Bridging the Digital Divide with GIS

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Abstract

This paper reframes the problem of the “digital divide” and proposes teacher education in Interdisciplinary Geographic Information Systems and related pedagogy (problem based learning, design pedagogy), in order to equitably bridge this gap, empower students and the community, and better prepare students for the knowledge-based economy with 21st century skills.

Keywords: Digital Divide, 21st Century skills, design pedagogy, Critical GIS, Critical Race Theory, Problem-based learning, Participatory GIS (PGIS), Information and Communications Technology (ICT)
Bridging the Digital Divide with GIS

Over the last 50 years we have witnessed the basis of our nation’s economy shift from an industrial-based economy to a knowledge-based economy, the direct result of technology and globalization (Peters & Humes, 2003). And we are not alone in this; a similar transformation has occurred in other more economically developed nations as well. The implications of this transformation are a higher value on what the Organization for Economic Co-operation and Development called “tacit knowledge” (1996) which comes in the form of the skills required to handle codifiable knowledge. Craft refers to this type of knowledge as “21st century skills” (Craft, 2005), which are described in greater detail in the accompanying graphic. The OECD made clear that education will be paramount in the knowledge-based economy, where learning is “the tool of individual and organizational advancement” (1996, p. 14) and where learning-by-doing is essential (Peters & Humes, 2003).
Despite having good access to technology and relatively generous resources dedicated to public education, the United States is falling behind in preparing its young citizens for the knowledge-based economy. Underscoring this problem, many teachers use technology less often today than they did thirty or forty years ago (Keengwe, Onchwari, & Wachira, 2008). On a macro institutional level, Education has not responded well to disruptive technologies. First, it is slow, ignoring new technology, and then when it does finally adopt new technologies, it tends to use them in the commission of outmoded tasks (Cuban, Kirkpatrick, & Peck, 2001; Whitney, 2010). This is an institutional problem, according to Whitney, who claims “educational dogma is inhibiting schools from changing in ways that will prepare kids for the knowledge economy” (2010, p. 453). Furthermore, the practitioners often resist change and new technologies due to their own entrenched epistemological beliefs regarding what teaching is and should be (Keengwe et al., 2008; Ratinen & Johansson, 2005). With regards to Geographic Information Systems, the situation is even bleaker. A study of inclusion determined that in 2003, less than 2 percent of American high schools had adopted GIS technology. A digital divide has been forming within the United States, to say nothing of the International situation. This paper will deal with the digital divides that exist on national and more local levels, but will include case studies and other researches from around the world, because that is where much of the data comes from. The United States defines the digital divide as “inequalities of access to technology based on factors of income, education, race and ethnicity” (Rhode & Shapiro, 2000) but this paper does not accept this definition, as it seems to be framing the wrong problem since it does not address inequality, merely access. After all, merely giving disadvantaged groups access to technology can have a detrimental effect since greater saturation of technology benefits the elite who already have the access and the skills to make use of it, while those who are already marginalized become more so.
This paper recognizes that only addressing the issue of access to technology can lead to further exploitation and therefore looks to address the digital divide by providing both access to emerging technologies and 21st century skills for empowerment. Despite some of the dangers that new technologies present, the implementation of GIS in education could have a considerable impact on empowerment (Kerski, 2003; Sieber, 2006). However, GIS is not, and may not soon become, a subject in the national curriculum at any level, nor is it couched within any discipline. Fortunately, GIS can be adapted in pedagogy for nearly any discipline (not just geography); in fact, it is advantageous to use GIS in this way. Thus, this study proposes the addition of GIS to the teacher training curriculum in order to promote equity and reduce the digital divide, increase the social capital of marginalized groups within places of power, and better prepare our students for the knowledge-based economy.

Implementation

In this section we will look at the current state of GIS in secondary school education in the US, advantages to using GIS in education, barriers to implementation, and barriers to empowerment.

Current State of GIS in Education

Although GIS has become more common in secondary school education in the US, it still does not have a role in most states’ curricula (Milson & Roberts, 2008). Of the schools that do utilize

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1 For the purposes of this study, empowerment has three forms: distributive change, procedural change, and capacity building (Elwood, 2002). Distributive change describes things like land tenure and property rights. Procedural change, on the other hand, seeks to alter political processes so that new or marginalized groups are given increasing legitimacy and voice in decision making. Capacity building is “generally framed as an expansion in the ability of citizens or communities to take action on their own behalf” (Elwood, 2002, p. 909).

2 “It is likely that the diffusion of GIS in education will remain slow due to continued challenges with IT infrastructure, educational support, and standardized testing, coupled with new and serious shortfalls in educational funding at state levels” (Milson & Kerski, 2012).

3 In 2008 a study (Milson & Roberts) found that 22 states had mentioned GIS, GPS, or the analysis of geographic data with technology in their geography standards for secondary schools, yet only five had standards in place to apply higher-order thinking about spatial practices (Milson & Kerski, 2012).
it, GIS is most commonly incorporated into subjects such as earth, life and environmental science, chemistry, and geography, although it is “on the rise” in subjects such as history, mathematics, and English language arts (Milson & Kerski, 2012).

**Advantages.** As mentioned before, GIS, when coupled with the “tacit knowledge” to apply it to local problems, is empowering. GIS is influential in policymaking in education, business, and government (Kerski, 2003; Sieber, 2006), thus using GIS as a tool to frame local problems or issues will give students and their communities greater sociocultural capital in places of power. Kirman asserts that GIS and transformative pedagogy can mobilize “geographic skills into ethics-based action” (2003, p. 93). Pacheco, et. al., invoke Paolo Freire and urge teachers to use “GIS and maps in their work toward achieving a larger goal of social change through education” (2009, p. 276). There are plenty of case studies that support this. For instance, in the Andes of Chile, a group of secondary students analyzed the water tables in the rural valleys of the dry Atacama region in order to determine whether the activities of a transnational mining project was contaminating the water (Muñiz-Solari & Moreira-Riveros, 2012). Another study documents the use of remote sensing and GIS in order to “assist indigenous peoples to claim and defend ancestral lands and resources” (Chapin, Lamb, & Threlkeld, 2005, p. 620). There are many more, and thus “the connection between empowerment and GIS appears certain and replete with possibility” (Sieber, 2006, p. 491).

GIS is inherently interdisciplinary (Bodenhamer, Corrigan, & Harris, 2010; Fitchett & Good, 2012; Milson & Kerski, 2012; Tinker, 1992; Yaghi, 2012) and can be adapted in most disciplines. As such, its application is limited only by the imagination. It will require synthesis

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4 This is “often slow to acquire and much more difficult to transfer” than “codifiable knowledge” (Pryor, 1999).

5 “‘Geographers are both importers and exporters of knowledge’ and thus geography serves as a sturdy bridge crossed by many disciplines” (Ayers, 2010)
GIS will enable students to produce cultural products, namely maps, which will benefit the community. They will gain sociocultural currency as a result; not just within their own social group, but also other groups because maps are an intercultural medium.

GIS allow for multiple narratives, especially when juxtaposed with our Historical tradition, which only allows for one dominant narrative. This is because of the limitation of presenting history from a linear perspective—“time is needed to tell the story of how an individual place developed to become what it is now, however without space there is only one story and thus the risk that this is seen as the only possible story and the inevitable story. Space is needed because it allows for more stories and thus for a diversity of experience” (Gregory, 2010).

GIS is an effective medium for problem framing. GIS provides learners with a visual perspective that makes the subject matter relevant. GIS uses map projections in order to make data apparent spatially. It connects data sets to the world, and learning to the world of the learners, both locally and globally, thus allowing learners to discover how the subject relates to themselves. Furthermore, when users place problems into a frame like GIS, their voice is more likely to be heard as GIS has an influence on decision-making in public policy and government.

**Barriers to Implementation.** Keengwe, et. al., drew a distinction between external and internal barriers to implementation of ICT (2008). External barriers are “first-order” obstacles like access to technology and resources like training. These barriers engender the commonly-accepted definition of the digital divide. Although the US has great access to these resources, there are still some places in the USA where the Internet and ICT are rare. Furthermore, as recently as 2003, schools listed the cost of infrastructural improvements needed for
implementation of GIS as the main deterrent (Kerski). However, technology is ever-increasing, exponentially (Kurzweil, 2005). It is not far-fetched to think that in only a few years, smartphones will be free or close to it and we will achieve total smartphone diffusion in the United States (for better or worse). This prospect, combined with the proliferation of web-based GIS applications, means that cost and IT requirements will be minimal, as even a tablet or smartphone can access GIS technology, thus making cost a veritable non-issue for adoption. A second issue is that professional development opportunities in GIS are not commonly available to practitioners. This study aims to address this core issue by proposing the curriculum below.

Finally, the lack of national mandate for GIS in curriculum is an external barrier, although the common core standards do imply a need for GIS. Seen holistically, the lack of a national mandate is probably a good thing, as top-down reform does not typically lead to more equitable outcomes (Warschauer 1998).

Internal barriers, on the other hand, include institutional obstacles such as the culture of the discipline. The institution of education does not respond well to disruptive technologies, first ignoring and then finally adopting them albeit in the commission of outmoded tasks (Whitney, 2010). Indeed, “educational dogma is inhibiting schools from changing in ways that will prepare kids for the knowledge economy” (Whitney, 2010, p. 453). Also included here is teachers’ own resistance to change and technology due to their own entrenched epistemological beliefs regarding what teaching and learning are and should be (Keengwe et al., 2008; Ratinen & Johansson, 2005). Teachers must be major stakeholders, and if they are not committed to integration and delivery of ICT or GIS where it is mandated (as it is in Norway), how can we

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6 However, Educational Systems Research Institute (ESRI) does frequently partner with schools both domestically and abroad to provide training in its GIS systems such as ArcGIS or GISeXplorer (Milson & Kerski, 2012; Muñiz-Solari & Moreira-Riveros, 2012).
reasonably expect effective delivery of the curriculum\textsuperscript{7}? How can we expect efficacy? Finally, due to the external factors of No Child Left Behind and Race to the Top, teachers are faced with the dilemma of having to teach for the national assessment, which results in a pedagogical culture of memorization and instructionist chalk-and-talk. As a result, they are often demoralized and left without the resources such as time and space within the curriculum to implement the changes this study suggests.

**Barriers to Empowerment.** Barriers to empowerment can be logistic, pedagogical or institutional. Assuming GIS is integrated into the curriculum, what are the barriers to empowerment? One barrier might be a lack of access on the part of the learner to tools and gadgets with which they might apply GIS to real-world problems and scenarios. Thus even though they might have the tools in school and the applicable “tacit knowledge” they lack access to these tools in the real world, where they will truly realize the power of the tools and knowledge. Fortunately, as mentioned above, the costs of technology and gadgetry are constantly falling, so it’s reasonable to believe that in the future this barrier will not be significant, but for now, it is. Another obstacle is related to pedagogy: perhaps the class is taught about GIS rather than with GIS. This might happen in a career/vocational training course where GIS is taught on its own rather than couched in another discipline. As a result, the student might not be able to make a connection between the tool and its relevance to their life, nor its potential beyond the prospect of finding a job. Furthermore, GIS might be presented via instructionist pedagogy, without fieldwork or self-directed projects that engender the discipline, which would likely result in no empowerment. In fact, many people (Critical GIS and PGIS\textsuperscript{8} proponents, particularly) would view GIS on its own, applied “objectively” without a critical lens, as a return to positivism

\textsuperscript{7} Particularly in places where it is not mandated by government policy.

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In this view, GIS represents merely another means of capital control and government or industrial surveillance (Pickles, 1995) and this perspective underscores the danger of GIS and ICT, in general. They are not neutral tools (Feenberg, 1991), but rather simply “one more global arena in which struggles over the distribution of resources, power and information will be fought out” (Wiseman, 1998, p. 85). That is why the question of pedagogy is paramount to implementation, and that pedagogy should be informed by Critical GIS, PGIS, and/or design pedagogy.

Institutional barriers to empowerment are difficult to see unless one uses a critical lens such as Critical Race Theory or Marxist Theory. For instance, many theorists postulate that schools function as reproducers of social inequalities (Apple, 1993; Bourdieu & Passeron, 1990; Collins, 2009). Consequently, it is highly unlikely that top-down educational reform would result in empowerment or more equitable outcomes. Top-down change bypasses the teachers and does not permit them to be stakeholders. For example, in Norway, a very progressive Scandinavian country that routinely scores highly on International standardized tests, the government passed the Knowledge Promotion Reform (K06), which became their national curriculum (Rød, Andersland, & Knudsen, 2012). K06 explicitly mandates that students learn how to use digital maps and GIS in their geography and geoscience courses. A study of the

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9 For the purposes of this paper, Critical GIS is defined as a sub-group of GIScience that challenges the widely held epistemological and ontological assumptions of GIScience, and acknowledges the precedent that GIS has best served large corporations and governments rather than the underrepresented and marginalized (Pickles, 1995; Schuurman, 2006). It accepts that GIS is inherently political, just as a map projection is, because “the map is an abstraction of reality, one that incorporates points of view” (Schuurman, 2006, p. 730).

10 Participatory GIS (PGIS), or PPGIS (public participation GIS), attempts to better represent disenfranchised groups (Schuurman, 2004; Sieber, 2006; Young & Gilmore, 2013). Some consider PGIS to be “subsumed into what is now called Critical GIS” (Schuurman, 2004, p. 493; Sieber, 2006). This pedagogy would involve getting students outside to do self-directed fieldwork projects that address the needs of their community. Several examples are mentioned above in the “advantages” section.

11 Design pedagogy emerged from the community of practice, although it was strongly influenced by the Bauhaus school (Lawson & Dorst, 2013; Schön, 1985; Shaffer, 2007). Some of its salient features include iterative processes wherein open-ended problems are explored and resolved through a series of intermediary solutions, the open environment and culture of the studio, and the dialogic process of presentation and feedback (Shaffer, 2007).
geography teachers’ opinions regarding GIS in the geography curriculum found that 56.6% of the teachers were doubtful of the “added value” of GIS to the curriculum. Furthermore, there were pedagogical barriers as a result of the top-down mandate with 67.2% of respondents claiming that the best way to teach GIS would be solitary learning; problem-based learning was considered as the favorable approach for only 27.9% (Ratinen & Johansson, 2005). Remember that this is one of the most progressive countries with high marks in the gender equality index\textsuperscript{12}, and low marks in the rich-to-poor statistic\textsuperscript{13} that measures economic equality. In this instance, the goal is to better prepare Norway’s young people for the knowledge economy by giving them 21\textsuperscript{st} century skills they will need to thrive in an era of uncertainty (Whitney, 2010), but without the teachers onboard as stakeholders, they will only be able to provide these skills in a perfunctory manner, which is about all one can expect from the teachers above who voiced their skepticism of GIS’s efficacy and their preference for “solitary” learning, which sounds a lot like Instructionism or Freire’s “Banking” pedagogy. The result is neither 21\textsuperscript{st} century skills, nor empowerment. It’s fairly clear from the literature that progressive educational reform needs to start at a much lower level, such as the teachers.

**Curriculum Proposal**

This curriculum proposal is informed by the aforementioned obstacles, and shall consist of the following sections: scope, goals, description, and implications.

**Scope**

The scope of this curriculum proposal is aimed at teacher’s colleges, universities and practitioners. Ultimately, however, the project is aimed at improving the lives of students and practitioners. Ultimately, however, the project is aimed at improving the lives of students and


their communities in marginalized areas with high poverty such as Indian reservations and urban centers.

In order to implement GIS most effectively in secondary schools, practitioners must be on board as stakeholders. Therefore, there is little point in rolling out a curriculum for a hypothetical class of students that does not and probably will not exist. GIS for educational reform is not a top-down process, and one can observe in Norway the negative response of practitioners to the mandate of incorporating GIS into their geography curriculum (Ratinen & Johansson, 2005). Moreover, curriculum should not be formulated by someone outside the community and distributed to practitioners for execution, particularly when the goal is to match the curriculum with local situations or problems (Lather, 1986). Rather, GIS training should be incorporated into teacher training. Practitioners should be taught subjects with GIS using the targeted pedagogy so that they may also develop a deep and meaningful understanding of these tools and that they may design and teach their subjects in a way that is efficacious to the learner and beneficial to the community. They, like their future students, should learn by doing; they should learn with GIS, and not about GIS. If we look at the example of the design school, we see that their instructors have received no explicit pedagogical or teacher training, but rather have learned it by doing since the time they were in design school and continued to learn and use it within their professional practice. Design pedagogy, in fact, is something that emerged naturally from within the community of practice (Lawson & Dorst, 2013; Sawyer, 2014; Schön, 1985; Shaffer, 2007). Thus it is reasonable to conclude that GIS pedagogy, or any pedagogy that we might want teachers to utilize for better learning and equitable outcomes, is something that should be learned by doing in their own professional schools. Instructionist pedagogy is not an approach that is well-equipped to prepare students for the knowledge economy and 21st century
skills, but if we want our teachers to use other approaches, we need to train them using those targeted pedagogies. Pedagogy is often treated as codifiable knowledge and, in a vacuum, it may be that; in practice, however, it is tacit knowledge. It is not codifiable knowledge because “real-world problems do not come well-formed” (Schön, 1985, p. 15) and pedagogy must operate in the real world. Just as the designer’s moves “talk back” (Schön, 1985), so do teachers’ materials talk back to them. Teachers colleges do not train technicians, after all—they train professionals.

**Goals.** The goals of this curriculum project are two-fold, both of which involve empowerment. The first is to bridge the digital divide by providing access to GIS and the opportunity to engage GIS in deep and meaningful ways. The second is to deliver 21st century skills in order to prepare learners for the knowledge-based economy. Both of these goals require the proper pedagogy, as explained above.

**Description.** Two courses planned to prepare teachers with the tacit knowledge necessary to design and execute a class using GIS in their discipline. They are:

1. A narrative journey through GIS
2. Mapping our spaces

**A narrative journey through GIS.** This course focuses on using GIS for storytelling. The course is somewhat grounded in English/Literature, but would also feature some social studies topics. The first units will use Google Earth, while later units will use a web-based version of ArcGIS, either on a laptop computer or a tablet device.

The first unit uses Google Lit Trips14 and Google Earth in order to recreate a character’s journey using GIS.15 First students would read a novel in which a journey is central to the story. While reading the novel, the students will be instructed to record different locations in the book

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and what happened there. Later on, these journal entries will become the data for their map. Students will learn how to georeference their data and impose it upon Google Earth as layers of information, and thereby constructing their maps. They can also look on Google Lit Trips to see some examples of maps that other people have made to illustrate a story. Google Earth would provide an easy user interface for the learner for them to get comfortable with the new medium. Finally, they will present their story to the class in the form of a digital map.

In the second unit, the students will think about perishable items they consume, and choose one. Then they will learn to map the life span of the perishable item. This will require that they do some research regarding where the product came from, and where it stopped en route to the grocery store or cafeteria, etc. Then students will present their map and narrate what happens at each stage in the process.

The third project imposes an obstruction to the second project. Using the second project, the students must adapt a narrative and compose a short story. This could mean that they anthropomorphize their perishable item, or perhaps they instead choose to focus on the people whose lives are affected by the perishable item. They might incorporate the entire timeline and the different spaces, or get rid of some of them that no longer relate to their story. They are free to adopt or disregard the constraints of the project as they so choose, or as their ideas dictate. The final product will be a short story and a map that corresponds to it.

The final unit focuses on local current events. Working in groups, students will choose a recent news story from which they will generate map ideas through brainstorming and dialogic processes. (What is at stake in this news story? What areas are affected? So what? Etc.) Then

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15 Although some GIScientists might not consider Google Earth to be a GIS, practitioners in education do not need to draw that distinction.
students will construct a map based on this news story\textsuperscript{16}. This project will require field work, the use of gadgetry and collaboration.

**Mapping our spaces.** The theme of this course is the intersection between space and time. The first unit will look at the student’s local workspace. First, all students will take a multiple intelligences quiz to try to see where their strengths might lie. Then they will go home and take a photo of their work environment. In fact, they will take multiple photos of their workspace in order to present the space as accurately as possible to the class. They will present their workspace to the class and explain how they use it productively, why it is what it is, and how they might like to change it. The class will give them feedback. Their follow up assignment will be to perform an intervention on their workspace and take pictures. Later in the course, they will present a compare/contrast between the two workspaces, describing the differences, explaining their decisions, and reflecting on how the changes have influenced their work. Ancillary issues include what the photos inevitably leave out.

This unit has an environmental focus, with a skills emphasis on portraying time via maps using layers and the same illusion utilized by time-lapse photography. Students will at first examine how their hometown has progressed over the years through the critical lens of some environmental issue (of their choice) and they will write their first paper about that.

The third unit will involve students creating a photo essay regarding the spaces that are important to them within their community. They will present the photos in a chronologically based order using the medium known as Pecha Kucha, which features twenty images for twenty seconds each. Afterwards, they will georeference their photos and descriptions as data and create GIS layers, however their descriptions of the photos must conform to certain constraints.

\textsuperscript{16} If necessary, the instructor shall produce several maps based on factual data that \textquote{tell a story}. 
The final project adapts “The Five Obstructions” from Lars Von Trier\textsuperscript{17}, whereby students will present their previous projects as a map and the class will co-create five obstructions for each student to overcome and execute. Each student has the power to reject one of the obstructions, choosing four. This project will duly emphasize constructivism over individualism, and typologies over one singular product.

**Implications.** The courses above are guided by design pedagogy and social constructivist principles, but one can also see how these activities might relate to CRT. Students must work together, at times collaborating on data gathering, sometimes giving feedback, and other times sharing their GIS maps, which are cultural artifacts that they created. The maps might represent a story they wrote, or an issue regarding their neighborhood. Furthermore, the course on storytelling through GIS reflects the belief that “social reality is constructed by the creation and exchange of stories about individual situations” (Delgado, 1989; Matsuda, 1989; Tate, 1997, p. 210). Moreover, learning these 21\textsuperscript{st} century skills, notably problem-finding and self-directed learning, will give students more sociocultural currency—not just in the school or the community, but also in places of power where well-formed, visualized data sets will earn them a place at the table.

**Conclusion**

Change is coming soon; the writing is on the wall. The knowledge-based economy demands it, and this represents a situation analogous to Bell’s interest-convergence principle, which states that significant progress for blacks is achieved only when the goals of blacks are consistent with those of whites (Tate, 1997). When that change comes, it will no doubt be in the form of a top-

\textsuperscript{17} “The premise is that Lars von Trier has created a challenge for his friend and mentor, Jørgen Leth, another filmmaker. Von Trier's favourite film is Leth's The Perfect Human (1967). Von Trier gives Leth the task of remaking The Perfect Human five times, each time with a different 'obstruction' (or obstacle) given by von Trier” – Wiki entry (Livingston & Plantinga, 2008).
down mandate. Hence, we have to be careful when we bridge the digital divide so that marginalized groups do not become exploited by new technology. We need to prepare our teachers to deliver an empowering set of interdisciplinary GIS skills through PBL and design pedagogy by training our teachers in these subjects, using these methods, at teachers colleges.

References


