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Integrating Geospatial Technologies Into Existing Teacher Education Coursework: Theoretical and Practical Notes from the Field

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Abstract

Although instruction related to learning management systems and other educational applications in teacher education programs has increased, the potential of geospatial technologies has yet to be widely explored and considered in the teacher education literature, despite its ability to function as an engaging pedagogical tool with teacher candidates. This practitioner article discusses uses of geospatial technologies in a social studies teacher education program as a way of demonstrating how other teacher educators might use geospatial technologies to prompt teacher candidates to new ways of thinking about pedagogy and the world at large. An overview is provided of the value and relevance of integrating geospatial technologies within teacher education, followed by three examples of how geospatial technologies have been included in existing teacher education courses. In each example the activity and its connection to geospatial technologies are described, as well as the assessment and experience of teacher candidates. Teacher educators, especially those with limited experience in geospatial technology use, are provided with exemplar ways they might integrate geospatial technologies into the courses they teach—whether it be a course on methods, curriculum, a content area, or beyond.

Geospatial technologies are a set of tools that include dynamic and interactive maps and globes, remotely sensed imagery, geolocation devices, and the information systems that power these technologies. They are inherently interdisciplinary because they merge data and knowledge available from a multitude of subject areas about the processes and events in the world.

Using geospatial technologies in educational contexts opens up possibilities for teaching and learning because students must interact, analyze, and represent their understandings and experiences with and in the world in a new digital form. With some basic knowledge of their function, teacher educators can easily incorporate a number of these sense-making tools into their practice with teacher candidates. Learning management systems and other educational applications are increasingly presented in teacher education programs, but the potential of geospatial technologies has yet to be widely explored and considered in the teacher education research.

Heeding various calls for multidisciplinary approaches to research and practice in geospatial technologies education (Baker et al., 2015; Kerr et al., 2013), I situate this practitioner paper between the fields of teacher education, geography/geospatial technologies, and geography education. I discuss my own use of geospatial technologies with teacher candidates in a social studies teacher education program as a method to prompt new ways of thinking about the world and the pedagogy they may eventually use in practice.

Ultimately, this paper shows how teacher educators, even those with limited or no experience in geospatial technologies, might incorporate them into practice to accomplish their various pedagogical goals. First is an overview of the value and relevance of integrating geospatial technologies within teacher education, followed by three examples of including geospatial technologies in existing teacher education courses. Each example includes a description of the activity and its use of geospatial technologies, as well as the assessment and experience of teacher candidates.

These three detailed examples show teacher educators how they might integrate geospatial technologies into the courses they teach—whether it be a course on methods, curriculum, a content area, or beyond. The examples illustrate a rich use of geospatial technologies that do not require any previous experience with the technology and are pertinent across disciplines. Also, all of the examples are free and require access only to a device with an Internet connection (computer, laptop, tablet, or smartphone).

Geospatial Technology in Teacher Education in Theory

In education, cautions abound against using "technology for technology's sake" (e.g., Hicks, Lee, Berson, Bolick, & Diem, 2014, p. 437). For example, asking students to read a textbook chapter on the computer that they could read from a printout or the textbook itself is not an effective use of a device or its embedded technology. Teachers and teacher educators are, instead, urged to "consider whether the technology is allowing them to learn in a way they could not without the technology, or if they are at least learning in a more meaningful ways" (p. 437). Engaged and informed use of geospatial technologies follows this recommendation, because these technologies can enable new types of interactions with data and representations of space that a paper map—while still valuable in its own right—will never be able to offer.

Although the "claims that technology would transform or even reform...teaching and learning seem, from today's vantage point, misguided or, at the very least, premature" (Crocco & Leo, 2015, p. 56), the proper harnessing of geospatial technologies could lead to a major change in how students, teacher candidates, and teachers relay, understand, and interact with information in the classroom. Geospatial technologies, at their core, are sense-making tools that develop critical thinking, as well as the abilities to assess data, design representations, and form new understandings of the processes at work in the world (Fargher, 2013; Kerski, Demirci, & Milson, 2013).

Further, geospatial technologies are interdisciplinary in that they use data and maps rooted in a variety of disciplines and are embedded with the knowledge that stems from decades of statistical and analytical data created in a variety of fields (Baker et al., 2015; Biddulph, Lambert, & Balderstone, 2015; Fargher, 2013). Although using geospatial technologies might seem most natural for geography teachers, the potential exists for the creation of relevant assignments across all disciplines. Therefore, giving all teacher candidates, regardless of certification concentration, the space to experiment with geospatial technologies in meaningful and context-rich ways is important.

Through these investigations, teacher candidates can further develop the intertwined skills and knowledge related to technology use, content knowledge, and pedagogy. In this way, experimenting with geospatial technologies during teacher education addresses the development of teacher candidates' pedagogical content knowledge (Shulman, 1987) by contributing to their "understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8).

Importantly, addressing geospatial technology in teacher education also engages teacher candidates' development of technological pedagogical content knowledge, also known as technology, pedagogy, and content knowledge (TPACK). As Hammond and Manfra (2009) described in their discussion of TPACK in social studies education, TPACK is a conceptual framework in teacher education that "provides a common language to discuss the integration of technology into instruction and builds upon the concepts of pedagogical content knowledge, [as well as] teacher as curricular gatekeeper" (p. 160).

They presented a three-scale model for effective classroom technology integration based around teacher and student expectations in relation to the sequence of "giving, prompting, and making" (Hammond & Manfra, 2009, p. 163). The model suggests a sequence in which the teacher (a) provides information to students (giving), (b) facilitates student interaction with materials, and (c) supervises and challenges students as they create some type of product.

Hammond and Manfra (2009) noted that the use of technology, even following an integrative and informed model, does not automatically enhance the quality of teaching and learning associated with it. In fact they stressed that "the pedagogy should lead the technology, not technology lead the pedagogy" (p. 163).

The kinds of activities described in this article heed this call, as they emerge from previous pedagogical tasks that I believed could be augmented through the integration of geospatial technologies. The activities are clearly aligned with both the *prompting* and *making* levels of the model, in which students are challenged first to "observe detect patterns, create associations or make inferences" (Hammond & Manfra, 2009, p. 164) and then transfer their understanding and skill through the development of a tangible product. These types of activities move teacher candidates beyond tasks requiring rote memorization and teacher-directed instruction.

In addition to offering an active form of student/teacher (educator) engagement and a chance to develop skills and knowledge related to technology, content, and pedagogy, geospatial technologies can offer unprecedented access to looking at and understanding the world. Unlike any other tool, they can be used to swiftly input, model, and modify various data points in ways that illuminate spatial disconnections and connections. For example, a number of research studies espouse the educational benefits of various geospatial technologies in classroom contexts relevant to teacher education, such as the technologies' ability to function as a tool for engaging in inquiry (Fargher, 2006;

Scheepers, 2009), bridging content across disciplines (Sinton & Lund, 2007), augmenting place-based activities and community engagement (Mitchell & Elwood, 2012), prompting critical (spatial) thinking (Kim & Bednarz, 2013; Milson & Curtis, 2009), connecting personal experiences to school curricula (Shin, 2007), and even developing empathy (Thomas-Brown, 2010). The commonality between these varied uses is that geospatial technologies integrated in educational contexts can offer "new ways of viewing, representing and analyzing information for transformative learning and teaching" (Alibrandi & Palmer-Moloney, 2001, p. 483).

The ability to see, think about, represent, and understand the world in new ways is an essential function of education that geospatial technologies can aid in prompting and promoting. All of these abilities matter greatly in the context of teaching and teacher education. A major goal of many teacher education programs is to prompt teacher candidates to think about the lives of their students and the communities in which they live. The places where students reside are often deeply imbricated with social lives, interests, and relationships. Knowledge of place and the types of social networks therein, therefore, has the potential to allow teacher candidates to teach their future students in effective, culturally responsive, and equitable ways.

Although teacher educators have effectively used place-based pedagogies to engage with these ideas (Ajayi, 2014; Dubel & Sobel, 2008), geospatial technologies offer another modality by which teacher educators can help teacher candidates learn about communities, schools, and their students. Geospatial technologies can add to the experience gained through place-based pedagogy (among other forms of community/place-rich pedagogy) by engaging with relevant spatial data of those contexts—data, for example, related to demographics, income levels, educational attainment, presence of amenities, and infrastructure. In this way, geospatial technologies have the ability to augment, if not transform, teacher education practices related to learning about communities, their diverse populations, and other place-specific qualities.

When used in ways that are informed by knowledge of the content, technology, and related pedagogy, geospatial technologies can function effectively on two levels for education across disciplines and context: (a) as a tool to engage students with the learning of content across disciplines and (b) for teachers and student to learn more about their communities and how those spaces influence and come to matter in the classroom. Despite their potential to seem overwhelmingly complex, pedagogical practices infused with geospatial technologies can be simple to implement in the teacher education classroom in meaningful and context-rich ways. Geospatial technology use is built around the facilitation of authentic skills and tasks, and data come from real-world contexts that can spatially illustrate nearly any phenomenon from the social and physical world (Alibrandi & Palmer-Moloney, 2001; Kerski, 2012; Johansson, 2003).

Further, geospatial data on nearly any topic are available widely and freely available, making them an accessible resource for teachers. Thus, teachers and teacher educators wanting to teach about sustainable environmental practices, for example, can access relevant data sets ranging from spatial statistics on rainfall to point data demonstrating access to recycling and composting centers to yearly data on a county's water use.

These data can then easily be plotted, layered, reviewed, and queried using a variety of technological platforms and can enhance student learning across contexts—whether they be the learning of content as guided in the standards or learning about the communities in which teachers and students live. While the learning of these concepts is not new to many teacher education courses, geospatial technologies offer tools to enhance the

teaching of these ideas in ways that help teacher candidates visualize processes in both novel and meaningful ways.

Although geospatial technologies afford teachers a toolkit for critical thinking and sense-making, many teachers candidates and in-service teachers have limited exposure to these technologies; even those with some training in geography (Baker, Palmer, & Kerski 2009). This limited exposure is problematic for the potential implementation of geospatial technologies in the K-12 classroom because, as numerous researchers have found, teachers are unlikely to adopt technologies that they are uncomfortable with and have not been taught to use for pedagogical purposes (Kerski, 2003; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Wright & Wilson, 2009).

This finding is echoed in the results of a survey of geography teachers I conducted to further understand the challenges faced by geography teachers as part of a larger study (Kerr, 2016). Only seven of the 47 participants (15%) said they used geospatial technologies in their instruction. Further, a total of eight participants (17%) said they would feel comfortable using geospatial technologies in their instruction.

While the vast majority of respondents were not comfortable with using geospatial technologies in their instruction, 33 participants (70%) said they would be interested in learning how to use geospatial technologies pedagogically. These findings were reinforced in a free response portion of the survey, where one participant wrote,

Learning more in undergraduate courses could have helped...I also really struggle with GIS. I took a class on using Google Earth, but it was extremely basic. I don't recall learning anything that I didn't already know about Google Earth....In my district, there were nine 7th grade geography teachers and eight 6th grade geography teachers. None of us had majored in geography, and only a handful of us had even taken a geography course in college. So content was something of a struggle for everyone.

Similar responses were reiterated throughout the survey, as well as the larger body of literature. Teachers often enter the field unprepared to teach geography and use geospatial technologies pedagogically. Therefore, if the ultimate goal is to have teachers using geospatial technologies, let alone in robust ways, their use must become integrated into the teacher education experience. Although geography teachers expressed these sentiments, the pedagogical strategies presented in this article are useful for all kinds of teaching and learning in teacher education. Furthermore, the feelings communicated by the geography teachers are likely not dissimilar from the feelings of teachers in other disciplinary areas.

Geospatial Technology in Teacher Education In Practice

In my work as a social studies teacher educator at a large southeastern U.S. research university, I was tasked with creating interventions and additions in the teacher education experience by using geospatial technologies in the existing context of our program. I saw firsthand how geospatial technologies could open up a world of opportunities in the relaying, management, and interpretation of complex data about the world. As such, I sought to expose teacher candidates to geospatial technologies early and often, so that they may invite their future students to think about, understand, and see the world through new technologically enhanced ways.

This activity is important for a number of reasons. First, geospatial technologies are now used in a number of different professional contexts—from environmental groups to over

two thirds of Fortune 500 companies that use Esri GIS products to guide their operations (Clancy, 2014). Therefore, teacher candidates and their students will likely encounter geospatial technologies in some capacity in their future careers and civic life.

Second, competency in geospatial technologies can improve critical thinking across contexts and disciplines. If the goal of teacher education is to prepare teacher candidates to become educators that effectively prepare their own students for career and civic life, introducing them to geospatial technologies is crucial.

The activities described here were integrated into existing courses for both undergraduate and master's level students with a social studies education degree focus. In order to increase teacher candidates' awareness of the potential of geospatial technologies, I took the existing course goals and worked to augment them through the incorporation of geospatial technology-based activities that added real-word context to educational content and standards, allowed for creative work, and prompted a reorientation to problems in the social and physical world. For a list of example course goals and related geospatial technology-based activities, see Appendix A.

To first lay the groundwork for activities based in geospatial technologies, I reintroduced students to geographic thinking. Many, if not most, teacher candidates in these courses likened geography to the naming of places on maps. To help dispel this notion, the courses—in addition to maintaining their original content on methods and curriculum for the social studies classroom—focused on using geography and geospatial technologies as sense-making tools for teachers and students. I aimed for students to think about the connections between the social world and the spaces within which it exists.

Each of the assignments discussed in this paper met a variety of goals I had laid out for the teacher candidates: incorporation of and exposure to geospatial technologies, critical questioning of a social issue pertinent to education, use of creative skills, and connection to pedagogy. Although I focus on geospatial technology integration in a social studies context, the bulk of these activities could be easily modified to suit the needs of other content areas, because the knowledge that can be gleaned about communities and the world at large is important for any type of culturally responsive practice, not only within social studies education.

In general, the activities prompted teacher candidates to consider new information that is important for their future work as teachers, ideas related to structural issues of race, gender, language, class, and sexuality. Learning about and recognizing the power of race, gender, language, class, and sexuality is an important practice for thoughtful teachers of all disciplines. The use of geospatial technologies can add to teachers' knowledge bases in thinking about how these structures function in their work as educators and as major factors in their students' lives. In the context of these courses, for example, we used geospatial technologies to learn more about food deserts, income inequality, walkability, climate change, and the spread of disease. These are types of current events and phenomena that all teachers should have knowledge of to be a socially responsive and aware pedagogue. The activities allowed teacher candidates to interact with various interdisciplinary phenomena in ways that would likely not have been possible without geospatial technologies.

Photomissions (Geotagged Photos)

The first interaction that students in a course on social studies and geography pedagogy had with geospatial technologies was through their completion of

photomissions. Building upon the work of Juan Carlos Castro (2012), as well as Sarah Mathews and Erin Adams (2016), photomissions prompt teacher candidates to read an assigned text and then take a photograph of a concept they identified from the reading.

In the context of this course, photomissions were assigned as weekly homework to help teacher candidates prepare for in-class sessions. For example, on a week when they engaged with ideas related to gender and space, teacher candidates first read excerpts from Doreen Massey's (1994) *Space, Place, and Gender* and were then tasked with taking a photograph of how they perceived the connections between gender and space, as informed by their reading, in their daily lives. These photographs were then uploaded to the class Flickr®group and given a several-sentence caption explaining the supposed connection between reading, content, and photograph.

Each week, teacher candidates were encouraged to review their classmates' photographs. Then, every class began with a review and critique of the group's photographs, as well as review of the Flickr-generated map of the photographs. In addition to evaluating the points students brought up about their own and others' photographs in these discussions, I assessed teacher candidate work by reviewing their photographs and the respective captions. These readings provided me with more data to gauge a teacher candidate's understanding of the assigned geographic concept. I looked for the ways that teacher candidates connected elements of their assigned readings to objects, entities, or scenes they encountered and photographed. While this assignment did not use maps as part of the formal assessment, the initial exposure to GIS that Flickr offered was important in other components of the course, where teacher candidates were tasked with digital mapping/geospatial initiatives.

A specific requirement of the weekly photomissions was that photographs had to be taken with mobile devices that utilized location services. As such, all of the photographs' digital metadata contained geographic coordinates (geotags) that could be plotted using a GIS. In the case of these photomissions, the class used the Flickr map functionality (see Figure 1) as a way for the teacher candidates to familiarize themselves with dynamic maps and engage with a basic use of geospatial technologies. When photographs are taken with geotags and uploaded to Flickr, the web tool automatically generates an interactive and dynamic map.

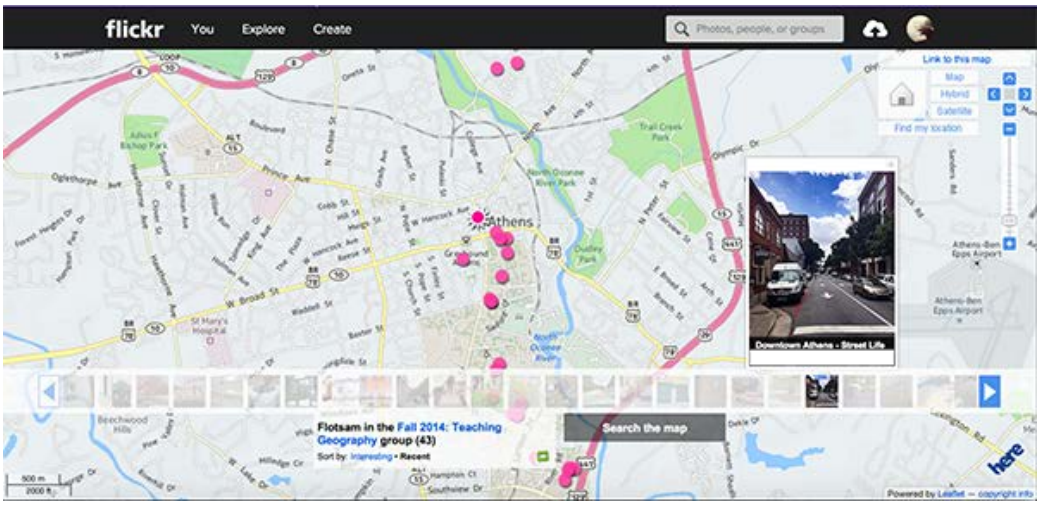

Figure 1. *A Flickr map that is automatically generated when uploaded photographs contain geotags in their metadata.*

The Flickr map function is an effective starting point for geospatial technology beginners because it does not require any actual digital mapping skills. It automatically generates point data (denoted by pink dots in Figure 1) using the photographs' geotags. As such, it allows teacher candidates to familiarize themselves with the dynamic nature of maps—zooming in and out at different scales, clicking on points to illuminate certain data points (in our case, photographs), and moving the map so that it focuses on different areas, and adding/subtracting data layers—while simultaneously removing some of the technical angst associated with learning how to create, upload, layer, manipulate, and analyze data sets manually.

To further familiarize themselves with some of the functionality of GIS-type maps, the class could set the parameters in the Flickr map so that the map displayed photographs taken from a certain time period or in certain geographic regions. Thus, teacher candidates could review the map created by photographs for specific photomissions or look at the cumulative map of all of the photographs taken throughout the semester. This functionality prompted various discussions about the connection between the location of a photograph and its content.

For example, one photomission asked teacher candidates to read excerpts from Jeff Speck's (2012) work on walkability. Teacher candidates were then prompted to take photographs of examples or nonexamples of walkability in our university's town. The benefits of this specific photomission were twofold: (a) teacher candidates were able to represent their understanding of the reading and connect it to a real-life context, and (b) because photographs were compiled in the Flickr photo map, the class was able to do a basic cluster analysis to help them think about what parts of our town had greater prevalence of photographs depicting walkability and which ones had nonexamples.

In the review of the dynamic Flickr map and the photographs, teacher candidates quickly realized that more instances of walkability examples were identified in neighborhoods that were close to the university or that housed affluent populations. In contrast, they noticed that the preponderance of nonexamples were clustered in low-income and historically African American neighborhoods. From this realization, we were able to have a meaningful conversation about the intertwined nature of walkability, socioeconomic status, and race in the United States—concepts of great importance to schools and education at large. The map and the photographs plotted on it invited teacher candidates to have this in-depth conversation. Without these elements, this specific discussion and learning opportunity may not have been possible.

WebGIS Maps

After teacher candidates were primed with a basic introduction to WebGIS maps through their participation in photomissions using Flickr, they completed a free online course from Esri about the use of GIS in education, called *Teaching with GIS: Introduction to Using GIS in the Classroom*. ***[Editor's Note: Website URLs are included in the Resources section at the end of this paper.]*** Completion of this online web course taught teacher candidates how to find, create and use WebGIS maps; pose educational questions that could be answered using a map; create relevant lessons using GIS classroom activities; guide students through the geographic method of answering questions using GIS; and create a simple WebGIS map presentation. Teacher candidates then put those new skills to use by completing an activity that connected a photomission with the creation of a simple, collaboratively made class map using ArcGIS Online.

ArcGIS Online is an "online, collaborative web GIS that allows [users] to use, create, and share maps, scenes, apps, layers, analytics, and data" (Esri, 2015). With a public account, users can work with ready-made interactive maps and data sets or create their own for free. They can then save and share their maps with any audience, making it an excellent education tool. Further, ArcGIS Online is a useful resource for teacher candidates because it offers a simple interface that can help people new to geospatial technologies begin to feel comfortable with the creation of and interaction with digital maps. Additionally, as teacher candidates develop their mapping competencies, ArcGIS Online offers a number of functionalities for the more advanced user.

In the first activity using ArcGIS Online, teacher candidates were prompted to complete a photomission that asked them to empty the contents of their book bag and take a photograph of the items and the bag. When they uploaded their individual photographs to the Flickr group, they captioned the photograph with a list detailing where their book bags and the items were manufactured (Figure 2). Following this activity, we had an in-class discussion in which teacher candidates talked about what they thought the generalities would be. Then, individuals read aloud the origins of their items.

Figure 2. *Examples of teacher candidate photographs of their items' origins and their respective locations in a map created using ArcGIS Online.*

As teacher candidates read the name of the country, one designated pair of students created pin markers in ArcGIS Online to denote where the item originated. Although more elegant ways exist for creating this type of map, I aimed for this activity to be a simple and fast way to allow teacher candidates to experiment with a digital map of their own creation.

By simply learning to plot points on a digital map, teacher candidates seemed to gain confidence and comfort in the technology use, an important step toward incorporation in

their future classrooms (according to Kerski, 2003; Wright & Wilson, 2009). Once all students had read where their items came from, we had a map with a heavy cluster of pins in China. In a discussion that followed the creation and discussion of the map, teacher candidates noted that they had previously known that China manufactured many items they used in their daily lives. Yet, upon seeing the cluster represented on a map that *they* had created, their orientation to this idea shifted.

Mapping their own items' origins created relevance and also provided an explicit example of the ways relationships across the world are built and maintained through globalization. While we could have had this conversation through a reading or by graphing statistics, the creation and reading of the map made the content especially meaningful and relevant to the teacher candidates. Several of them made comments after completing this activity that reaffirmed their confidence in digital mapping was improved.

When asked on an informal end-of-semester survey if they thought this activity was a type they might complete with their future students, 90% of the teacher candidates responded by saying they felt it was something they could easily add into lesson plans on a variety of topics in a number of different disciplines. One of the most important aspects of this lesson was the way it prompted preservice teachers to think beyond only replicating this lesson in their practice.

On another occasion, the class returned to creating, critiquing, and assessing (both peer and instructor) lesson plans that incorporated ArcGIS Online. In this assignment, teacher candidates created lesson plans for a content area and standard of their choosing and incorporated a mapping activity. Then, they shared their lesson plans with each other and me to provide critique and feedback about the lesson's structure and feasibility. In this way, teacher candidates were not simply replicating a map or lesson plan including a map but creating their own maps and connected lesson plans.

Over the course of the semester, teacher candidates developed a wide variety of lessons that utilized ArcGIS Online and their new knowledge of it in different ways for both in-class assignments and formal ones. Although some teacher candidates created lessons that involved active map creation on the part of the student, other lessons prompted the teacher to create a map, or find a ready-made map. Use of ArcGIS Online prompted teacher candidates to discuss and experiment with the robust ways that they might use geospatial technology with their own students.

Once they had learned the basics, creating lesson plans put the use of this geospatial technology into the context of pedagogy and made it especially relevant to a teacher education setting. Several teacher candidates who were concurrently enrolled in courses with field placements also tried using ArcGIS Online with their students—either in the act of map creation or by having students review and use the map the teacher candidate had created. While I did not see these lessons enacted, following these teacher candidates into the field in the future to see how and how effectively or engagingly they implemented GIS with K-12 students would be valuable.

WebGIS maps were used many times throughout the semester with teacher candidates beyond lesson creation. They explored the various available data sets and connected them to the content we discussed in class. Teacher candidates made maps, lesson plans, and map-infused presentations using data related to farmer's markets, rates of obesity, voting districts, water levels, race, and socioeconomic status.

As part of their final project, where teacher candidates investigated the presence of different geography concepts at our institution, they created a map documenting places that were representative of their concept at work (e.g., "What photographs could you take to represent that connection between gender and space on campus?"). They used ArcGIS Online to create a visual that accompanied their written work. Another way we used WebGIS maps was to create our own version of the automatically generated Flickr maps. Through this activity, the teacher candidates learned to extract the metadata of their photos and how to create Microsoft Excel spreadsheets with spatial data that could be uploaded to ArcGIS Online.

In all of these activities, we layered data, drew conclusions, did spatial analyses, and talked about how we might use these maps with students. By creating relevance, as well as building competency and confidence, I primed teacher candidates to use these tools in their future practice effectively (Wright & Wilson, 2009). Because this study was not longitudinal and did not follow teachers into the field, I cannot say with any certainty whether or not these practices will endure in practice. However, upon the completion of these various courses, I felt confident in the teacher candidates' ability to infuse ArcGIS Online into lesson plans in meaningful and robust ways. In the plans teacher candidates were creating by the end of the semester, their use of WebGIS maps was clearly done in ways that would potentially augment the content and delivery, not simply using technology for technology's sake.

Ready-Made Interactive Maps

In addition to working with ready-made maps in ArcGIS Online, I further promoted the use of geospatial technologies with teacher candidates by having them work frequently with other online interactive maps. Teacher candidates can augment their learning about a particular topic by actively engaging with an interactive representation of the phenomenon at hand. The maps discuss in the following section represent a variety of topics that are pertinent to social issues all teacher candidates should be familiar with and should also understand at a basic level. While the maps are diverse in content, all of them allow teacher candidates to interact with data that are relevant to the content they might teach their future students. These maps also function as a way for teacher candidates to learn about their schools' local communities.

Prior to sending teacher candidates out into the field, they should learn more about the community in which their placement schools are a part. One way that teacher candidates can do this is by working with the USDA Food Access Research Atlas, an online mapping tool that prompts users to investigate the various factors that pertain to food access. Specifically, it provides data up to the census-tract level that estimates where cheap healthy food is accessible and where it is not. Users can also add layers that illustrate income levels, and other data about peoples' living situations (e.g., access to a working, reliable vehicle).

In one course, teacher candidates used this mapping tool after reading several newspaper articles on food deserts in our local community. The reading of the articles provided some baseline knowledge of this phenomenon, but it was the interaction with the USDA Food Access Research Atlas that prompted teacher candidates to think deeply about the effects of varying degrees of food access on the lives of their future students. (See Figure 3.) After working with the map, for example, many were surprised to learn that their placement schools and the adjacent neighborhoods were considered food deserts; areas devoid of access to cheap and healthy food.

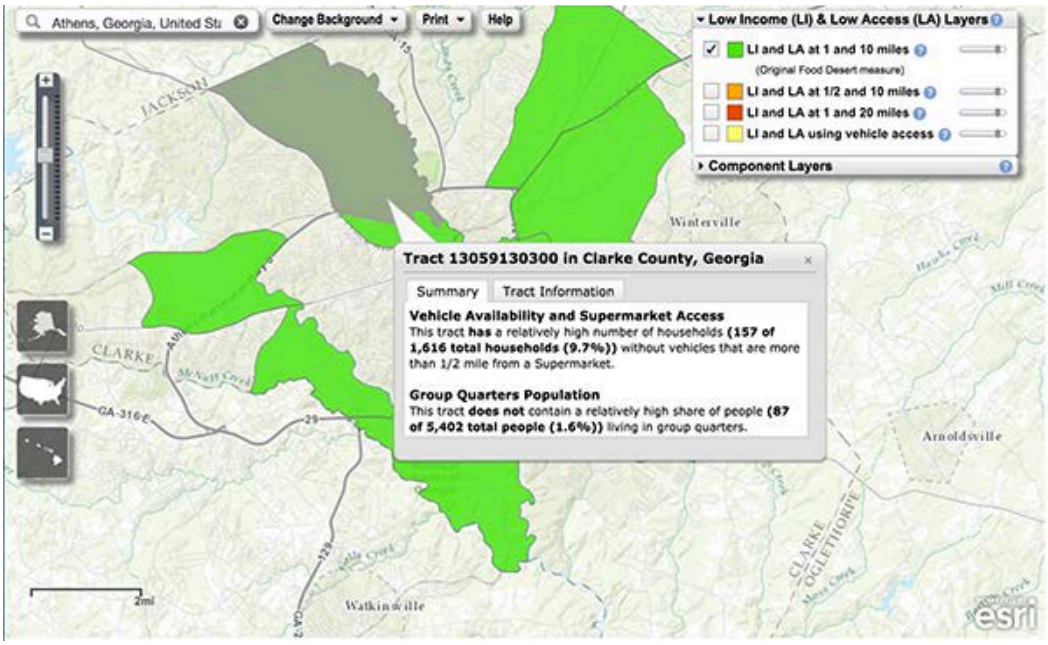

Figure 3. *An example of a map generated in the USDA Food Access Atlas depicting the location of food deserts in Athens, GA.*

Upon seeing these maps, the teacher candidates were able to have an engaging conversation about how hunger and health might relate to the performance and happiness of their future students. While these ideas might be most explicitly connected to those taught in a social studies curriculum, it is important for all teacher candidates and teacher educators to be aware of the social forces at work in their daily lives.

The USDA Food Research Atlas mobilizes data available through the Census Bureau, but this agency itself also has its own interactive mapping application that allows users to explore census data in an online map. The Census Data Mapper provides a simple interface where users can create, save, and print maps based on U.S. Demographics. Users can map county-based data on age and sex, population and race, as well as family and housing. Once a data set is selected, users can choose a color palette, the data classification ranges (e.g., quantile, equal intervals, or manual), as well as the number of classes. The application creates a fully customizable map that can highlight various demographic features.

Use of the Census Data Mapper served several functions in my courses. First, teacher candidates were able to see the variations in demographics between nearby counties. Second, after reading Avner Segall's (2003) "Maps as Stories About the World," teacher candidates were able to learn more about the subjective nature of maps and data representation by adjusting the number of classes and classification ranges. Through this activity, they learned how maps with the same data could look vastly different depending on how the data are displayed. This activity reinforced other activities discussed in their teacher education coursework that assisted them in finding the authorship and bias in all texts (Werner, 2000)—a crucial skill for the critically oriented pedagogue.

A critically oriented pedagogue also knows that all data tell stories in different ways based upon their presentation (Segall, 2003; Werner, 2000). To think more about the stories

that data tell, especially in spatial form, teacher candidates explored Esri's Story Maps, an extension of ArcGIS Online. Story Maps combine maps created in ArcGIS Online with curated accompanying content like multimedia, text, and images that help narrate the processes of different phenomena present in the map. Anyone can create their own Story Map or browse the Story Map Gallery where there are thousands of premade Story Maps on a multitude of themes.

When browsing the gallery, users can find Story Maps on topics ranging from mass shootings in the United States, to the living wage in different places to tourism tips when visiting new travel destinations. In my experience, Story Maps are always popular with teacher candidates. They are continually excited by the available and frequently updated content that is pertinent to the standards they are teaching or will soon teach. In fact, the Story Maps Gallery has become a go-to resource for many teacher candidates who are in the midst of their practicum or student teaching placements. They find these maps to be engaging with students, while also allowing them to grapple with important content in meaningful ways. (See Figure 4.)

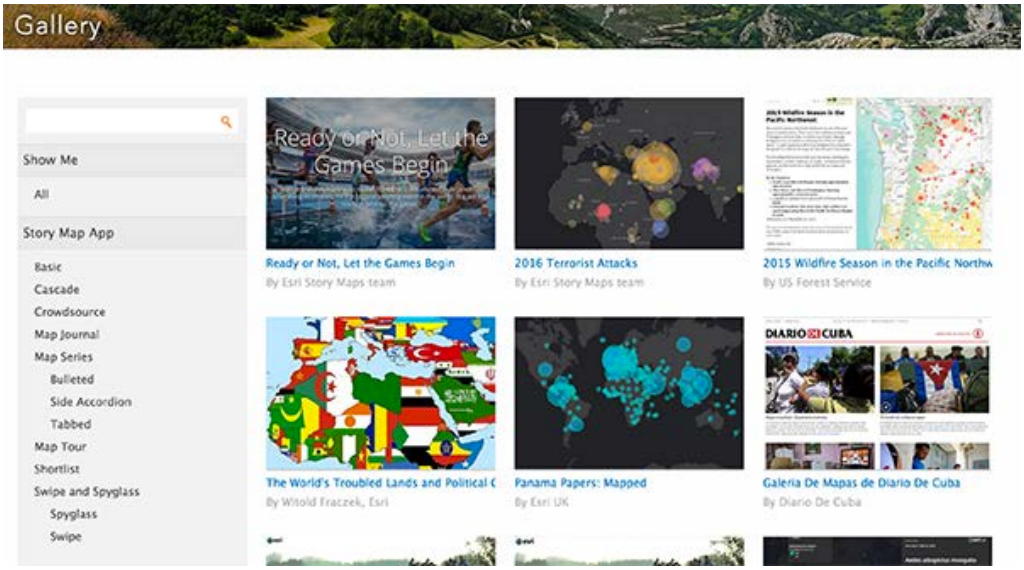

Figure 4. *A depiction of some web maps available in the Story Maps gallery.*

Conclusions

This article does not present an exhaustive list of the types of geospatial technology activities used in our program's teacher education courses, nor does it demonstrate the extent of what is possible for the use of these technologies in teacher education. I have highlighted three types of activities that would be easy to recreate in other teacher education spaces, especially by teacher educators who have access to limited (technological) resources or are unfamiliar or uncomfortable with geospatial technologies.

Other activities in which teacher candidates engaged have engaged in my courses are attending webinars hosted by the National Council of Geography Education on integrating online maps into pedagogical practice, using Google Earth™ to create flyovers and virtual fieldtrips, retrieving and analyzing remotely sensed imagery of our town and university to visualize how these places had changed and developed over the years, using

various functions in Google Maps™, and reviewing school demographic and testing data in preparation for instructional planning. By incorporating some form of geospatial technology into nearly every class session, teacher candidates become more familiar and comfortable with its potential use in pedagogical contexts.

I cannot claim with any certainty that teacher candidates in these courses will (effectively) use geospatial technologies in their future practice. I am aware, however, of the ways that frequent geospatial technology use in context-rich ways allowed them to develop more robust understandings of the potential of geospatial technology in education as well as everyday life. For example, a student who self-identified as "terrible" at geography and technology use in a get-to-know you survey and performed similarly on a basic geography skills assessment, completed an end-of-course reflection that said, "I was intimidated by GIS when it was first introduced in class, but after the training class and working with these resources, I think this is going to be a great tool for my future social studies class." In accompaniment to this final reflection, she and a partner created a chart that listed each social studies discipline and how they could use geospatial technologies to enhance their pedagogy (see Appendix B).

Another student who self-identified in similar ways and had a comparable performance on the initial assessment said,

Something I could have my students do as an activity is to create a story map using Esri Story Maps. Using this same app, I could have them write an explanatory or informative paper to go along with it. I also teach Language Arts, so this would tie in another content area. I love how with GIS you can tie in all the subject areas.

While these are just two examples of student reflection upon completion of their respective courses, I witnessed similar changes across the board, in which teacher candidates were showing signs of the ability to plan successful lessons with geospatial technology integration.

Ultimately, the incorporation of geospatial technologies into teacher education courses can lead to a wide range of benefits. As several teacher candidates mentioned in course evaluations, they "never knew that geography could be so interesting!" and "The content was very interesting and really made you think in a new way. I learned a lot of interesting stuff about geography and now have a new perspective on it." These comments, and others like them, may be attributed to the interspersing of geospatial technologies in relevant and context-rich ways that truly impacted the learning of content. The creation, critique, and analysis of digital maps and related representations of the world gave teacher candidates the opportunity to examine phenomena holistically and delve into authentic tasks relevant to the work of teaching content, as well as building relationships with students.

Developing skills based in geospatial technologies also added to teacher candidates' toolkit in terms of having a variety of ways to engage students with important information about nearly any topic. This practice in teaching enables different types of learners to be reached using different types of information. Teacher candidates can learn that maps do not necessarily have to be the main focus of a lesson, but their incorporation can play an integral role in their students' interaction with new information and concepts to be learned.

As a teacher education device, geospatial technologies not only offer a type of pedagogical tool, they also provide the means for teacher candidates to learn more about their

students and the communities within which they live through the mapping of different spaces and the structural forces at work in those spaces (e.g., race, gender, and class). In this way, geospatial technologies can help teacher educators cultivate a disposition that recognizes the importance of knowing about the community and the surrounding spaces of a school.

References

Ajayi, L. (2014). Investigating effective teaching methods for a place-based teacher preparation in a rural community. *Educational Research for Policy and Practice*, *13*(3), 251-268.

Alibrandi, M., & Palmer-Moloney, J. (2001). Making a place for technology in teacher education with Geographic Information Systems (GIS). *Contemporary Issues in Technology and Teacher Education*, *1*(4) 483-500. Retrieved from http://www.citejournal.org/volume-1/issue-4-01/social-studies/article1-htm-18/

Baker, T.R, Battersby, S., Bednarz, S.W., Bodzin, A.M., Kolvoord, B., Moore, S., ... & Uttal, D. (2015). A research agenda for geospatial technologies and learning. *Journal of Geography*, *114*(3), 118-130.

Baker, T. R., Palmer, A.M., Kerski, J.J. (2009). A national survey to examine teacher professional development and implementation of desktop GIS. *Journal of Geography 108* (4), 174–185.

Biddulph, M., Lambert, D., & Balderstone, D. (2015). *Learning to teach geography in the secondary school: A companion to school experience*. New York, NY: Routledge/Falmer.

Castro, J. (2012). Learning and teaching art: Through social media. *Studies in Art Education*, *53*(2), 152-169.

Clancy, H. (2014, November 21). This software entrepreneur wants executives to think like cartographers. *Fortune Magazine Online*. Retrieved from http://fortune.com/2014/11/21/connected-jack-dangermond-esri/

Crocco, M. S., & Leo, S. L. (2015). Digital citzenship: A response to Hicks et al. *Contemporary Issues in Technology and Teacher Education*, *15*(1), 56-67. Retrieved from http://www.citejournal.org/volume-15/issue-1-15/social-studies/commentary-digital-citizenshipa-response-to-hicks-et-al-s-2014-guidelines/

Dubel, M., & Sobel, D. (2008). Place-based teacher education. In D. A. Gruenewald & G. A. Smith (Eds.), *Place-based education in the global age: Local diversity* (pp. 49-64) London, UK: Routledge.

Esri. (2015). *What is ArcGIS Online?* Retrieved from http://doc.arcgis.com/en/arcgis-online/reference/what-is-agol.htm

Fargher, M. (2006). Linking lessons learnt from the classroom with research findings on pedagogies with GIS. *Esri European Conference Proceedings, Stockholm*. Retrieved from http://www.herodot.net/conferences/stockholm/esri/Fargher(paper).pdf

Fargher, M. (2013). Geographic information (GI): How could it be used? In D. Lambert & M. Jones (Eds.), *Debates in geography education* (pp. 206-218). London, UK: Routledge.

Hammond, T. C., & Manfra, M. M. (2009). Giving, prompting, making: Aligning technology and pedagogy within TPACK for social studies instruction. *Contemporary Issues in Technology and Teacher Education, 9*(2),160-185. Retrieved from http://www.citejournal.org/volume-9/issue-2-09/social-studies/giving-prompting-making-aligning-technology-and-pedagogy-within-tpack-for-social-studies-instruction/

Hicks, D., Lee, J., Berson, M., Bolick, C., & Diem, R. (2014). Guidelines for using technology to prepare social studies teachers. *Contemporary Issues in Technology and Teacher Education*, *14*(4). Retrieved from http://www.citejournal.org/volume-14/issue-4-14/social-studies/guidelines-for-using-technology-to-prepare-social-studies-teachers/

Kerr, S.L. (2016). *Navigating lack: K-12 educators' preparation and practices for the teaching of geography*. Manuscript in preparation.

Kerr, S., Collins, L., Jo, I., Monroe-Ossi, H., Ray, W., Whitcraft, A.K., ... & Stoltman, J.P. (2013). Teacher education and geography: Research perspectives. *Research in Geographic Education*, *15*(2). 44-58.

Kerski, J. J. (2003). The implementation and effectiveness of geographic information systems technology and methods in secondary education. *Journal of Geography*, *102*(3), 128–137.

Kerski, J.J. (2012) *Connecting GIS to social studies: 11 linkages between GIS and social studies education*. Retrieved from https://rigea.files.wordpress.com/2015/03/gis_and_social_studies_education.pdf

Kerski, J. J., Demirci, A., & Milson, A. J. (2013). The global landscape of GIS in secondary education. *Journal of Geography*, *112*(6), 232-247.

Kim, M., & Bednarz, R. (2013). Development of critical spatial thinking through GIS learning. *Journal Of Geography in Higher Education*, *37*(3), 350-366.

Johansson, T. (2003, June). *GIS in teacher education: Facilitating GIS applications in secondary school geography*. Paper presented at the The 9th Scandinavian Research Conference on Geographical Information Science, Espoo, Finland.

Massey, D. (1994). *Space, place, and gender*. Minneapolis, MN: University of Minnesota Press.

Mathews, S., & Adams, E.C. (2016). Examining community with pre-service teachers through the use of participatory photography projects. In A. R. Crowe & A. Cuenca (Eds.), *Rethinking social studies teacher education in the twenty-first century* (pp. 295-321) London, UK: Springer.

Milson, A. J., & Curtis, M. D. (2009). Where and why there? Spatial thinking with geographic information systems. *Social Education*, *73*(3), 113–118.

Mitchell, K., & Elwood, S. (2012). From redlining to benevolent societies: The emancipatory power of spatial thinking. *Theory & Research in Social Education, 40*(2), 134-163. doi: 10.1080/00933104.2012.674867

Mueller, J., Wood, E. Willoughby, T., Ross, C., & Specht, J. (2008). Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration. *Computers & Education, 51*(4), 1523-1537.

Scheepers, D. (2009, July). GIS in the geography curriculum. *Position IT,* 40-45.

Segall, A. (2003). Maps as stories about the world. *Social Studies and the Young Learner, 16*(1), 21-25.

Shin, E-K. (2007). Using geographical information system (GIS) technology to enhance elementary students' geographic understanding. *Theory and Research in Social Education, 35*(2), 231-255.

Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Sinton, D.S., & Lund, J. (2007). *Understanding place GIS and mapping across the curriculum*. Redlands, CA: Esri Press.

Speck, J. (2012). *Walkable city: How downtown can save America, one step at a time.* New York, NY: Farrar, Straus and Giroux.

Thomas-Brown, K. (2010). Using "When the levees broke/teaching the levees" to teach middle school students about empathy and social justice. *Social Studies Research & Practice, 5*(2), 76-90.

Werner, W. (2000). Reading authorship into texts. *Theory & Research in Social Education, 28*(2), 193-219.

Wright, V. H., & Wilson, E. K. (2009). Using technology in the social studies classroom: The journey of two teachers. *Journal of Social Studies Research, 33*(2), 133-154.

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Resources

ArcGIS Online - http://www.arcgisonline.com

Census Data Mapper- https://www.census.gov/geo/maps-data/maps/datamapper.html

Story Maps - https://storymaps.arcgis.com/en/

Story Maps Gallery - https://storymaps.arcgis.com/en/gallery/

Teaching with GIS: Introduction to Using GIS in the Classroom - http://training.esri.com/gateway/index.cfm?fa=catalog.webCourseDetail&courseid=2198

USDA Food Access Research Atlas - http://www.ers.usda.gov/data-products/food-access-research-atlas.aspx#

Appendix A
Examples of Course Goals and Related Geospatial Activities

Example Course Goal	Example Connection of Geospatial Technology Use to Achieve Goal
Understands the central concepts, tools of inquiry, and structures of the geography and creates learning experiences that make geography accessible and meaningful for learners to assure mastery of the content.	Teacher candidates completed photomissions related to concepts from geography, mapped the photographs using Flickr, and did basic cluster analyses to make connections between the presence of geography concepts and their placement within the local community.
Understands how to connect concepts and use differing perspectives to engage learners in critical thinking, creativity, and collaborative problem solving related to authentic local and global issues.	Teacher candidates used ArcGIS Online and several ready-made maps available through National Geographic Education to map and review maps related to the differing life experiences of women in Israel and Palestine.
Plans instruction that supports every student in meeting rigorous learning goals by drawing upon knowledge of geography, curriculum, cross disciplinary skills, and pedagogy, as well as knowledge of learners and the community context.	Teacher candidates planned a lesson for a content area outside of geography that incorporated an active use of ArcGIS Online and/or Story Maps to learn more about specific academic standards in the respective discipline.
Engages with, and considers the challenges and dilemmas of teaching and learning in the context of community.	Teacher candidates learned about their placement schools and respective communities through the use of USDA Food Access Atlas to research the presence and prevalence of food deserts in the communities. They also used the Census Data Mapper to map demographic information of their students and their communities.

Appendix B
Example of a Teacher-Candidate-Created Planning Chart for Using GIS in Social Studies

Geography	Human and Physical Geography can easily incorporate GIS. One way to use GIS in Human Geography is to use a layer and find out different city populations, mortality rates, and demographics. Or- if you wanted to use it for Physical Geography, GIS can be used to show climate, contour lines, and even something like carbon dioxide emissions.
World History	GIS can also be used in World History. When trying to engage a class in a discussion about the Ottoman Empire for example, can really limit your discussion if a student or class does not know where the Ottoman Empire ruled, what cultures were influenced, and what the fall of the Empire's lasting effects were. Creating a GIS map could help students see where this empire existed and how its legacy persists in today's world.
American History	In American History, GIS can be used to show the evolution of the original 13 colonies to the fifty states. You can layer the map to show the physical barriers that had to be conquered in order to expand the territory for example, the Appalachian mountains and the Mississippi River. You can also view how the Native Americans were pushed out as Europeans moved in.
Economics	One way to incorporate GIS in Economics is to show per capita income, where people buy foods locally/abroad. There is even a map that shows "2013 Retail Goods Spending in the United States."