre- and in-service teachers in developing their use of this technology, many opportunities will arise in the future for educational researchers to engage in this field.

The Future: The Next Quarter Century

With the arrival of cloud-based computing, real-time data sensors, autonomous routing of drones and vehicles, and near ubiquitous adoption of mobile devices, geospatial tools are now, more than ever before, readily accessible, easy to use, and free for precollegiate education. Moreover, some instructional designers are advancing the mainstream adoption of these tools by removing many of the last technical barriers to adoption (such as logins, installations, or platform dependencies) and demonstrating how these tools can enhance instruction in a wide range of disciplines using traditional instructor-led approaches or more advanced field-based or project-based inquiries. The class of technology has matured elegantly and is clearly ready to serve mainstream school instruction.

The dramatic lessening of technical requirements may change the very nature of classroom use as well as teacher professional development with geospatial tools in the future. Today, instructional designers think more about levels of adoption than data formats, projections, or specific GIS technology. Designers begin building professional development by first considering whether the technology needs to meet the educator and their classroom using the existing pedagogies and curricula or if the professional development intends to change the way an educator teaches, typically toward more project-based, local field investigations.

For some trainers intent on changing (or advancing) pedagogy, the majority of effort now lies in effecting instructional change (rather than technical skill building), such that the instruction can take full advantage of geospatial tools, effectively using the tools more like professionals do in day-to-day work. This approach can be effective, particularly, when trainers or their organizations provide some degree of ongoing GIS technical support (e.g., creating and hosting a particular data service that can be used in student maps).

While the use of these technologies is becoming more prevalent and easier to integrate, concern should be directed toward equipping students—and first, their teachers—to use this information responsibly. Modeling and providing instruction in how to use these technologies for analysis and critical thinking is largely still necessary to be geospatially literate, and sustained research in these areas will help inform best practices. The scholarly work in this special issue serves as a step in this direction.

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