From Guided Exploration to Possible Adoption: Patterns of Pre-Service Social Studies Teacher Engagement with Programming and Non-Programming Based Learning Technology Tools

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Abstract: Social studies teachers are being asked to teach data literacy, defined as the ability to read, analyze, interpret, evaluate, and argue with data and data visualizations. State standards are encouraging them to have students learn via inquiry where they analyze data and build their own visualizations. However, few social studies teachers have had opportunities to learn much about data literacy themselves. Additionally, analyzing data and creating data visualizations requires technological tools with which teachers are unlikely to be familiar. In this paper, we use participatory design methods to understand the needs of social studies around technologies for data visualizations. We describe the first participatory design session where pre-service teachers used a programming-based professional visualization tool (Vega-lite), a non-programming based pedagogical visualization tool (CODAP), and a purpose-built visualization tool whose design was informed by earlier design sessions with social studies teachers (DV4L). Although most pre-service teachers preferred the purpose-built tool, the justification provided painted a more nuanced picture. Some make a distinction between what they would use as teachers to produce class materials versus what they would want students to use to develop their computational skills while keeping them engaged. We use the Technology Acceptance Model to categorize the pre-service teachers' responses to predict future adoption in their classrooms.

Introduction

Recent social studies state standards require students to develop the competency of data literacy. Data literacy is the ability to read, analyze, interpret, evaluate, and argue with data and data visualizations. State standards recommend learning data literacy via inquiry. Exploring data and creating data visualizations requires the use of computational technology. However, few social studies teachers have had training in teaching data literacy, and many are uncomfortable working with data and computers in their classroom (Shreiner, 2019; Shreiner & Dykes, 2020). This is our fundamental tension. This tension causes teachers to struggle to develop data literacy competencies in their K-12 classrooms. Teachers find it challenging to apply principles of data inquiry without curriculum or tools as guides; they often know students and classrooms thrive when students are self-directed and asking questions but are unsure of how to incorporate it in their lessons. We wonder how best to introduce social studies teachers to technology they can use in teaching data literacy, particularly in an inquiry model where students are to analyze their data and construct visualizations.

Technological tools for data analysis and visualization, from Microsoft Excel to Tableau and SPSS, already exist. In our work, we are exploring the creation of social studies-specific data visualization technology. Pedagogical support in the technology can scaffold the incorporation of inquiry-based data literacy instruction into teachers' social studies curriculum. This paper reflects continuing work with social studies pre-service teachers to inform the design and evolution of new data literacy technology tools for social studies classrooms.

Our goal is to create experiences that lead to in-service teacher adoption of a data literacy curriculum and tools. We use the Technology Acceptance Model (TAM) (Lee et al., 2003) as a theoretical lens to describe the teachers' experience. TAM suggests that teachers evaluate technology in terms of what they perceive as useful and usable. Use of any technology requires effort from the teacher. They are willing to make that effort if the tool helps with their pedagogical goals (perceived usefulness) and is easy to use while fitting within the constraints of the given classroom (usability). We use qualitative methods to analyze teacher feedback for responses that address these two critical points:

RQ1: How do the teachers see technology tools as helpful in achieving inquiry-based learning objectives/curricular goals?

RQ2: When did these pre-service teachers see learning technology as worth the effort?

The following sections will discuss our session design approach and implementation for our third session. The last two sections address the research questions we explored.

Method

We use the Participatory Design method (Spinuzzi, 2005) as our guiding people-focused philosophy in designing our sessions. A teacher-centric philosophy is important since we are designing tools to specifically support social studies teachers in teaching data literacy. Students can use a wider range of tools than teachers (Wilkerson, 2017), and teachers are the gateways into the classroom. In our PD sessions, we garner feedback from future social studies teachers and observe their tacit use of existing data visualization tools to inform the design of our tool, while co-designing with an experienced social studies teacher educator.

We have conducted three hour-long sessions over eighteen months with three different groups of social studies pre-service teachers. We use participatory design (PD) in an iterative process to inform the development of technology tools specifically designed to support social studies teachers teaching data literacy through inquiry. Each session informs our design and leads to changes in our tools. The research team (from social studies, computer science, and engineering education) use this iterative, design-based method to increase the odds of teacher adoption and integration of the technology-supported data literacy curriculum. The results of our first two sessions have been published (Naimipour et al., 2020) and used to inform our first prototype (DV4L) that was used by the teachers in the third session. This paper focuses on how our first two sessions with pre-service social studies teachers inform our third session, and the results from their exploration of three tools that can support data literacy instruction and student learning.

Context and Participants

Shreiner has designed a semester-long upper level university course at a large midwestern university to guide pre-service teachers' data literacy instruction in their future social studies classes. She has been a co-designer and collaborator along with the first two authors, since the beginning of this work. Through her class, pre-service teachers learn about data literacy planning and most will be student-teaching the year following Shreiner's class. Our focus in this paper is on our 'data visualization tools for data literacy' session that took place during Shreiner's class in 2020. For this special session the first and second author introduced the pre-service teachers, our design informants, to technology tools that could support their future data literacy instruction. Shreiner was present during the entire class session, but only had access to anonymized survey data and was not aware of the identity of the students that consented to participate in the study. Complete data from nineteen pre-service social studies teacher

participants is considered in this work, with roughly 60% of them being elementary education and the other 40% being secondary education focused.

Data Sources

Our data sources include pre- and post-session surveys, observations of pre-service teachers' tacit use of the tools, and notes on the whole group discussions where the goal was to elicit their design ideas and needs.

We asked the pre-service teachers to explore three technology tools that could be used for creating visualizations, one of which was our prototype, History in Data Visualizations (DV4L) that can be seen in Figure 1. DV4L was informed by our first two sessions with other pre-service teachers. The other two tools were the programming-based tool Vega-lite, and the 6-12th grade non-programming tool CODAP. This was the first session where DV4L was included, but none of our participants knew it was our prototype until the end of the session to facilitate a less biased discussion and greater feedback.
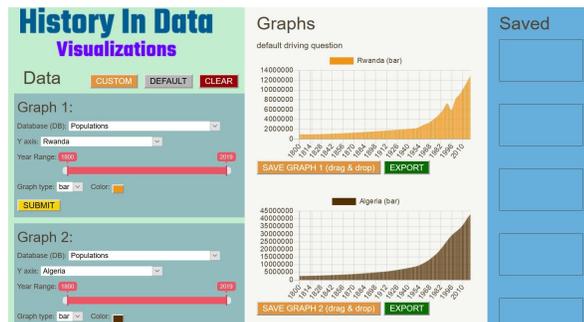

Figure 1. DV4L Tool

Positionality

As researchers in this qualitative study, we realize that our subjectivities, training, experiences, and interests influenced the path of investigation (Luttrell, 2010). We would like to make our positionality transparent in order to increase the trustworthiness of our study. All authors are middle or near middle age, with three of the four researchers identifying as women and one as a man. All researchers have backgrounds in education with levels of experience ranging from three to twenty-six years. One researcher has 10 years of experience as a secondary social studies teacher and is currently a social studies teacher educator. Two researchers also have technical backgrounds, one in computer science education with more than twenty-five years of experience, and the other is an engineering education graduate student. One researcher has a background in educational administration (Ilana).

Session Design

After introductions in the in-class session, we asked a few of the pre-service teachers to explore each of the three tools for ten minutes. We scaffolded social studies data manipulation and visualization with activity sheets (Wilkerson, 2017) to guide pre-service teacher use of the technology tools. Then they came together as a whole group to discuss their experiences for ten minutes. At that point, based on their initial experience and the class discussion, the pre-service teachers chose what tool they wanted to explore for the following ten minutes. This approach gave teachers the agency to choose and made them more inclined to provide their thoughts and opinions while being more engaged in the tool they chose to explore. After ten minutes, everyone came together to discuss their experiences as a group for the remaining thirty minutes of class. This was a longer more fruitful discussion since most had tried a second tool and were able to compare and discuss what they liked or did not like about the tools they tried. The following week, each participant anonymously reflected on their experience and current tool preference in writing. This process can be seen in Figure 2.
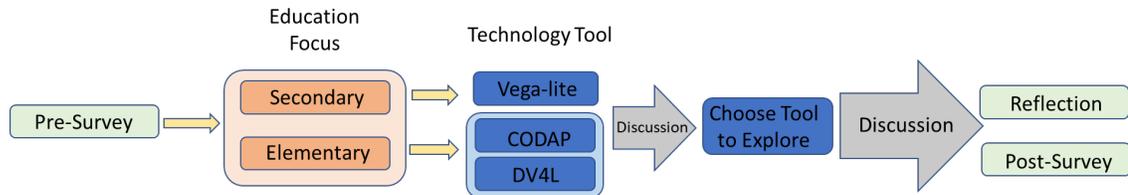
Figure 2. Session Design

Compared to our previous two sessions, this session was designed to be more participatory and give the pre-service teachers more agency by choosing the tool they wanted to explore. Previously, teachers explored tools irrespective of their elementary or secondary focus. This was causing us to get feedback that was somewhat hard to interpret. Elementary focused pre-service teachers were not interested in more programming tools like Vega-lite seemingly because they could not see their elementary students being able to program, while secondary focused pre-service teachers were not as interested in more colorful non-programming tools like CODAP because they weren't sure it would capture their data literacy goals. Therefore, in this session, pre-service teachers with a secondary focus tried Vega-lite first, while elementary focused teachers started with either CODAP or DV4L.

Analysis & Results

Our prior results describe how pre-service teachers from our first two sessions provided feedback that aligned well with the main branches of the TAM. Most pre-service teachers in our first session wanted a tool that they 'perceive as useful' for their students' learning, while those in our second session preferred tools that they 'perceive easy to use' (Naimipour et al., 2020).

Analysis Approach

All four authors were present during the participatory class session. After the session and completion of the post-survey by the participants, the first and last author individually looked for themes throughout the data sources. They then discussed the common themes and agreed on a common codebook. Using the common codebook, both researchers coded a few of the open-ended survey questions and then reviewed and discussed differences until reaching consensus.

The participatory design method often calls for focusing on participant representatives rather than all participants (Spinuzzi, 2005). With this in mind, we noticed that two secondary and two elementary education pre-service teachers contributed to the discussion much more than others did. After sharing our thoughts with Shreiner, she confirmed that these four teachers would serve as great representatives for the session. Based on Shreiner's familiarity with the pre-service teachers in her class, data from all nineteen participants was considered in our analysis, but more attention was paid to these four specific participants after looking for larger patterns in all the data. Since the pre-service teachers were asked to work in pairs during the session, the four pre-service teachers representing the whole class are actually two pairs of teachers. One pair of elementary focused pre-service teachers represented the pre-service teachers focusing on elementary education and how the tools applied to their needs, while the other represented the needs of secondary educators. Therefore, in the final step of our analysis, responses for all the survey questions pertaining to the four representatives were coded and the initial themes were refined accordingly.

Pre-Service Teacher Engagement

In the beginning of our analysis, we saw all four representatives mention that they want to use the class textbook to support inquiry activities for their students, but none wanted to do so after the session. This intrigued us so we started to dig deeper into the data as to why this might have happened. We began to find that the pre-service teachers bring up two reasons for why they would choose a certain tool to support an inquiry activity more frequently. The first pertains to pedagogical goals that went beyond the basic social studies learning objectives. For example, they are concerned with students developing computational skills. The other reason relates to how pre-service teachers feel certain tools better support their own needs when thinking about preparing their data-literacy

curriculum and classroom examples. Both of these reasons relate to our first research question regarding how these pre-service teachers see technology tools helping them achieve inquiry-based learning objectives and curricular goals.

When talking about their reasons for preferring K-12 technology tools over other things like textbooks, around half of the pre-service teachers express preferences for tools that they perceive will support their own needs when preparing their own data-literacy curriculum. One teacher said: "(with discipline-specific K-12 technology) I did the research and know the sources of the data I am inputting". Or another pre-service teacher said "(with discipline-specific K-12 technology) I like that if you are able to create your own visualization you can format how your students think about the visual". Both of these teachers address how technology allows them to have more freedom and control with the data and the ways they want to use visualizations in their classrooms. We see these statements as different from the pre-service teachers wanting something that makes their lives easier, and instead describing how they think their data-literacy pedagogical goals cannot be met with textbook visualizations alone.

More than a third of the pre-service teachers went beyond technology preferences to discuss how making their own visualizations changes the ways they and their students might think and learn about data-literacy. We heard one teacher say: "I think making your own data visualization allows for a deeper connection and understanding of the data" and another teacher said "It (technology) helps one better understand how data works and what it is telling to someone." These pre-service teachers talk about how technology tools that allow users to create their own visualizations, help social studies teachers achieve data-literacy pedagogical goals that go beyond the basic learning objectives they may not have thought about before. Therefore, these pre-service teachers now see a social studies data-literacy pedagogical basis for K-12 technology tools that they did not see prior to our session.

Data visualization tools might be used by the teacher to create exemplars or models for students or might be used by students in their own inquiry. More than half of the pre-service teachers, including our four representatives, wanted the same features for themselves and their students. Where they were different, seems to help us answer our second research question regarding when we think these pre-service teachers see learning technology as worth the effort invested to learn and integrate the tool into their curriculum. Part of the answer lies in the explanation to our first question. Pre-service teachers prefer tools that support them in designing inquiry-based curricula and helps students reach state data literacy standards, in addition to supporting their overarching goal to cultivate better informed citizens. But stopping here does not tell us more about what tools might move teachers beyond preference to actual adoption of a tool.

With the introduction of our prototype DV4L in the third session, pre-service teachers reveal interesting insights into the educational possibilities it has to offer. Many pre-service teachers talk about looking for a tool that 'encouraged deeper questioning of issues and understanding of data'. This was similar to what was seen in our first session but not as clearly expressed, possibly because they only had two programming-based tools to explore. Pre-service teachers in the third session described why they preferred our prototype over other tools because "(with the prototype DV4L) I found myself asking questions connected to the data itself, rather than asking questions in order to figure out how to work the visual". And another pre-service teacher felt that DV4L "focus(ed) on the information being relayed rather than the coding that goes into creating it". These pre-service teachers want to adopt a tool for themselves that "focus(es) more on the data then on trying to figure out how to use the tool". Tools like DV4L offer them all these possibilities, while also respecting a teachers' time limitations, making it worth the effort for them to adopt DV4L into their data-literacy curricula. Ultimately, all four of our representatives and around three fourths of all these pre-service teachers preferred DV4L over the two other data visualization tools CODAP and Vega-lite.

The final important key finding that this data brought to our attention is the necessity for a tool to be 'engaging' in order for it to lead to possible adoption. This paper is focused on what future social studies teachers are looking for in a tool, not their future students, because ultimately, they are the ones that have the power to choose what to bring into the classroom and know what their students need to learn. But without teachers believing that a tool will also be engaging to their students, these pre-service teachers told us that their adoption might be short lived. Statements like "Interactive technology engages students and sparks inquiry." or "(K-12 technology tools) helps students get engaged with what they are learning. It will help them be more hands-on", show us that in future work, we need to consider working with students on the finer visual features of our tools. This will allow us to make sure our social studies data literacy tools are engaging for students as well and increase likelihood of long-term social studies teacher adoption.

Conclusion

In summary, pre-service teachers in our third session appreciated the programming-based tool Vega-lite, but preferred a simple tool centered around their social studies data literacy and inquiry goals when considering adopting a tool. They felt intimidated and overwhelmed by Vega-lite, which does not increase their tech efficacy and help their sense of agency.

We believe that the more student centered, detailed feedback obtained in our third session was partly due to two session design differences that were realized in our first two sessions. The first difference was that we asked the pre-service teachers to choose the second tool they wanted to explore based on the session discussion after exploring one of the tools. The second difference was in asking the teachers to reflect on their session experience by asking them to choose a tool they preferred and briefly explaining their reasons.

Based on the TAM, we hypothesize that our data literacy technology will be adopted because it was co-designed to be inclusive and representative of the social studies pre-service teacher community from the early stages of our technology tool design. Through early and continued collaboration with researchers, future teachers contribute their professional expertise to shape the tools of disciplinary-specific practice in collaboration with researchers. Our current phase of research involves in-service social studies teachers in a professional learning program about data literacy for social studies. This work informs and reflects on teacher-researcher collaboration in the social studies' educational technology design space.

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