INCORPORATING ARCGIS ONLINE IN THE SOCIAL STUDIES CLASSROOM:

COMPARATIVE CASE STUDIES

by

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Abstract

Social studies in general, and geography in particular, have been sidelined in many secondary schools in recent years in favor of Science, Technology, Engineering and Math (STEM) focused instruction. This situation continues to exist in spite of the growth of usage of geographic information systems (GIS) technology at the university level and throughout numerous professional fields. GIS, though underappreciated at the secondary level, provides educators with the tools needed to apply a STEM focus to social studies classrooms in a manner that is both authentic and academically rigorous. In keeping with that we set out to develop a lesson plan that can overcome barriers to adoption of GIS in the classroom and evaluate the efficacy of using GIS to teach spatial concepts over more traditional methods. The feedback received from educators was largely in line with expectations set by reviewing relevant literature and highlighted specific strengths of using GIS in a secondary classroom and what obstacles might stand in the way of future adoption.

Introduction

Rapid changes in American society have driven a shift towards a STEM (Science, Technology, Engineering and Math) focus in our public education system (Lynch et al., 2017). This push towards more technology in the classroom and STEM-based education often accompanies a de-emphasis of social studies education and in particular geography education (Gnagey & Lavertu, 2016). In the State of Texas this change is exemplified by the removal of World Geography from state graduation requirements in 2014.

As STEM has become a focus of education reform, the liberal arts and social sciences have taken a back seat, even in social science fields with an obvious STEM component. Schools that have made efforts to adopt integrated campus wide STEM programs tend to force social studies (and language arts courses) to transform their curriculum and learning objectives to ensure they meet an existing STEM model (Goodwin, Healy, Jacksa, & Whitehair, 2016) rather than using technology inherent to the learning objectives of that discipline; like Geographic Information Systems (GIS) in geography. Generally speaking, GIS can be described as frameworks for gathering and analyzing spatial data for the purposes of visualization and represent the technological and practical application of geographic concepts.

An unfortunate knock-on effect of these decisions and an industry wide focus on STEM education has led to glacially slow, in some cases non-existent, adoption of GIS in the K-12 classroom (Wheeler, Gordon-Brown, Peterson, & Ward, 2010) despite their growing ubiquity across industrial and academic applications. This is certainly not the first time this claim of less than ideal adoption of GIS tools in the K-12 classroom has been made – "Despite manifold endeavors during the last fifteen years, we can still call the usage of geographic information systems (GIS) in the geography classroom marginal…" (Höhnle, Fögele, Mehren, & Schubert, 2016) – nor is it likely to be the last. Nevertheless, the potential for GIS in teaching spatial literacy in a classroom setting remains ever present and largely untapped usage of these technologies.

The lack of geographic literacy amongst high school students is not limited to Texas. Researchers have identified similar causal factors that might explain the general geographic illiteracy of American high school students (Passow, 2017) including the lack of formal curriculum in most school systems and lackluster geographic literacy among most social studies teachers. Indeed, the United States is the only major developed nation in "which a student can pass from primary school through to university without ever taking a course in geography" (Carr 2005, 42). Several researchers have identified the role that technology in general can play in bridging the knowledge gap that exists amongst students and teachers (Carano & Berson, 2007).

The specific benefits of ensuring a robust and rigorous grounding in geography and geographic literacy amongst high school students are many and varied and run the gamut from ensuring students have an understanding of and introduction spatial power politics (Seow & Chang, 2016) to the practical application of problem solving using GIS (Sinha et al., 2017). It is beyond the scope of this particular research, however, to analyze or justify the inclusion of geography education in American high school social studies curriculum and the benefits of its conclusion will be taken as a given.

GIS represents a unique tool for bridging those geographic literacy and skills gaps amongst students and educators while carrying tremendous potential to increase spatial thinking skills if utilized effectively (Manson et al., 2014). Additionally, the effective usage of GIS in the classroom has been shown to improve academic skills outside of the geography discipline while simultaneously re-enforcing geographic literacy (Baker & White, 2003) and contributing to efforts at campus wide STEM integration. The definition used here for spatial thinking is taken from the National Research Council and is given as “a collection of cognitive skills comprised of knowing concepts of space, using tools of representation, and reasoning processes” (National Research Council 2006, 12).

Given the disconnect between potential of GIS as a teaching tool and the lack of large-scale adoption in secondary education it stands to reason efforts to bridge that gap and explore the reasons for its existence should be undertaken.

Therefore, the purpose of this research is to find ways to seamlessly integrate GIS into both geography and non-geography social studies classrooms with the aim to familiarize students -- and teachers -- with the benefits and power of GIS for education. Additionally, I intend to expose educators and students to a more accessible version of GIS - ArcGIS Online. ArcGIS Online is a browser based public (and free) version of GIS technology.

The usage of a browser-based GIS program allows for more flexibility among students, educators and schools considering the adoption of GIS for classroom usage (Baker, 2015) and further lowers cost concerns in that the software runs on the vast majority of internet capable devices. All the participants used the browser-based version of ArcGIS Online and two of the three used it on Google Chromebooks while a third used desktop PCs. Most schools are eligible to apply for free access to some of the additional tools offered by ArcGIS Online that are not part of the free package available to individual users. As such, a financial barrier to adoption of ArcGIS Online is minimal and adoption will not incur ongoing upgrade and maintenance costs that adoption of unique hardware would entail.

The reason for focusing on GIS technology for this research is that GIS can be easily folded into an Inquiry Based Learning (IBL) module aimed at incorporating authentic problem solving that lends itself to collaborative and cross-curricular lessons, methods and practices that have been proven to be effective for both students and teachers (Duch, Groh, & Allen, 2001; Park & Ertmer, 2008; Favier & van der Schee, Joop A., 2012) in learning and demonstrating mastery of a variety of academic concepts. IBL are generally considered learning activities that are structured around students discovering solutions or explanations to real world phenomenon through their own inquiry into the causes of that phenomenon. It can be organized around a social problem (Problem Based Learning) or around a generalized observable phenomenon. Educators may choose to craft structured/guided IBLs that drive students towards particular avenues of research or allow for a more open ended inquiry structure. The structure followed here is one of guided inquiry.

In keeping with the broader themes of STEM focused education as a driving force "authenticity" (in regards to GIS based IBL units) is best defined here as activities that can act "as a form of apprenticeship [emphasizing] the epistemic aspects of scientific practice" (Sandoval & Reiser, 2004, 3). Although, as was discovered during our data collection the varying epistemologies of educators will effect whether or not they perceive an educational activity as authentic or not. Furthermore, this research aims to show that broad adoption of GIS may lead to increased familiarity amongst students and staff and thus allow for further and future experimentation and evidence of the efficacy of using ArcGIS Online for geographic literacy in secondary social studies classrooms.

Given the current climate of de-emphasis of social studies education and the emphasis of STEM-based learning and inquiry, it is vital that social studies teachers be given the tools needed to adapt and incorporate more technologies in their classroom despite the general resistance amongst this cohort to *modernizing* their teaching techniques (Combs, 2010) in order to both provide authentic learning opportunities for their students and ensure that they are not left behind as schools turn towards STEM focused classrooms. In addition to the obvious benefit of ensuring social studies does not get left behind the very real benefits of GIS in teaching spatial concepts and spatial thinking (Kolvoord, Uttal, & Meadow, 2011) while allowing for an opportunity to visualize other concepts within social studies cannot be discounted.

With this in mind, the design of the lesson, “Incorporating ArcGIS Online in a Social Studies Classroom,” was intended to allow novice users of ArcGIS Online to effectively and efficiently use the available tools in order to provide a deeper analysis of economic and geographic variables present in the decision making process facing small business owners. While, at the same time, exposing those same novice users to the potential inherent in GST tools like ArcGIS Online in their classrooms and introducing inquiry based learning that may model professional and academic authenticity and allowing students an opportunity for shared investigation that aligns with purported goals of STEM education (Kapon, Laherto, & Levrini, 2018).

The research will focus on the efficacy of ArcGIS Online as an instructional tool as perceived by high school social studies teachers who have little or no prior experience with it. This focus – perceived efficacy -- has been selected for reasons that are explained in more detail in the methodology section.

The definition used here for perceived effectiveness is vital. For the purposes of this analysis I use, as a theoretical basis, Davis’ Technology Adoption Model which posits that adoption and usage of technology is inherently connected to the user’s perceived efficacy and perceived ease of use.

As such, the definition used for perceived efficacy is “the degree to which a user believes that a particular system will impact their job performance” (Davis 1989, 319-340). Davis’ definition of efficacy provides the framework through which I evaluate the utility of our lesson plan as designed and proposed. Interestingly, Davis does not rigidly define the term *job performance* but rather leaves up to the individual to identify it as something “advantageous to the organizational context” of their position. For educators, job performance is defined as teaching their content/curriculum within the context of their classroom or school. In short, if a teacher perceives a technology or software tool to be effective, they are more likely to make an effort to utilize that technology in their classroom and/or explore how that technology can be used to effectively teach their curriculum (Er & Kim, 2017)

Research Questions

This research aims to address two fundamental questions related to the lesson, “Incorporating ArcGIS Online in social Studies Classrooms.” First, is the lesson - as designed - perceived by the educators to be effective for teaching geographic and economic concepts in high school social studies courses? Second, is this lesson perceived to be effective to introduce geographic concepts (and spatial thinking) into a high school level cross-curricular IBL module?

This study also aims to identify, in a narrow sense, a method in which geographic concepts and themes that have been receiving short shrift in public school curriculum in recent years can be given a new pride of place through a cross-curricular “STEM” centered introduction of GIS into existing curricula. Especially as the potential for multi-disciplinary exploration is well documented (Schuurman, 1999) as are the debates surrounding the melding of empirical data and social information through the medium of GIS (Martin & Martin, 1996).

ArcGIS online is considered as a potentially ideal vehicle for these concepts (merging empirical data and social information through a spatial lens) because of its low monetary adoption costs and its relative ease of use coupled with its ability to produce products and opportunities for data and spatial analysis that go well beyond what is normally found in a social studies classroom. Incorporating GIS in non-geography coursework has been successful at the various levels of education (Baker & White, 2003) and ArcGIS Online has been identified for the ease at which it allows for practical and hands on professional learning, (Molikevych, Bohadorova, Kovalova, & Okhremenko, 2019).

This study simply attempts to use those previously identified benefits and leverage them in a high school setting.

Literature Review

Broadly, the relevant research into this topic can be divided into two categories germane to our inquiry: firstly, research related to the adoption of technology by teachers in the classroom and secondly the usage of Geographic Information Systems (GIS) technology in high school classrooms in the United States of America.

Technology Adoption

Using Davis' research and Technology Acceptance Model (TAM) as a starting point (Davis, 1989) and the more recent research that resulted in the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) the vast majority of authors concede that the acceptance and use of technology in the classroom is similar to that of other fields and is deeply context based (Lestari and Indrasari, 2019) - meaning that adoption depends upon specific applications and perceptions of utility for those applications as well as relying on the flexibility of the users to adapt to and adopt new methods.

Context based teaching styles, form a part of what has become known as the contingency model of teaching that deviates from the standard student-centered versus teacher centered spectrum of teaching models. The model suggests that teachers are more flexible in their adoption of alternative methods of teaching if they believe those methods to be effective in addressing learning objectives (Gregory & Jones, 2009).

Additionally, at least in the developed world, second-order barriers to utilization are far more powerful (Ifenthaler and Schweinbenz, 2013) in dissuading the adoption of those technologies. Most potential users in the developed world have the financial means to adopt popular technologies and any limitations in widespread adoption are based not in financial concerns but rather perceptions of utility, ease of use and willingness to change existing methods.

It is those *second order barriers* that are the primary concern of our analysis as they include intrinsic obstacles, such as personal beliefs in the efficacy of a particular technology as well as personal levels of comfort in utilizing that technology (Khe & Brush, 2007). Some researchers have delved deeper into this consensus with the aim of examining how a classroom teacher's views of epistemology and theories of knowledge acquisition fundamentally alter and affect their willingness to adopt technology in their classrooms and how effectively that technology is than utilized (Kim et al., 2013)
In short, one can argue that one's view of the construction of knowledge will affect how willing an individual (student or teacher) is to perceive a particular technology or methodology as effective and as such will color their performances on any number of tasks that call for higher order thinking (Schommer-Aikins, Duell, & Hutter, 2005). In research related to epistemological views and educational practices the primary focus is using those views to predict outcomes that include adopting specific educational methods (Schommer-Aikins & Hutter, 2002). Such an analysis is beyond the scope of this proposal but may still hold utility in asking participants to reflect on their own

epistemological views in order to fully and more accurately judge the perceived efficacy of the instrument.

In brief, the research suggests that those with constructivist views of knowledge (based on own experience and world views) are more likely to be willing to incorporate new technologies in their classrooms than those who have a social-constructionist background (knowledge based on interactions with peers and educators). Some researchers have suggested that this linkage between constructivist viewpoints of knowledge and a willingness to adopt technologies that encourage minimally guided student learning has its roots in the way science has traditionally been taught and a bias amongst science educators towards empiricism and a view of authentic learning that closely mirrors the scientific method (Kirschner, Sweller, & Clark, 2006). Additionally, how those educators implement the technology in their classroom will also be dependent on those pedagogical backgrounds, but is subject to change as teachers grow more comfortable with specific technologies (Burke et al., 2018). Furthermore, positive attitudes towards the perceived usefulness of a particular technology amongst learners impacts the likelihood of the adoption and utilization of that technology (Lee, Yeung, & Cheung, 2019; Domingo & Garganté, 2016) highlighting that an educator’s own attitudes towards GIS (or any classroom technology) may go a long way in integrating that technology.

GIS Usage in High School Classrooms

In the state of Texas there is, as of 2014, no requirement for students to complete a course in World Geography in order to graduate from high school. The state of Texas has never required students to complete a course - even an introductory course - in Geographic Information Systems (GIS). In fact, the only mention of GIS in the state standards (Texas Essential Knowledge and Skills 2019) for the (optional) World Geography Studies course is that "The Student is expected to: describe the impact of new information technologies such as the Internet, Global Positioning System (GPS), or Geographic Information Systems (GIS)" and "use case studies and GIS to identify contemporary challenges and to answer real-world questions" (TEKS Subchapter C.113.43.C.21& 23).

A GIS focused Career and Technical Education course was created in 2013 for students in grades 10-12 in the state of Texas, but as of 2017 only 207 students - out of over 350,000 students taking geography courses in Texas - were enrolled (Texas Alliance for Geographic Education, 2017). Couple that lack of enrollment with lack of access, GIS CTE courses are only offered in 7 school districts in the state of Texas (TAGE, 2017) and the fact that the state of Texas does not consider a university degree in Geography as qualifying one to teach a GIS CTE course (Texas Education Agency, 2017) it is no wonder that these courses -- and by extension the knowledge and application of GIS they engender -- is virtually absent in Texas high school classrooms.

Research into the adoption of GIS technologies into high school classrooms is far more limited than research related to the idea of technology adoption in general, but has generally held that perceived usefulness is a primary indicator and driver of adoption (Lay, Chen, & Chi, 2013) thus informing our decision to focus our research on the perception of usefulness and efficacy by our participants.

What research does exist regarding the specific adoption and integration of GIS technologies in high school classrooms in the United States is focused almost exclusively on how in service teachers can be taught via workshops (Stonier & Hong, 2016) how they may utilize GIS in their classroom and even the widest ranging of this research has reported that second order barriers - specifically issues regarding perceived ease of use and efficacy -- present the strongest obstacles to implementation (Baker, Palmer, & Kerski, 2009).

Much of the literature surrounding the adoption of GIS technologies in the classroom has focused on schools and school systems outside of the United States and has remarked on the slow adoption of GIS in the United States' education system relative to other economically developed nations (Bednarz & van der Schee, 2006). The research that has been centered on classrooms within the United States has been almost exclusively concentrated on the introduction of GIS within the framework of a broader curriculum rather than as an additional tool for the classroom teacher to use as appropriate given existing curriculum (Khe & Brush, 2007) as this lesson proposes to do. A handful of similar studies exist and focus primarily on quantitative student outcomes centered around using GIS in the classroom, but even these student performance focused studies acknowledge that teacher's perceptions of "utility" and "effectiveness" are invaluable in determining the likelihood of adoption in the classroom (Linn, Kerski, & Wither, 2005). Generalized research surrounding student usage and adoption of technology suggests that a student's environment (particularly school environment) plays a fundamental role in determining what technologies those students use, how comfortable they are with their usage and their likelihood of using those technologies outside of a classroom setting (Katz, Felix, & Gubernick, 2014).

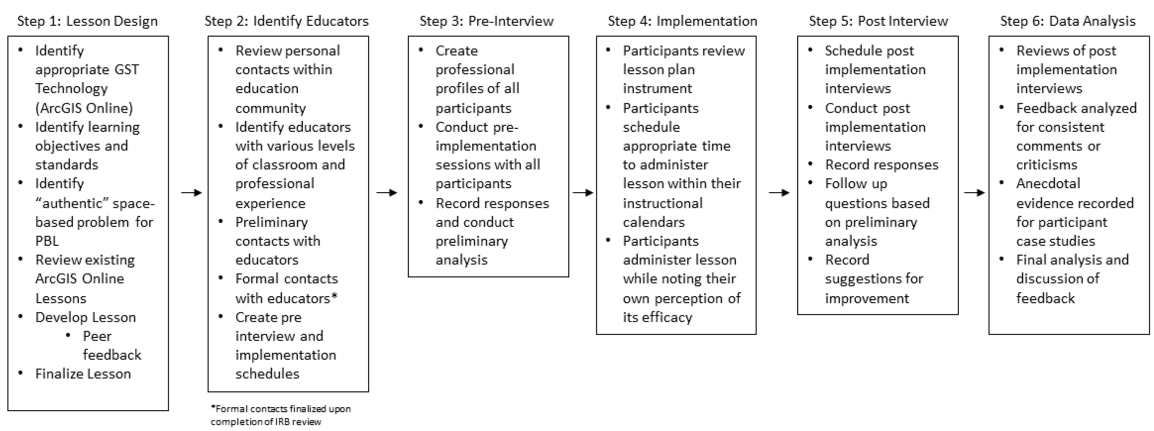
Previous research has also shown that regular usage of GIS produces more efficient spatial thinkers among educators and students (Bednarz & Bednarz, 2008) and improvements in a student's spatial thinking abilities have been correlated with greater success in STEM fields (Sorby, Veurink, & Streiner, 2018) implying that normalizing the usage of GST within a classroom setting holds the potential to spur more familiarity and thus adoption of these technologies outside of institutions of higher education.

Methodology

Research design

The design of this research proceeded from: 1) the design, and refinement, of an appropriate lesson incorporating ArcGIS Online; 2) The identification of educators who could – based on their background and experience - administer the lesson, provide valuable feedback and are not experienced ArcGIS Online users; 3) Preliminary data collection culled from pre-implementation interviews; 4) The implementation of the lesson in a high school classroom; 5) Data collection via post-implementation interviews; and 6) Analysis of feedback and data gathered during post-implementation interviews (See Figure 1).

Figure 1: Research Design Outline



ArcGIS online lesson: "Incorporating ArcGIS Online in Social Studies Classrooms"

The lesson (See Appendix 1), originally crafted as part of graduate level coursework in pursuit of a Masters of Applied Geography, was designed for the specific goal of teaching geographic concepts and standards through the use of technology and IBL. An early decision was made to focus exclusively on GIS that were available freely to users and soon after that ArcGIS Online was identified as the ideal technology to adopt for these purposes. The next step was to create an IBL activity that fits within existing social studies standards, such as Texas Essential Knowledge and Skills as well as National Geography standards (see Appendix 1), for complete list of applicable standards. The lesson was then developed to mirror existing ArcGIS Online activities and designed to be easily implementable by those with little to no prior experience, but also be open-ended enough to allow for adaptation in its incorporation. Finally, in line with concepts and theories related to the educational benefits of both IBL and PBL, the early ideas crafted were joined with an authentic problem whose solution was both geographic and economic; ideally, setting a framework for future (multi-disciplinary) problem solving activities with relatively minor modifications from the educator.

Participant Profiles

Classroom teachers with a varying level of expertise and across different curricular backgrounds were identified in order to generate multiple avenues of feedback and identify areas of implementation and improvement that may have been overlooked by the researcher. The participants themselves were not chosen randomly but rather based on their potential ability to offer "insight and contribute to emergent concepts related to the research question" (Tong, Winkelmayer, & Craig, 2014). Based on that framework, the teachers participated in pre- and post-administration of structured interviews designed to elicit open-ended and wide-ranging responses.

All participants are professional educators with a variety of backgrounds and experiences. They were explicitly tasked with commenting on their perception of the efficacy of the lesson.

Participant 1.A high school educator with roughly five years of classroom experience within the United States and abroad. Participant 1 has taught at both the undergraduate and high school level. As a high school teacher, he is experienced with grades 10 through 12. His educational background includes degrees in computer science and related technology. Participant 1 has worked professionally within the computer science industry as well. He administered the lesson to a mixed grade class of computer science students.

Participant 2.A high school educator with more than a decade of classroom experience. He has taught grades 6-12 in Texas over their career in several different schools and settings. His educational background includes an undergraduate degree in a liberal arts field and a master's degree in education and curriculum. Participant 2 is currently teaching in an early college high school environment and administered the lesson to a class of 9th grade geography students of mixed skill levels.

Participant 3. A high school educator with less than three years of classroom experience. He has taught grades 6, 9 and 12 in Texas and has only worked in one school. His educational background includes undergraduate and graduate degrees in international relations. Prior to becoming an educator, participant 3 worked extensively in international economic and political consulting both in the United States and abroad. He administered the lesson to a class of 9th grade Advanced Placement Human Geography students.

Pre-Implementation Interviews

The method of data collection chosen for this research was that of the participant interview. This was chosen primarily because of the ability of interview questions to explore the unique perspective of the individual participants and examine the "why" behind their actions and motivations. The core of the data analysis therefore was structured around identifying core themes and concepts from the "thick description" of participant responses (Patton, 2002).

Some of the pre-administration questions were designed to prompt the participants to evaluate their own attitudes towards the adoption of technology in the classroom and think on what barriers they anticipate arising as research suggests the attitudes of the teachers before, during and after the adoption of new technologies play a significant role in their ultimate success or failure (Miller & Glover, 2002). Although not directly asked to classify or identify their own epistemologies or pedagogical philosophies, their characterizations were used to inform follow up questions in the post-implementation interviews and identify trends suggested in the literature.

Open-ended interviews were chosen as the primary method of data collection as the intent of the research question is not to obtain generalizable data, but rather a “deeper, more nuanced, understanding of underlying behaviors that might impact adoption and implementation of technology in the classroom” (Judkins & Hand, 1994). The questions were designed to follow established practice (Rosenthal, 2016) of incorporating truly open-ended and neutral questions that were iterative and evolved based on the participant responses. The pre-implementation interviews were conducted either in person or, based on the availability of the participants, virtually using a web-based meeting software (Zoom). Regardless of whether the interviews are in person or web based the interactions between the participants and the researcher have been recorded, and notes of the conversation were created to aid data analysis. An outline of pre-implementation questions is in Appendix 2, and participant’s answers to pre-implementation questions were used to inform follow up questions during the post-implementation interview sessions. The interviews themselves were structured to follow an open-ended interview model to solicit honest feedback reflective of the individual participants experience and expertise.

Lesson Implementation

After completing their pre-implementation interview session as described above participants were asked to implement the lesson in their classrooms within a two-week window that fits best within their personal schedule and the scope and sequence of their curriculum guide. The implementation took between 60 and 90 minutes and sometimes required more than one period of classroom instruction, depending on how each educator's class schedules were structured. In order to implement the lesson plan as designed, participants were required to ensure access to desktop or laptop personal computers with reliable internet access as well as enough copies of the lesson plan to distribute to their students. The participants decided whether to have students work individually or in pairs.

During implementation the participants were instructed to make notes on the following:

- Their understanding of the instructions and objectives of the lesson plan
- How easily their students were able to follow the instructions
- Specific questions or misunderstandings raised by their students
- Generally, how they assess the "ease of use" of ArcGIS Online in their classrooms.
- Generally, how effective they feel ArcGIS online was in achieving the learning objectives laid out in the lesson plan (Appendix 1)

Post-Implementation Interviews

Like the pre-implementation interviews, the post-implementation interviews were conducted either in person or, based on the availability of the participants, virtually using a web-based meeting software like Zoom or Skype. Regardless of whether the interviews are in person or web based, the interactions between the participants and the researcher were recorded and notes of the conversation were kept in order to conduct data analysis.

An outline of post-administration questions can be found in Appendix 3. Individual questions were altered in response to participant's pre-implementation interview responses.

Analysis and Results

Broadly speaking, the data analysis was conducted within a framework of grounded theory – allowing for individual respondents to inform our thematic analysis and conclusions – while acknowledging that the construct of the interview questions was originally drawn from conclusions or gaps identified within the literature review. As such, the individual results derived from the one-on-one interviews varied quite a bit due to the varying levels of experience and different academic and professional backgrounds of the participants. As mentioned previously, the interviews themselves were recorded, and notes were taken during the interview. I reviewed the recordings later to ensure that the summary notes were an accurate reflection of the views, opinions and experiences of the participants. The interviews were not transcribed as it was unnecessary due to a belief that an informed qualitative analysis was more beneficial to the research than a rote transcript (Stonehouse, 2019). They are presented here on a case-by-case basis and then responses were synthesized in order to identify common threads and themes.

The data analysis approaches employed include positivist approaches to the qualitative data generated - Likert scales - to a thematic approach aimed at drawing broad conclusions on behavior that may be organized for more generalizable research in the future (Lester, Cho, & Lochmiller, 2020). This decision was made in part due to the small sample size of respondents and the goal of the inquiry to have an in depth personalized response to the questions posed in the pre and post interviews and a question structure that allowed for both template analysis and story analysis of responses. The former being useful for identifying and organizing broad themes and the latter for eliciting deep responses unique to each respondent (Cassell & Bishop, 2019).

Participant 1. The pre-implementation interview was conducted with Participant 1 in person during a 35-minute session on 10/29/2019. The framework of the interview questions can be found in Appendix 2. What follows is a summary of Participant 1's responses to the pre-implementation interview and then a summary of Participant 1's responses during the post-implementation interview.

Participant 1 had very little experience with GIS beyond a cursory understanding that it was somehow related information technology and drones. In fact, the only geographical software Participant 1 was familiar with at all was Google Maps which he praised for its intuitive and user-friendly interface. In general, Participant 1 is very comfortable and interested in utilizing new technologies in his classroom – as might be expected of a computer science and technology application teacher. He expressed his belief that the primary barrier to implementing new classroom technologies in his experience was bureaucratic – in that school administration often posed and created a logistic and financial barrier to experimentation and adoption of new technologies. As such, Participant 1 argued, free or browser-based technology was far more likely to be adopted – in his opinion. As the interview progressed, we discussed how Participant 1envisions the effective implementation of new technology. Participant 1 affirmed on multiple occasions that he felt the two primary sources of hesitancy he has experienced are a lack of clear instructions for students and a lack of expertise from the instructor teaching using these new technologies. Follow up questioning revealed that Participant 1's teaching methods (when using unfamiliar technology) was to review the proposed lessons himself to identify any errors. During this time, normally an hour or so, Participant 1 said he evaluates the lesson or module for two criteria: the first being that the module is understandable to students with clear goals and objectives and that it is something he thinks is relevant to the students progression within the field of computer science or information technology.

On this last remark Participant 1 suggested that he feels the best way to begin incorporating technologies like GIS into a high school curriculum is through a pilot program from a university or professional organization as the experience of the educators is likely lagging behind that which is found in the field. At the end of the interview session Participant 1 was given an opportunity to review the lesson as designed and offer preliminary observations he might have. Being unfamiliar with ArcGIS Online, he could not say for certain if he anticipated any difficulties with its implementation but observed that, based on his experience, the formatting and step-by-step instructions in the lesson were similar to his experience with other technology based lessons.

The responses solicited from Participant 1 during the pre-implementation interview that helped to craft the post-implementation framework were his focus on the 'perceived utility' and 'real world application' of any technology he used in his classroom to ensure that students were getting authentic exposure to technology and technology applications. This viewpoint aligns with his pedagogical philosophy regarding the role of a teacher as a facilitator (constructivism) and his view that the primary purpose of a technology is the function of the technology itself and its practical application; he views educational authenticity in a similar way to Sandoval and Reiser.

The post-implementation interview was conducted with Participant 1 in person on 12/19/2019 over a 40-minute period. The implementation in Participant 1's classroom that occurred on 12/17/2019 varied slightly from other participants. To begin with, Participant 1 implemented the lesson plan not in a World Geography or Human Geography class but rather in an Advanced Placement Computer Science class. Additionally, Participant 1 was the only participant who administered the lesson using desktop computers rather than Chromebooks or tablets – the key technical difference being a wired mouse rather than a touchpad. Prior to implementation of the lesson plan Participant 1 had attempted to use the lesson two weeks prior but had difficulties and was unable to implement it. This was resolved after permission and sharing settings were changed, but it highlighted the necessity to ensure that any technology applications intended for classroom use be as streamlined and user friendly as possible to ensure maximum educator's comfort levels that lead to adoption and implementation (Combs, 2010).

On the first question, rating the overall efficacy of the lesson, Participant 1 gave the lesson a 5 out of 5. When asked to elaborate on their reasoning for that score the participant focused on how he felt that the structure of this particular lesson fit their self-professed "style" as an educator in that he viewshimself as a facilitator rather than an instructor. Participant 1 prefers to let students "figure things out for themselves" as they progress through technology usage, during the lesson the students asked “one or two” “low level” questions that he felt comfortable answering. For the most part the instructor was fine with allowing students to answer their own questions through the framework of the lesson. As the students completed the lesson, the focus of their questions were not on the technology but rather specific terminology that the instructor had not pre-taught given that it is not a World Geography or Human geography class. This reinforces the need to ensure that appropriate academic vocabulary is incorporated fully into the secondary social studies classroom (Cruz & Thornton, 2012; Harmon, Antuna, Juarez, Wood, & Vintinner, 2018).

As Participant 1 is a computer science and technology applications teacher, the question on whether or not ArcGIS Online improved over “traditional” methods had less relevancy than with other participants but had significant commentary on the utility and usability of the technology itself and how ArcGIS Online compared to other technology applications the participant is more familiar with. Prior to the administration, the instructor reviewed the lesson and accompanying instructions and found that they were “easy to follow” and as such he did not anticipate any substantive problems with the implementation. The instructor commented that he felt the ArcGIS Online interface was “intuitive” and would be easily understood by anyone with experience using technology applications. The participant followed up with students after the implementation to solicit feedback and summarized the student feedback as stating that the lesson was “understandable and clear” and that he was comfortable navigating ArcGIS Online. This portion of the post-implementation interview focused primarily on preferred teaching methods and what is effective vs. ineffective teaching in the instructor's experience. As stated previously, the instructor views themselves as a facilitator and viewed the ArcGIS Online lesson as very effective in that he felt it put students into a position that required problem solving and that "outcome/objective based learning" is the ideal form of education for Secondary Students. In light of this and in regards to the lesson vs. "traditional methods" Participant 1 thought that the traditional role of teacher was fast becoming "obsolete" and that in their experience students often viewed classroom teachers as "another form of Google" and an easy reservoir of information that allows them to avoid learning for themselves. As such, he felt that "traditional methods" are ineffective at promoting authentic learning experiences.

On questions specifically related to spatial thinking the participant had difficulty verbalizing and analyzing these concepts but was able anecdotally elaborate on some student work that touched on the potential for ArcGIS Online in teaching these concepts. During the implementation of the lesson students researched neighborhood/demographic statistics through ArcGIS Online's available layers to get a more nuanced understanding of location-based analysis. Specific examples included researching income levels of a specific neighborhood as a way to justify the potential location of a niche health food restaurant and the discovery of students, on their own, of various additional layers and data that supported (or refuted) their original location analysis. Another example of a specific cross-curricular outcome was students having to research the term "jurisdiction" in order to adequately understand the zoning implications of their potential decisions.

Participant 1 had strong opinions on the utility of classroom technology (perceived and/or practical) and feels that any technology used in the classroom must have practical application outside of the classroom. Elaborating, Participant 1 stated that authenticity is a key to student buy-in/ownership and he feels (philosophically) that educators should be focusing on preparing students for the workforce. Analogies he used to further drive home their point were the potentially disutility of teaching programming languages like Cobol or Pascal, that while they still appropriately covered core concepts of computer science were obsolete and thus impractical. Participant 1 likened using impractical classroom technology to teaching cursive writing in 2020.

Our first participant had “no real experience with GIS” prior to administering this lesson. However, he had previously used geolocation data for the development of several apps, but never dedicated GIS technology. When asked how he may implement ArcGIS Online in future lessons or projects Participant 1 stated that they viewed the lesson as “an experience” that while not directly useful for their classroom or their work was something that could be called upon later to assist with future app development. The instructor had no substantial problems with ArcGIS online and said he saw no barriers to prevent future use as needed, especially if the technology is representative of “industry standards” so that he could be confident their students are receiving practical instruction.

I ended our post-implementation interview with a discussion of observed strengths and weaknesses of the lesson. Participant 1 thought that the biggest strengths were the “step-by-step” instructions and the intuitive interface of ArcGIS Online. The biggest weakness he identified, one that might be mitigated in a geography classroom and/or through proper pre-teaching of concepts, was students not understanding how to determine the relevancy of layers and data that they discovered and how to judge which information was more valid to their conclusions.

Participant 2. Participant 2 is a far more experienced teacher than Participant 1 in terms of both classroom experience and familiarity with GIS and similar GST. He has an educational background that includes a master's degree in curriculum and instruction and a professional background that includes several years of teaching Advanced Placement Human Geography courses, of which GIS – specifically ArcGIS Online – is an encouraged classroom resource.

As Participant 2 was familiar with ArcGIS Online as both a user and a facilitator of its use in a classroom setting, the bulk of the pre-implementation interview focused on his perception of barriers and obstacles faced by educators when implementing new technology in their classrooms. The perspective of Participant 2 was further informed by the fact that he has been teaching at a 1:1 (that is one device for every one student) campus for the last four years and has seen firsthand both the opportunities and limitations to technology in the classroom.

From an administrative perspective Participant 2 identified an inability from school administration to judge the inherent value of newly proposed technology and with a focus on implementing a new technology rather than ensuring that students experience "authentic usage" of that same technology, referring to most efforts to adopt/implement new technology as "shallow". His experience further supports existing research, identified in the literature review, that first order barriers are not as relevant to technology adoption in the classroom and the bigger obstacle are second order barriers that interfere with practical technology adoption. Expanding on this notion, Participant 2 referred to his students – and by extension current high school students – as the "thumb generation". When asked to elaborate, he offered up his analysis that though the current generation of high school students has unprecedented access to technology, the majority of them have a superficial understanding of its application and cannot, without instruction, do much more than *swipe* the surface of the interfaces and technologies to which they are exposed. As a result, he feels, the usage of technology in the classroom must be extremely well planned before its introduction up to and including ensuring that step-by-step plans are provided for both the educator and the student to ensure engagement, Participant 2 mentioned on more than one occasion the need to teach students how to "digitally manage themselves" a process that requires good lesson design as well as an instructor comfortable in using that technology.

Participant 2 consistently commented on what he referred to as the "digital ***literacy*** divide" (emphasis his) in technology education and that in 2019, in the United States at least, access to technology itself was a much smaller obstacle to overcome than an in depth understanding of the potential and usages of those technologies. In depth research is needed to ensure that when technology is being implemented in the classroom it is implemented effectively. Similarly, to Participant 1, Participant 2 discussed how the technologies used in the classroom must be perceived by the students as useful and authentic in order to maximize their potential for teaching non-technological objectives.

He commented on his mixed success with ArcGIS Online in the past as he observed that students found its interface too difficult for students to use it effectively and as a result student engagement with the technology interfered with the goals and objectives of the lesson as intended. Participant 2 did say that despite his previous experiences, he feels that ArcGIS Online would be an effective tool for teaching spatial concepts if the lesson was designed and implemented effectively.

As the interview wrapped up we discussed more macro level concerns about the adoption of technology in the classroom and Participant 2 mentioned again the barrier school administration can pose and his opinion that administrators need to have knowledge of the technology, the related content, and related learning objectives in order to effectively coordinate the implementation of new technologies in the classroom. He acknowledged, however, that level of administrative engagement was “rare”. Participant 2 also noted the headwinds facing geographic education in the state of Texas and identified the importance of ensuring that geographic concepts continue to be taught in our public schools despite the structural shift away from their importance.

Participant 2 suggested, similarly to Participant 1 that the perception of utility outside of the classroom was a key factor into whether he'd feel comfortable adopting this technology in their classroom going forward.

The post implementation in with Participant 2 was conducted via Zoom on March 11, 2020 over a 45-minute period.

On the first question (rating the efficiency of the lesson) Participant 2 scored the lesson a 4 out of 5. The primary driver for his score was that he felt the lesson allowed students to be exposed to practical applications of GIS technology and that it fits in well with his campus's focus on career readiness education. He felt that ArcGIS Online was a very good example of technology that doubled as both a teaching tool and a system with practical workforce applications. Participant 2 felt that ArcGIS Online was an effective method for teaching identified objectives and that increased regular and rigorous uses of technology in the classroom will maximize the efficacy of this or any other classroom technology.

Similarly, Participant 2 rated the lesson as a 4 out of 5 in how effective it was at teaching spatial thinking concepts to students. The experience of Participant 2 relative to Participant 1 allowed for far different and more in-depth response to this question. He emphasized repeatedly that although this lesson could be used to teach spatial thinking and spatial concepts in order to ensure maximum efficacy and utility, it would be wise to ensure that these concepts are pre-taught and that students have a baseline of spatial thinking competency before engaging in the lesson. He stated that his classes (Advanced Placement Human Geography and World Geography) are structured around expectations that students learn the "how" and "why" of spatial patterns and as such were primed to make spatial connections and to succeed when confronted with inquiry based learning objectives.

Specific examples highlighted by Participant 2 included students using layers of data above and beyond what was prescribed in the lesson to ensure that students made more and deeper connections to spatial concepts. In so doing, he felt that ArcGIS Online was particularly effective in allowing students to use "real world data" and ground an academic assignment in practical terms, expectations and outcomes.

Participant 2's views on the utility of technology were broadly similar to those of Participant 1. He felt that technology used in the classroom should (ideally) have a practical utility for students beyond academics, but felt that technology could still be justified for classroom use even if it didn't have a direct usage outside of a classroom setting. He generally felt that technology should be used more frequently and regularly in social studies classrooms and that the ultimate metric for the applicability of technology boiled down to two questions: 1) Can a teenager use it? and 2) Is there a simpler alternative available?

If the answer to the first was yes and the second no he saw no reason to not incorporate technology in their classroom as he firmly believes that teachers should embrace “constant” device usage in the classroom as it is both an acceptance of existing realities as well as better preparation for post-academic careers.

When pressed on how much understanding of ArcGIS Online he felt would be necessary to effectively utilize it in a classroom setting, Participant 2 said that instructors should have a basic understanding of any technology that they use but that ultimately ArcGIS Online is “self-explanatory, visual and local” and thus relatively easy for students used to classroom technology to figure out and utilize effectively.

Participant 2 was fairly experienced in using ArcGIS Online so didn’t feel that he learned anything new about the software other than he was more exposed to the variety of data and layers available. He felt that students were able to use ArcGIS Online with relative ease and were able to complete the tasks with little difficulty. Participant 2 felt strongly that ArcGIS Online is particularly useful tool in allowing students to make inferences using a variety of data and apply that data spatially in a way that is difficult to do in more “traditional methods”.

In identifying potential barriers to usage, he mentioned that timing issues with specific schools and/or districts in regard to their individual scope and sequence and curriculum guides may make adoption of technologies like ArcGIS Online difficult. Additionally, he commented on how usage of ArcGIS Online doesn’t align with traditional ways of grading assignments and thus teachers may have to be more creative with assessing student work and progress.

Finally, Participant 2 re-iterated his belief that ArcGIS Online is an important tool and that more social studies classrooms (not just limited to geography) should incorporate it and other widely available digital tools into their classrooms in order to re-enforce that many of the concepts at the root of social studies classrooms aren't just academic and have a grounding in the workforce. This view of ArcGIS Online as a tool through which students can more effectively learn spatial thinking and spatial concepts differs significantly from Participant 1 who approached ArcGIS Online as a subject for learning in of itself and one whose authenticity (and therefore validity) was based on its real world practicality. As such, their interpretations of the perceived utility of the technology were developed from different pedagogical frameworks.

Participant 3. Of our three participants, Participant 3 was the least experienced in terms of classroom teaching, which may have brought a different perspective to the study results. Participant 3 also identified himself as the least comfortable with new technologies in general, referring to himself on more than one occasion as a "caveman" in terms of adopting new technologies in his personal life or the classroom.

This observation drove the initial part of our pre-implementation interview as I sought to find what he found to be effective technology uses despite his own reticence to integrate technology into his classroom. Participant 3 identified three major criteria that would drive him to explore the adoption of a new technology: ease of use, perceived importance and (for the classroom) if it was a technology that would "clarify a (learning) objective and affect student success." With this as a basis he discussed his exposure to ArcGIS Online as part of a professional development session run by the College Board. His experience was summarized by two, perhaps conflicting, takeaways: 1) The interface was overwhelming and not user friendly and, as a result, he didn't feel confident in using the software in his classroom or otherwise; 2) He recognized the importance of GIS for teaching spatial thinking in general and geographic concepts and particular and expressed a desire to either learn how to use GIS effectively or be given an opportunity to use it effectively in his classroom.

Spatial thinking dominated a large portion of our pre-implementation interview and Participant 3 argued that it is a skill set that is vital for a number of careers – citing his own experience in international relations as an example – and something that most high school students sorely lacked. When asked for examples Participant 3 said that students have "no understanding of space" which leads them to lose critical analytical dimensions when studying conflicts (both historical and contemporary). He also said that an inability to make those spatial connections limits their ability to fundamentally understand key concepts that span the breadth from physical to cultural to political phenomena.

He was optimistic that if employed correctly GIS could be used to effectively teach spatial concepts and expose students to those basic tools needed to truly and deeply understand the world in which we live. However, Participant 3 worried about the technological capabilities of the average student and (like Participant 2) acknowledged a general technological capability amongst his students but worried that complex tasks were beyond the grasp of the majority of most students and would only create frustration and failure to both master the technology and grasp stated learning objectives. Participant 3 did not employ the same turn of phrase but was describing a similar *digital literacy divide* as Participant 2.

In response to follow up questions meant to elicit how one might overcome those barriers, Participant 3 spoke about how complex tasks needed to be effectively sub-divided ("chunked") into manageable tasks that would not leave the students feeling lost. Additionally, he mentioned that the technology itself must be seen (by both educator and student) as "both important and necessary" in order for them to realistically adopt and integrate that technology.

Participant 3 had fewer comments than our other subjects in regard to administrative support (or the lack thereof). He did feel that, generally, school administration is "not supportive" of change up to and including the adoption of new technologies. He suggested, however, that much of that resistance may be rooted in a cost aversion from an administrator and a lack of understanding how the technology in question can assist teachers in teaching specific objectives. Both of which, Participant 3 offered, could be overcome with no cost/low cost technologies and an informed well-trained classroom teacher.

The post implementation interview with Participant 3 took place via Zoom on 2/14/2020 from 11:30-12:00 PM. The instructor had a different experience from participants 1 and 2 in that he found working with ArcGIS Online to be fairly difficult. The lesson was conducted over several days as part of a 9th grade Advanced Placement Human Geography class and was used to supplement traditional instruction rather than as a standalone lesson. Students used the lesson as part of a unit on industry and was intended by the instructor to supplement lessons on economic sectors and their spatial patterns.

On the first question of overall efficacy Participant 3 labeled the lesson as a 3 out of a possible 5. The primary driver of this score was that the participant did not find ArcGIS Online to be user friendly or intuitive and that this interfered with learning objectives and made classroom management of this technology more difficult. He did feel, however, that there was significant potential for improving over traditional methods of teaching specifically because of the visual components of ArcGIS Online that allow students a concrete way to "visualize abstract concepts" like the relationship between different phenomena both spatial and non-spatial. The response to this bled into the second question about the specific efficacy of teaching spatial thinking (which he scored a 4 out of5) in that traditional methods do not provide an opportunity for students to visualize and interact with spatial relationships.

On whether technology used in the classroom needed utility outside of the classroom Participant 3 balked at providing a definitive answer. Rather he summarized his beliefs in the utility of classroom technology as simply being whether "it helps teaching the concept".

Most of where Participant 3 varied from our other instructors was in his view on the accessibility (or lack thereof) of ArcGIS Online. Participant 3 had no experience with ArcGIS Online and described himself as a technological neophyte. He acknowledged that given time, training and opportunity to familiarize himself with the software, he would likely gain a foothold and a greater level of comfort, as it stands now he was overwhelmed by an interface that he described on multiple occasions as "not user friendly". Participant 3 gave this lesson to what he described as his more qualified students but even still identified only one student who had the technological confidence/capacity to "play around" with ArcGIS Online beyond the specific instructions provided. As a result of the an "unintuitive" interface Participant 3 identified the specific step-by-step instructions provided as necessary to ensure that he could implement the lesson at all in his classroom. He did stress that he would be happier with even more specific instructions to remove any areas of potential confusion. He described some students as "not even knowing where to click." Participant 3 suggested that more basic instruction with ArcGIS Online is likely needed before he would feel comfortable using it in his classroom consistently or recommending it for another teacher. He was particularly frustrated in that his students had repeated difficulties manipulating the layers of data, what participant 3 described as the most useful feature for teaching spatial concepts, and that students would have their data layers "disappear" and did not know how to remedy the situation on their own.

Ultimately, Participant 3 expressed a positive overall experience with ArcGIS Online despite the issues he had with it and would be interested in learning more about its potential uses in the classroom, provided he had an opportunity for more formal training and time to interact with the software on his own before implementing it in his classroom.

Discussion and Conclusions

In the beginning the questions that were asked were straightforward, based on existing literature and intimately interconnected.

1. Is ArcGIS Online an effective tool for teaching spatial thinking skills in a secondary social studies classroom
2. Do educators perceive ArcGIS Online as an effective tool for teaching spatial thinking skills in a secondary social studies classroom

The purpose of this research was, primarily, to create a lesson plan that would allow teachers of varying experience and skill level to successfully implement ArcGIS Online into their classrooms and to gauge its efficacy in teaching spatial concepts in a classroom setting. As research progressed that purpose expanded to include an analysis of reasons that might prevent educators from using ArcGIS Online in their classrooms and/or that have prevented them from adopting classroom technologies in the past based in part on theories gleaned from the literature review and from the participants own responses and reflections.

Research was conducted through a series of interviews before and after the implementation of a classroom IBL module centered on the usage of ArcGIS Online to answer questions about the ideal location of a small business in the Austin, TX area. The format of the IBL module adopted here was intended to solicit a structured student response rather than a completely open ended inquiry. This guided/structured approach was chosen, in part, to minimize any barriers for first time or novice users of ArcGIS

Online and ensure that participant feedback was focused on the efficacy of the platform and their perception of that efficacy.

Participant responses were then used to inform the conclusions and are presented here in three categories that align with previous literature and participant responses. Perceptions, Integration of GIS and Ease of Use.

Those reasons, as a review of the relevant literature had suggested, primarily were focused on the educator's perception of the utility and ease of use of ArcGIS Online. One factor that arose during our interview process that was not identified in our literature review was the necessity of potential workplace utility of a classroom technology in order to support its perceived effectiveness by the educator and its perceived *authenticity* by the students.

Perceptions

The responses elicited from our participants are aligned with expectations about how perceptions of technology and attitudes towards instruction would influence ease of adoption in the classroom. Participants 1 and 2 (though coming from different professional backgrounds) shared a similar educational philosophy surrounding the role of technology in the classroom and the building of knowledge through experience; an outlook that is more likely to correlate with effective adoption of new technologies in the classroom and reduction of barriers to that implementation (Demirci, Karaburun, & Ünlü, 2013). Specifically, both participants felt that effective implementation of technology in the classroom was vital for both teaching specific curricular objectives and for preparing students for careers and experiences beyond high school.

Participant 3, on the other hand, was much more of a novice when it came to classroom technology. The inexperience of Participant 3 is likely reflected in the difficulties he had, relatively speaking, in implementing the lesson as written and his reluctance to continue to use ArcGIS Online in their classroom without more extensive professional development and training. An attitude that reflects a persistent and common barrier for educators (Yu, Huynh, & McGehee, 2011).

Collectively, the responses of our participants also serve to confirm assumptions gleaned during the literature review that second order barriers are far more likely to impact the adoption of classroom technology than first order barriers. As the technology required to implement the lesson plan is readily and easily available the only actual obstacle to its implementation would be the comfort level of the educator and/or their perception of its efficacy. Participant 3 is representative of an educator with a low comfort level with the technology who nevertheless recognized its potential utility.

GIS Integration

The results also shed light onto how GIS is not a regularly used tool in many classrooms, confirming what previous research suggested. Participant 1 (Computer Science and Technology Application teacher) recognized the potential to use GIS for future classroom projects and identified that familiarity with it and normalizing its use would make him and his students more likely to consider GIS when creating applications with a geospatial component. Participant 3, despite being a World Geography and Human Geography teacher, had no practical experience with GIS and was eager, but wary, of implementing it in their classroom. The experience and responses of our participants likely highlight two factors about the adoption of classroom technology and specifically about the adoption of GIS in the classroom.

First, if not directly mandated as part of a course (either social studies or technology applications) GIS will not be consistently implemented in high school curricula. Second, regardless of the intention of curriculum writers and policy makers, mandating the adoption of GIS is unlikely to be effective without robust professional development and training intended to overcome second order barriers to adoption by individual teachers and perhaps encourage individual teachers to pursue professional development opportunities in GIS (Collins & Mitchell, 2019). Additionally, effective professional development could allow for teachers outside of social studies to identify cross curricular usages of which they may not have been previously aware and serve as a basis for multi-disciplinary IBL.

Ease of Use

Finally, the implementation of this lesson and the feedback received from the participants further support the literature that normalized and routine use of technology is vital for its adoption in a classroom or professional setting. Currently, the only standards existing in Texas for GIS instruction lay in teaching students *about* GIS (TEKS

Subchapter C.113.43.C.21& 23) rather than teaching students *with* GIS and how to effectively use it in confronting problems requiring spatial thinking.

As identified in the data collection phase of the study, students who had more experience using technology in general (or ArcGIS Online in particular) had much more success with completing the lesson. Additionally, those students who had a higher comfort level with classroom technologies were more likely to pursue solutions beyond the script of the lesson plan and engage with the spatial thinking objectives in a more in-depth manner. As envisioned and designed, the lesson plan implemented in the study was intended to be useable by teachers and students with a minimum of experience with GIS.

What I discovered is that the lesson is – as designed – implementable regardless of relative levels of competence and experience with ArcGIS Online. However, more experience with GIS (or classroom technologies in general) provided a higher level of comfort level for educators administering the lesson. I also predict that greater familiarity with GIS will create opportunities for more rigorous and authentic learning amongst the students as they learn to explore the application in unstructured ways and amongst educators as they find more and more ways to incorporate GIS in their classrooms.

Additionally, I discovered that educators view the potential for ArcGIS Online to supplement the learning of geographic skills as high and would be eager to incorporate it into their classrooms on a more regularly basis if empowered to do so. The biggest barriers to adoption remain second order barriers related to the personal comfort level of the educator asked to use it and the inability to fit projects designed around ArcGIS Online into a traditionally focused scope and sequence and curriculum that tends to be standardized at the district level and may allow for little variation from classroom to classroom.

The specific conclusions drawn here that support the existing literature -- namely that ease of use and perceived utility are primary drivers of classroom technology adoption along with conclusions that have less basis in the literature – that perceived utility may also include the practical application of technology beyond the classroom – may serve as the basis for broader more generalizable research. Additionally, the themes that emerged from the literature review and from the individual interviews may provide further analytical tools for decision makers considering the adoption of classroom technologies, like ArcGIS Online for use in their schools. The viewpoint of individual teachers, as they will ultimately be responsible for the success or failure of a new classroom technology, should be taken into account during the decision-making process. In short, the data supports the original purpose of the research in identifying potential barriers to adoption of GIS in the secondary classroom so as to implement methods and practices for overcoming those barriers.

Going forward broader adoption of GIS tools in American classrooms is likely to carry multiple academic benefits. The most obvious potential benefit is the return of geographic education to a more prominent place in traditional high school curriculum. Secondly, adoption of these technologies would allow for an ability to bring neglected social studies objectives into a STEM-focused campus. Additionally, the normalization and routinization of these technologies at a younger age would contribute to ensuring that spatial thinking remains central in the application and inquiry of other disciplines as students become familiar with the potential tools offered by GIS. Finally, adopting GIS technologies as routine within geography classrooms at the high school level would serve to bring American high school students closer to the expectations and experiences of their peers from around the world when it comes to exploring and exploiting the potential benefits of GIS technology.

Appendix 1

Economic Geography: Ideal location of a small business

Audience: HS Economics students in Central Texas Area

Time Needed: 2-3 60-90 minute class periods

Learning Objectives:

- **Students will be able to:**
  - Research costs typically faced by small business owners
  - Make economic decisions based on costs/benefit analysis
  - Make economic decisions based on competition
  - Identify demographic/socioeconomic variables that influence economic decisions
  - Create a business plan
  - Present/defend a business plan

Learning Objectives (GIS Specific)

- **Students will be able to:**
  - Analyze relevant spatial data
    - Interpret distance and location data
  - Use ArcGIS online to analyze economic viability of a proposed business location
    - Evaluate map layers for relevancy
    - Adjust business proposal as needed based on geographic data
  - Communicate findings to an audience with little to no geography background

Relevant Teks:

- World Geography:
- (6) Geography. The student understands the types, patterns, and processes of settlement. The student is expected to:
- (B) explain the processes that have caused changes in settlement patterns, including urbanization, transportation, access to and availability of resources, and economic activities.
- (10) Economics. The student understands the distribution, characteristics, and interactions of the economic systems in the world.
- (11) Economics. The student understands how geography influences economic activities. The student is expected to:
- (C) assess how changes in climate, resources, and infrastructure (technology, transportation, and communication) affect the location and patterns of economic activities.
- (23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings. The student is expected to:
- (A) plan, organize, and complete a research project that involves asking geographic questions; acquiring, organizing, and analyzing information; answering questions; and communicating results;
- (B) use case studies and GIS to identify contemporary challenges and to answer real-world questions; and
- Economics

- (22) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of valid sources, including electronic technology. The student is expected to:
- (E) evaluate economic data using charts, tables, graphs, and maps; and
- (16) Personal financial literacy. The student understands types of business ownership. The student is expected to:
- (A) explain the characteristics of sole proprietorships, partnerships, and corporations;
- (B) analyze the advantages and disadvantages of sole proprietorships, partnerships, and corporations;
- (C) analyze the economic rights and responsibilities of businesses, including those involved in starting a small business

National Geography Standards

- Standard 11. The patterns and networks of economic interdependence on Earth's surface.
- Standard 12. The processes, patterns, and functions of human settlement

Map URL: https://arcg.is/1mSeTP

Pre-Teach/Pre-Requisites

Before engaging with the lesson students should be familiar with the following economic/geographic concepts:

- Types of business organizations
- Methods to project revenue
- Methods to project costs
- How to complete a break even analysis
- How to conduct basic real estate research

Before engaging with the lesson students should be familiar with the following skills in ArcGIS online:

- Account creation
- Toggling between layers
- Editing layers
    - Symbology, data display types, legend, etc.
- Basic tools
    - Adding Map Notes
    - Distance Tools

Guiding Question(s):

Given a budget of $200,000 you (and a partner) will establish a small business and create a business plan to present to potential investors. Your business must meet the following criteria:

1. Within the greater Austin, TX metropolitan area **2. Have an initial startup cost of no more than $200,000** **3. Have a realistic potential for profit.** **As you prepare your presentation you must address the following questions:** ***1. What type of small business would you open?*** ***2. What type of customer will your small business serve?*** ***3. Where will you small business be located?*** ***4. Is your small business located in an ideal location to service your target market?***

Activity:	Teacher Notes
Open Map: https://arcg.is/18rejm ***1. Identify the type of business you and your partner will establish.*** ***2. Brainstorm 3-5 characteristics of your target customer profile:*** **a. Suggested characteristics: age, income level, education level, gender** **3. Save a copy of the shared map as "Economics Location Project_yourname"** **4. Activate Layer "Area of Interest". These are the boundaries within which your business must be located** **5. Using the internet, research available real estate that would make an ideal location for your business:** **a. suggested sources: www.loopnet.com or www.cityfeet.com** **b. On map, click on "Add"** **1) Click "Add Map Notes"** **2) Change name to "Proposed Location_yourname"** **3) In search bar in upper right, type in the address of your proposed location** **4) Mark the address with a point** **i) In the information window for the point you've created add the URL that directs to the property listing for your**	**Students will complete the attached handout as they progress and use as notes on presentation**

proposed location by copying and pasting the URL into the space that reads "URL" **5) Activate the layer "CMTA Routes"** **i)** ***Is your proposed location near Austin public transit routes? Is that a positive or a negative for your business?*** **6) Reference the layer "Area of Interest"** **i)** ***In what jurisdiction is your proposed jurisdiction? How might different cities jurisdictions affect small businesses?*** **7) Turn off all layers except "Proposed Location_yourname" analyze basemap** **i)** ***Identify major roadways that would provide customers access to your location*** **6. Using the internet, research existing businesses that would be competitors to you** **a. Suggested sources (Google Maps)** **b. On map, click on "Add"** **1) Change Name to "Potential Competition_yourname"** **2) in search bar in upper right, type in address of a competitor** **3) Mark the address with a <u>different symbol</u> than that used for step 4** **4) Repeat steps 1-3 for other competitors** **c.** ***What makes your location more advantageous than your competitor's locations?*** **d*****. How are your products or services differentiated from your competitor's?*** **e. EXTENSION ACTIVITY (requires organizational account)** **1) Click "Analysis" under the "Proposed Location_yourname" layer** **2) Click "Use Proximity"** **3) Click "Create Drive Time"** **4) Set drive time to "15 minutes"** **5) Select Use Traffic and set time for Monday at 5:00 PM** **6) Change Name to "15 minute drive time_yourname"** **i)** ***Are any competitors within a 15 minute drive of your proposed location? How will that affect your plans?*** **7. Explore the other map layers and identify which ones are relevant to your business idea**	

8. Toggle those relevant layers on and off to get a feel for the visibility of the data. **a. Click "Change Style" under layer "Popular Demographics"** **b. Select Choose Attribute to show** **c. Cycle through list** **1) *Which of these attributes would be most representative of your target market?*** **d. For the attribute most useful to you** **1) Select counts and amounts (color)** **2) Select a useful color scheme** **9. Identify one demographic/geographic characteristic of your customer base that is not present in the map layers** **a. Click add – Click Search for Layers – Search ArcGIS Online for the variable(s) you've identified – Click the filter option – Check only show content within map area** **b. Turn on the layer you've identified** **c. *For each relevant layer, discuss why that that specific information is relevant to your target market***	
Presentation:	Teacher Notes
1. Save your map **2. Select "Create Presentation" on upper right hand corner** **3. Create 7-10 slides that show the different relevant map layers** **a. Click options and select "Show Legend for all slides"** **4. Use the completed handout as a *script* for the presentation** **5. Present your map and conclusions to the class/audience** **a. Presentation should be between 3-6 minutes**	

Name(s):____

____

1. Identify the type of business you and your partner will establish (e.g. café, auto repair, clothing retail).
    a. ____

2. Brainstorm 3-5 characteristics of your target customer profile (Suggested characteristics: age, income level, education level, gender, etc.)
    a. ____
    b. ____
    c. ____
    d. ____
    e. ____

3. Where will you small business be located?
    a. Address: ____
    b. Is your proposed location near Austin public transit routes? Is that a positive or a negative for your business?

    ____

    ____

    ____

    ____

    ____

    ____

c. Identify major roadways that would provide customers access to your location

____

____

____

____

d. Whose jurisdiction you're your proposed location fall under? What are some reasons that the jurisdiction would matter?

____

____

____

____

____

4. Who are your primary competitors?

a. ____

____

____

____

____

b. What makes your location more advantageous than your competitor's locations?____

____

____

____

____

____

c. How are your products or services differentiated from your competitor’s?

____

____

____

____

____

____

5. Which population demographic characteristics are most relevant when building a model of your target customer?

____

____

____

____

____

a. Why?

____

____

____

____

6. Which demographic statistic/characteristic was not present in the layers provided? Why did you choose that statistic/characteristic?

____

____

____

____

7. For each relevant layer, discuss why that that specific information is relevant to your target market

   a. ____
      ____
      ____

   b. ____
      ____
      ____

   c. ____
      ____
      ____

   d. ____
      ____
      ____

   e. ____
      ____
      ____

Appendix 2

Pre-Implementation Questionnaire

1. Are you willing to adopt a new technology into your classrooms? Why?
    a. What is a recent technology you've adopted in your classroom?
        i. If you feel willing to adopt new technologies, what do you feel are the primary barriers in doing so effectively? Are they any specific frustrations you've encountered in incorporating new technologies?
        ii. If you are hesitant in adopting new technologies, what do you feel is the primary source of your reluctance?
2. What technologies do you regularly use in your classroom?
3. Have you heard of GIS before?
    a. Can you describe GIS in your own words or provide some examples of how it is used?
4. Have you ever used GIS software before?
    a. Have you had professional development on the usage of GIS software before?
    b. If you are familiar with GIS, have you ever used it in your classroom?
        i. If so, what was the context in which you used GIS in your classroom?
        ii. If not, why do you think you have not incorporated GIS into your classroom instruction?
        iii. In what ways do you think GIS can be used in your classroom?
5. How easily do you feel students can learn to utilize a new technology in the classroom when asked?
    a. If you feel students struggle with new technologies, what do you feel are the best methods for overcoming those challenges?
    b. If you feel students readily adopt new technologies, do you think it is something specific to those technologies or the educator that enables that ease of use?
    c. How much does your perception of the student's ease-of-use influence your opinion on when to introduce new technologies in the classroom?
6. Based on your experience how supportive is school administration in general at adopting new technologies for use in the classroom?
    a. How does the support of school administration affect your views on whether or not to utilize new technologies in your classroom?

Appendix 3

Post-Implementation Questionnaire

1. On a scale of 1-5 how effective do you feel this lesson was at teaching the specific content objectives outlined?
    a. Can you elaborate on why you gave it that score?
    b. If you feel like using this technology was an effective way to teach the objectives identified?
        i. If yes, how did this improve over "traditional" methods you might have used in the past?
        ii. If you don't feel like using this technology was an effective way to teach the objectives identified, what were the primary barriers that limited the efficacy of this lesson?
2. On a scale of 1-5 how effective do you feel this lesson was at teaching spatial thinking skills to students?
    a. Can you elaborate on why you gave it that score?
3. Does technology that you use in your classroom have to have utility outside of the classroom?
    a. If yes, why do you feel that's important to you and your students? Can you think of a counterexample?
    b. If now, how then do you judge the merit of a classroom technology?
4. In terms of this particular technology (ArcGIS Online)
    a. Did you learn anything about GIS that you didn't know prior to administering this lesson?

b. After administering this lesson do you feel more comfortable using ArcGIS online in the future?

c. Generally, were the students able to use the software and complete the task(s) of the lesson?

d. What would be the main reason(s) that would prevent you from using ArcGIS Online in your classroom?

e. After using ArcGIS Online in the classroom, how do you feel about the experience?

    i. What are some strengths of the lesson?

    ii. What are some weaknesses of the lesson?

5. Is there anything else you'd like the researchers to know?

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