Adapting Models of Teacher Training and Curriculum Development for Online Geospatial Inquiry in High School Science and Social Studies Classrooms

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Abstract: This spring our research team received approval from the National Science Foundation for a multi-site collaborative research project. As envisioned at the time of the grant proposal, the core procedures were to be conducted in traditional, face-to-face formats: in-person teacher professional development, in-person curriculum development meetings, whole-class instruction by teachers and support instructors, and small group data collection by students using school-provided mobile devices. The onset of the COVID-19 pandemic forced us to re-visit intended models of curriculum design and development, professional development, and students' use of technology for online learning environments. After revising and enacting our plans, we discovered that our teacher training adhered closely to our intended process, but curriculum development and instructional support took on a far more rapid pace and were in some cases entirely driven by our participating teachers. This paper reports on our original model, our revisions to accommodate 100% online professional development and learning, and our outcomes to date with five participating teachers across two high schools.

Introduction

In February, 2020, our research team received approval from the National Science Foundation for a multi-year, multi-site collaborative research project (Award #1949400). This project was to be a scale-up from a previous grant, in which a single university, Lehigh, worked with a single local high school to conduct a three-year process of teacher training and curriculum development to integrate geospatial technologies into high school science and social studies classrooms. The newly-funded project expands the scope of activity to three universities (Lehigh, Texas Christian, and Washington State) and six high schools across four states: Pennsylvania, Delaware, Texas, and Washington. This paper will focus on one university (Lehigh) and its work with five teachers across two participating high schools (in Pennsylvania and Delaware).

As envisioned at the time of the grant proposal, all procedures were to be conducted in traditional, face-to-face formats: in-person teacher professional development, in-person curriculum development meetings, whole-class instruction by teachers and support instructors, and small group data collection by students using school-provided

mobile devices. (For details on these procedures, see Carrigan et al., 2018; Hammond et al., 2018; Hammond et al., 2019). However, as was true for many other education research projects, we were forced to adapt to the onset of the COVID-19 pandemic: how to conduct online professional development and curriculum development, how to design instruction, and even whether we should still include student-centered data collection. This paper reports on our revision processes, the results of our online enacted model imposed by the pandemic, and several changes that emerged from the intersection of teacher practice, and the outcomes of our professional development. We discovered that some of the adaptations we could plan for and design for online learning environments; other adaptations were imposed upon us by the flow of events and the needs of our teachers during this unusual time.

Starting state: Socio-environmental science investigations (SESI) in face-to-face environments

Our project focuses on socio-environmental science investigations (SESI) which are typically taught in high school science or social studies classrooms. The following design principles inform the creation of SESI activities:

1. Focus on socioscientific issues, socially relevant, real-world problems that are informed by science (Zeidler & Nichols, 2009), which touch on both social studies and science education;
2. Engage in place-based education (Gruenewald & Smith, 2014; Sobel, 2004), grounding all curricular concepts in students' local environment;
3. Focus on inquiry-driven learning in which students seek to answer driving investigative questions about their local environment;
4. Incorporate authentic data collection by students within their local environment to answer these questions;
5. Use geospatial technologies to promote geospatial thinking and reasoning skills—specifically ArcGIS Online and its associated Collector app—for data collection and analysis to make inferences about the geospatial patterns and relationships in the collected data; and
6. Require decision-making by students—including both data interpretation and policy determination (Engle, 1960)—about the local community.

These design principles guided us through a successful three-year process of working with local teachers to design, develop, implement, refine, and disseminate a year-long sequence of curriculum-embedded SESI activities (Carrigan et al., 2019; Hammond et al., 2019; see also https://eli.lehigh.edu/sesi). Our training and development process had two distinctive features. First, all training on the technology used ArcGIS Online, free to K-12 schools (see Fitzpatrick, 2014) and was integrated within teachers' curriculum context – examples and exercises would be built around, for example, a curriculum topic such as plate tectonics or animal migration. Second, the curriculum development process was highly collaborative using a design partnership model (Hammond et al., 2019): teachers would select topics for development, and each step of the process (drafting, walk-through, prototype, and pilot testing) happened through meetings in which teachers' perspectives were privileged—if a dataset didn't make sense to them or if a pedagogical strategy wouldn't work for their students, we talked it through to find a different direction. Once we had a SESI activity ready for classroom implementation, we followed a gradual release model of instructional support: the research team might lead the first class in the activity, then the teacher and a researcher would team-teach the next class, and the teacher would take over full control of the lesson once he or she felt comfortable (see Hammond et al., 2018).

Our proposal for the scale-up grant envisioned the same process playing out across a larger set of universities and a wider array of high schools. With the arrival of the pandemic, we needed to re-evaluate each component of both our curriculum development model and the entire process of technology training, curriculum development, and instructional support.

Adapted model: Online teacher professional development and curriculum development

The first step we took in our revision process was to make a simplifying assumption: All work with teachers and students would take place online. This decision was driven both by necessity and practicality. The necessity was our university: our Institutional Review Board required that researchers suspend all face-to-face contact with research participants. The practical side of our decision emerged from the geospatial toolset that we were using: ArcGIS Online is cloud-based software used through the browser. Because there is no client-side software to install or troubleshoot, we could easily set up organizational accounts for our participating schools,

create accounts for teachers, and even manage student accounts and permissions. The practices for student data collection required use of a free mobile app, ArcGIS Collector. In our precursor grant, we relied upon school-issued iPads to run the app and serve as the input for collected data. During the pandemic, however, we felt that we could rely upon students to use their Android or iOS cellphones to conduct any required data collection.

After making this simplifying decision, we planned our teacher professional development and curriculum development procedures, focusing on the five participating teachers (one social studies and four science) across our first two partner schools Instead of day-long, intensive sessions—typically spending an entire week of 8-hour days together--we spread out shorter blocks of time over two months of summer work. In these sessions, we introduced our participating teachers to ArcGIS Online and its associated tools (the Collector app, Esri Story Maps, and others), explored the pedagogy of teaching with geospatial tools, and initiated our curriculum development process. This summer work proceeded largely as planned—the teachers were enthusiastic and active participants in these sessions and very quickly began identifying topics within their curriculum for which they would build SESI activities.

Speeding up: The disrupted model of curriculum implementation

Once the school year began, we found that our curriculum implementation and instructional support plans began changing rapidly and in unanticipated ways. Because the tools worked online, and because the data collection allowed for hands-on interaction with students, four of the five participating teachers elected to begin using geospatial technologies right away. One teacher, in fact, had his students log into ArcGIS on the very first day of class; two other teachers introduced it within the first week. In addition to this rapid implementation, we discovered that our teachers used geospatial tools in unexpected ways. Rather than construct SESI activities for curriculum instruction, three teachers in the group created getting-to-know-you activities for their students within ArcGIS. Across our group, three teachers used GIS for this social purpose, helping students develop a sense of classroom cohesion despite being fully online and serving to provide students with an initial exposure to the ArcGIS interface. (See Figure 1). We did not anticipate either of these trends: the rapid, start-of-school use of GIS or the non-curricular, social use of geospatial tools.

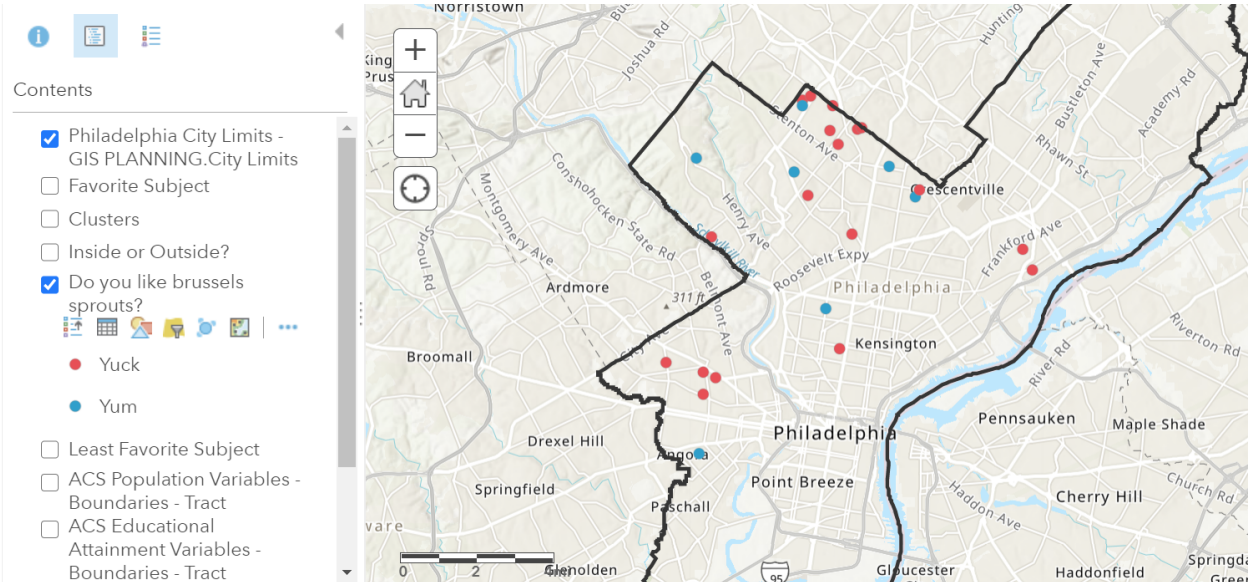

Figure 1: Screenshot of dataset assembled by a participating teacher. She polled her students on a variety of questions and then constructed different layers for students to view. The active layer shows students' responses to the question, "Do you like brussels sprouts?"

Once the teachers progressed beyond the first weeks of the fall semester, we found additional changes in our plans: rapid curriculum development and implementation and altered models of curricular and instructional support. Regarding curriculum development, our original plan called for a slow, phased process of building SESI activities with a target of two or more implemented activities for each teacher by the end of the academic year. Before the first month was through, however, three teachers had implemented one or more SESI activities, including one activity that a teacher developed independently, with no input from the research team. This teacher-initiated

curriculum development was a surprise for the research team. The teacher-designed activity involved student data collection, which always posed a significant technical and logistical challenges during the precursor grant. Up to this point, all data collectors had been built either by the university's GIS professional or by experienced university faculty. This participating teacher saw an opportunity to introduce a topic (classification of living vs. non-living objects) and felt comfortable with the technology and confident in her pedagogical choices; she therefore created the SESI activity on her own and presented it to the group. This independent action then triggered a secondary effect: another biology teacher in the group liked her activity and built his own version, with additional refinements; this was again a new development in our project.

In addition to this radical departure in curriculum development, we also found our patterns of curricular and instructional support changing. First, we found our teacher support expanding far beyond assisting with SESI activities. One environmental science teacher asked the research team to assist with building non-SESI instructional materials. He was struggling with adapting his existing face-to-face instruction to the new, online-only environment—including such mundane tasks as monitoring the chat, playing videos over Zoom, and managing student log-ins to the geospatial materials. To support this teachers' needs, we acted as both in-class teaching assistants—for example, monitoring the students' chat—and as instructional designers to assist with non-SESI instruction. This non-SESI instructional planning included brainstorming online activities that could substitute for a face-to-face lab and building materials for online lessons on data and the scientific process. Even though this work fell well outside of our intended scope of supporting SESI instruction, we felt that it supported the success of the project by helping the teacher's practice and building trust and rapport between the teacher and the research team.

Conclusions and implications

In our short span of work on this project, we have had to significantly alter our plans to meet the constraints of the pandemic and the needs of our participating teachers. We had planned a fast, intense process of professional development followed by a slow, linear, highly unified process of curriculum development and implementation. Instead, we experienced the inverse: a slow, unified professional development process following by a fast, intense, and diffused process of online curriculum development and implementation. The resulting process has been quite different than we planned, but it has also been richly rewarding both for us as researchers and for our participating teachers. We have found new ways to support teachers and engage students online with geospatial tools, even with the restricted conditions imposed by COVID-19. More importantly, our participating teachers have begun to innovate in ways that we did not expect, finding new applications of geospatial technologies and branching off into their own, independent development cycles.

While we are only in the first year of a four-year grant, we are confident that any, if not all, of the changes we are observing will persist beyond the end of the pandemic and the re-introduction of face-to-face teaching. The social uses of geospatial tools are a wonderful way to introduce students to the technology – as one member of the team observed, "It's the geo-data equivalent of a selfie!" Furthermore, we can now see that—in at least some circumstances—we can step back and observe as our participating teachers initiate their own, independent cycles of curriculum development and implementation.

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