Bridging STEM and the Civic Mission of Social Studies: Integrating Spatial Reasoning & Computational Thinking Into Decision-Focused Secondary Social Studies Instruction

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Abstract: Social studies has faced a crisis of relevancy, particularly in the ascendance of perceived high-value fields such as STEM. Furthermore, secondary social studies has struggled to reconcile the disciplinary organization of social studies curriculum (history, geography, economics, and civics) with the central mission of social studies, citizenship preparation. We suggest a new framework for bridging both of these divides, adding value to both social studies and STEM education. From the social studies literature, we adopt Engle's decision-focused approach to social studies education; from the emerging literature on STEM skills, we adopt spatial reasoning and computational thinking as highly relevant skills to social studies, and particularly a decision-focused approach. Illustrative examples are provided, and implications for teacher education are discussed.

Introduction

The field of social studies involves many discipline-specific ways of thinking and knowing: historical thinking, geospatial awareness, economic reasoning, and more. These disciplinary frameworks often overlap with other fields of study--historical thinking, for example, has much in common with literary textual skills, geospatial awareness is needed in earth sciences, civic thinking overlaps with language arts, and economic reasoning is, in essence, applied math. However, these connections are often difficult for social studies teachers to make salient and engaging for students. As a result, social studies can, from a student's perspective, seem superfluous to the rest of their academic career and irrelevant to any professional pursuit other than academia (Thornton, 2017). Secondary social studies teachers also struggle with the boundary between social studies as a field (a unified but disparate collection of curricula, all aimed at citizenship preparation) and the specific social science discipline that a given course focuses upon (i.e., history, civics, economics, or geography). Consequently, social studies instruction can become disjointed—how does the curriculum of the geography class connect to the curriculum of a history class?—and fail to serve the central aim of the field, preparing citizens. These relationships and disjunctures are shown in Figure 1.

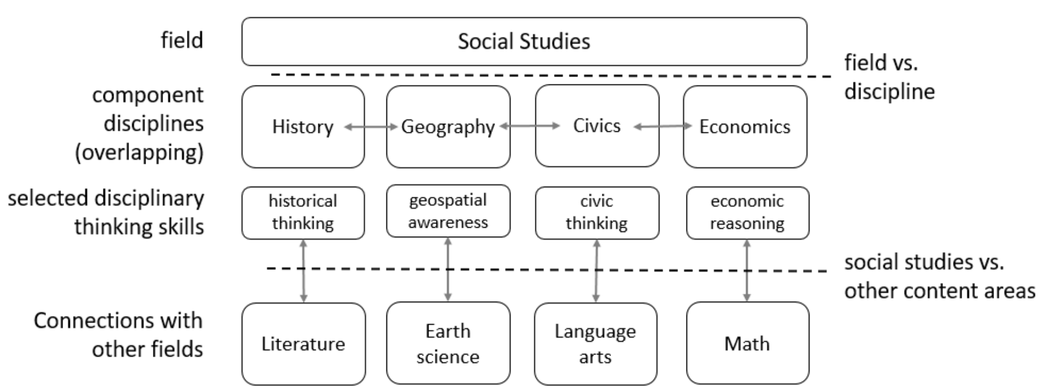

Figure 1. Social studies, its component disciplines, their thinking skills, and connections with other fields.

A second challenge faced by social studies in the 21st century is relevance, or rather a perception of irrelevance. Many students' experience of learning social studies suggests that social studies is, as a curricular subject, entirely self-referential: one learns history topics to later reference them...in other history classes (Zhao & Hoge, 2005). Concepts and skills learned in a geography lesson may show up in other social studies classes but generally not in one's math or language arts class. True, in an economics class students need some math, and in civics they often need persuasive writing/speaking skills, but these are in-bound transfers – the students bring other subjects into social studies; social studies is not (perceived) as having bearing on other subjects. As a result, social studies can feel hived off from the rest of a student's program of studies, a vestigial organ within the body of school curriculum.

To address both of these challenges—the bridging of the field versus the discipline and the connection between social studies and the rest of the curriculum—we have devised an integrated strategy, reaching back to both core social studies principles and emerging areas of the STEM skill set. First, to connect the social studies curriculum to other content areas, we propose integrating two relevant STEM frameworks--computational thinking (Wing, 2006) and spatial reasoning (NRC, 2006)--into secondary social studies subjects. Both frameworks are pertinent to high-need college and career paths and are highly relevant to all social studies disciplines and beyond. (See Table 1 for a listing of relevant spatial reasoning and computational thinking concepts.)

Table 1

Components of Spatial Reasoning and Computational Thinking with Relevance to the Social Studies

Spatial Reasoning (per NRC, 2006)	**Computational Thinking** (from Wing, 2005)
Solving problems by "by managing, transforming, and analyzing [spatial] data" (p. 230) ● Place & location (data definition) ● Distance vs. proximity ● Boundary & containment ● Density vs. dispersion ● Outlier vs. trend	Problem-solving strategies that integrate with computational tools ● Data definition ● Decomposition ● Abstraction ● Generalization ● Algorithms (rules) ● [Automation] ● [Recursion] ● [De-bugging]

Note: Items in brackets [ ] are part of the domain but presumed irrelevant to social studies purposes.

Second, to reconcile the tension between the field and its disciplines, we suggest focusing on decision-making. According to social studies education pioneer Shirley Engle, decision-making is the "heart of social studies" and takes place "at two levels: at the level of deciding what a group of descriptive data means…[and] at the level of policy determination" (1960, p. 301). Computational thinking and spatial reasoning are clearly relevant at both levels of decision-making (data analysis and policy) and at all stages of the process: studying an issue, identifying salient information, conducting the analysis, communicating with others, and so forth. Figure 2 identifies the roles these two integrations play in resolving the challenges of the field.

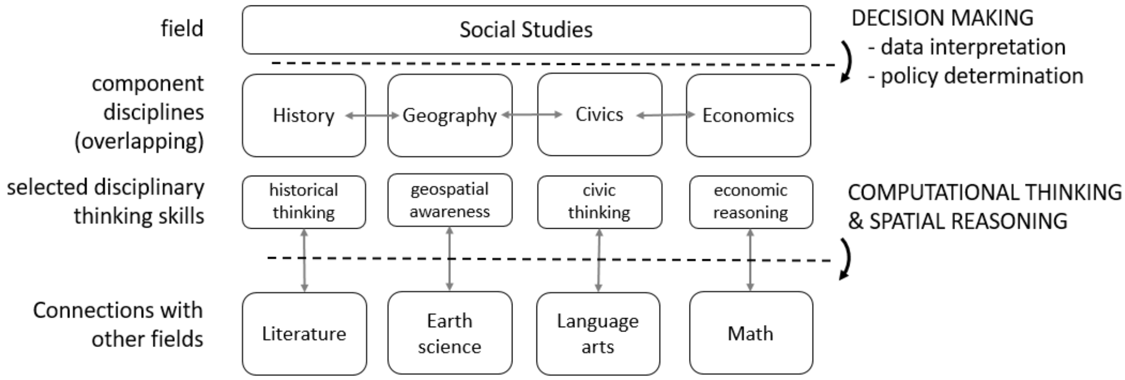

Figure 2. Resolving gaps in curricular connections: decision making, plus computational thinking and spatial reasoning

To illustrate the problem and our solution in an authentic instructional context, consider the American Civil War. The Civil War is a central topic in any the US History survey course, the most frequently taught course in the secondary social studies curriculum. A traditional instructional approach to this topic will focus on a political master narrative (Nullification Crisis, Fugitive Slave Act, Bleeding Kansas, and so on, up to the election of Lincoln) that transitions to a military narrative (Fort Sumter, First Manassas, and so on, up to Appomattox). Whether the teacher emphasizes a “great man” approach (Lee placing his loyalty to Virginia ahead of his oath to the Constitution, Lincoln’s struggles with his generals, the death of Stuart) or a trends-and-forces approach (relative economic, demographic, and diplomatic power of the north and south), the same narrative- and chronology-intensive organization will take place. Unfortunately, this satisfying disciplinary approach will fail—it will neither serve the broader goals of the field of social studies (preparing citizens) nor will it allow students to make connections with other curricular areas beyond the social studies.

Our contrasting approach addresses both problems. Consider, for example, the maps displayed in Figure 3 (below) – the map on the left presents a fairly traditional (if thoroughly geo-referenced) approach to the military narrative of the war’s primary theater of operations. Students are presented with a list of campaigns, and presumably will be expected to recall the major battles on a test. The map on the right, however, presents the same data with a purposeful color scheme: early battles (1861-62) are green; later battles (1864-65) are red. The factional capital cities (Richmond for the Confederacy, Washington for the Union) are also emphasized. This map embodies and supports computational thinking (specifically decomposition, data representation, generalization/abstraction) and scaffolds students decision making (as data interpretation) via spatial reasoning: the later battles are in close proximity to Richmond, and the early battles are either in the vicinity of Washington, D.C. or along the emerging boundaries (West Virginia splitting from Virginia and the coastal regions of the Confederacy). By analyzing this map, students can observe these patterns and infer the structure of the military narrative in this theater of operations: early, thwarted attempts to capture Washington, D.C., the emerging geographic isolation of the Confederacy (splitting off West Virginia and cordoning the coast), and the grinding campaign to capture Richmond and end the war. By making thinking skills—specifically, computational thinking and spatial reasoning—part of the explicit instruction in the classroom, the teacher will simultaneously engage the students in the relevant social studies curricular content, enhance their thinking skills, and allow them to connect these skills to other parts of their academic and career work.

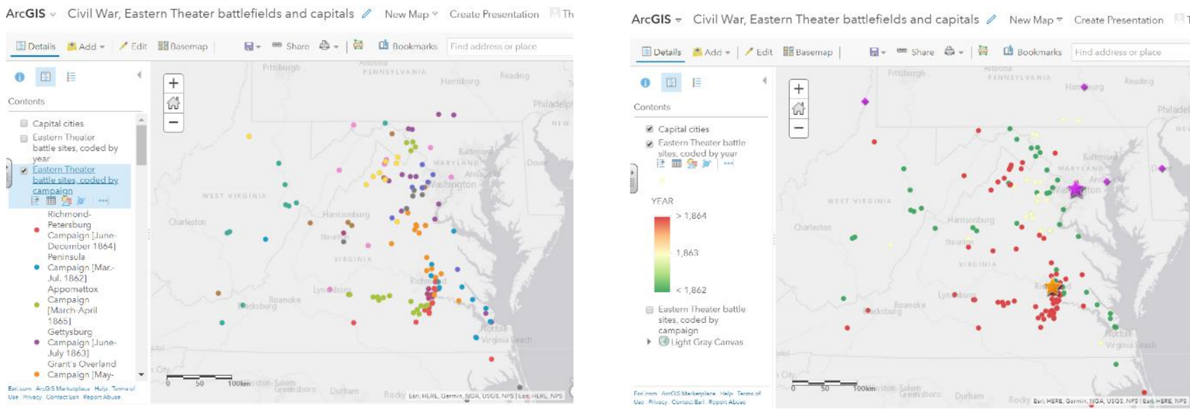

Figure 3. Two maps of the American Civil War battles in the Eastern Theater. On the left: battles color-coded by campaign. On the right: battles color-coded by year, plus capital cities. The large stars are Richmond and Washington, D.C.

These maps are two visualizations of the same dataset, displayed in a geographic information system (GIS). GIS is a highly appropriate tool for both spatial reasoning, due to the data visualization capabilities, and computational thinking, thanks to its built-in toolset for sorting (via data definition), filtering (decomposition), and analysis and visualization capabilities (abstraction, generalization, algorithms, and more). Prior projects, such as the American Migrations project from the University of Illinois-Chicago (https://americanmigrations.uic.edu) or the book *Mapping US History with GIS* (Bunin & Esposito, 2014), have explored integrating geospatial tools into selected topics of the social studies curriculum, and they have provided some attention to spatial thinking. However, no current work provides both a robust connection to thinking skills (such as spatial reasoning and computational thinking) and an emphasis on decision-making as a curricular design feature.

We therefore propose a four-part instructional model for enhancing social studies education to connect it with its civic mission as well as highly-valued STEM thinking skills, all without compromising its attention to the information, skills, and dispositions valued within the disciplinary frameworks of secondary social studies.

1. Engaging, decision-focused social studies instruction in alignment with the existing curriculum;
2. Explicit instruction on both spatial reasoning and computational thinking, including the technologies that will be used during instruction;
3. Application of these thinking skills in the context of learning a curriculum-aligned social studies topic through the use of technology to examine and manipulate the relevant data; and
4. Guided note sheets and other learning materials that integrate the critical thinking skills and the social studies content, as well as scaffold the decision-making process and (if necessary) the technology use.

To briefly illustrate this model–or at least the first three elements–we offer a civics education example, this time driven by a different technology: a spreadsheet instead of GIS. The driving questions in this case are, What patterns exist in the party affiliations of LGBTQ members of the House of Representatives? How and why have these patterns changed over time? These questions point at the dynamic nature of civil rights in the United States, and particularly the role played by the two major parties as they shift their stances over time. The questions present a *decision* to the students, this time aiming at data interpretation. The questions *align with existing curricula*; for example, the National Council for the Social Studies' C3 framework presents Civic standard D2.Civ.10.6-8: "Explain the relevance of personal interests and perspectives, civic virtues, and democratic principles when people address issues and problems in government and civil society" (2013, p. 33). The *accessible data* is a Wikipedia listing of LGBTQ House members (https://en.wikipedia.org/wiki/List_of_LGBT_members_of_the_United_States_Congress), which at the time of this writing lists 18 Representatives who were either out, outed, or posthumously identified as LGBTQ. To prepare students to address these questions, the teacher should address the relevant spatial reasoning and computational thinking components. In terms of spatial reasoning, the relevant concepts are *density* and *dispersion*: are the listed LGBTQ members of the House distributed in any particular spatial pattern? In this case, they are not – there is no concentration by state or region; they roughly map onto the population density of the United States, ranging from Massachusetts to Texas to California—the only potential outlier is Kyrsten Sinema of Arizona. The relevant computational thinking concepts are *data definition* and *algorithm*—what data are most relevant to the question, and what rules should guide our decision-making? The final step is *data manipulation*, in which students can use a spreadsheet to sort and refine the data presented in Wikipedia. They will then observe that in terms of the data provided—years of service, district represented, and so forth—there is a sharp disparity in those members currently serving (six, all Democrats) and those previously serving (mixed Republicans and Democrats). Clearly, the algorithm for determining the distribution of Republican and Democratic Representatives needs to account for time. After sorting by time and by party, students will discover that the divergence in party affiliation comes in 1996. Prior to that year, the distribution of LGBTQ members of the House was roughly equal across parties (7 Republicans, 5 Democrats) and slightly over-represented among Republicans (considering that they were the minority party in the House from 1954-1994). Since 1996, only Democrats have elected new LGBTQ representatives to the House. The pivotal event in 1996 was the passage of the Defense of Marriage Act (DOMA). During these debates, Republican Steven Gunderson was outed by fellow caucus member Bob Dornan for opposing the bill, marking the divergence between the parties: Democrats were increasingly in support of LGBTQ rights while the Republicans are almost uniformly opposed. Through the application of computational thinking, students can come to recognize that the party affiliation of LGBTQ members follows two different algorithms: pre-DOMA and post-DOMA, with distinct policy differences between the parties in the post-DOMA era. This understanding allows students to understand the future policy directions of the parties (for or against LGBTQ rights) and monitor indicators of change, such as a future election of an LGBTQ Republican House member (which, once it comes to pass, either signals or confirms a policy shift).

Finally, to show a more iterative and open-ended approach to students' decision-making, consider a final example, this time addressing the Great Depression. Within this time period, a salient topic is Franklin Delano Roosevelt's communication pattern, particularly his Fireside Chats and other use of emerging media. A project at Lehigh University is in the process of mapping correspondence between citizens and the White House, looking at themes of citizen comment and response to the issues addressed by FDR. A first question is, What is the pattern in citizens' communications with FDR's White House? Looking at the contiguous United States (see Figure 4, below), we see that the distribution of correspondence with the White House (purple dots) correlates closely with the distribution of the population at that time (the underlying polygons). Clicking on any individual dot allows the student to see the metadata for the correspondence and to follow a link to a digitized version of the archival primary source (inset).

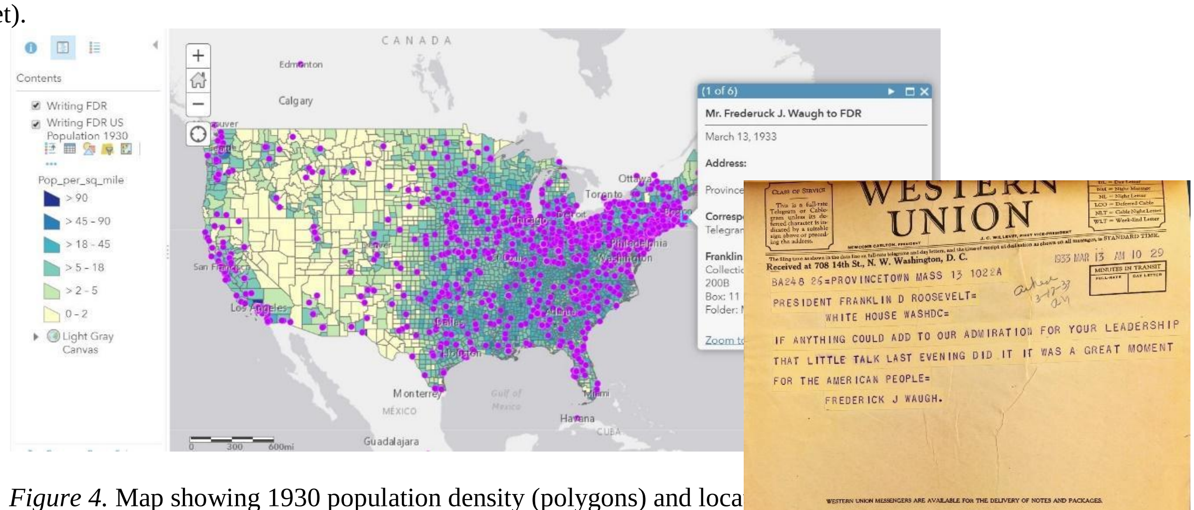

Figure 4. Map showing 1930 population density (polygons) and loca (dots) plus a linked primary source—in this case, a telegram sent to FDR from Provincetown, Massachusetts.

Once we begin to apply computational thinking, we can explore patterns within the data and begin to unpack the embedded primary sources. For example, using the capabilities of the GIS, we can decompose the problem, focusing on a part instead of the whole. In this case, we will filter out only correspondence from Pennsylvania, an area that would be relevant to students in our region. Next, we will change the data definition, coding the correspondence by whether or not the person received a response (red = yes, blue = no). Finally, we will take advantage of the automation provided by GIS to change the level of abstraction: individual points are now clustered, with the size of dot determined by the number of correspondents. The resulting map of Pennsylvania (see Figure 5, below) shows that the major urban areas of Philadelphia and Pittsburgh had contrasting patterns. Philadelphia sent 205 pieces of correspondence to the White House, and the majority of these were answered; this is similar to the national pattern, in which about 60% of all correspondence received a reply from the White House. In contrast, Pittsburgh sent less correspondence to the White House (70 pieces) and the majority of these were not answered. At this point, thanks to the application of computational thinking and spatial reasoning, new questions emerge: Why did FDR respond to one group at a higher rate than the other? Another question that may surface is what is similar between Pittsburgh and

Harrisburg? Both urban areas had a similar pattern of non-responses, in contrast to every other urban center in Pennsylvania (Philadelphia, Allentown, Erie, Scranton).

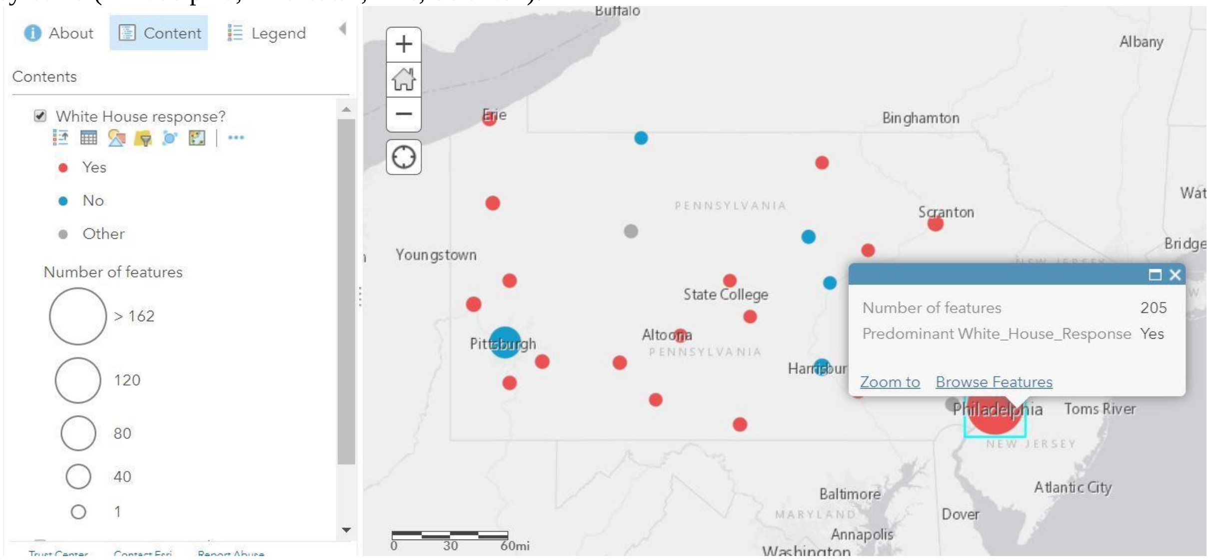

Figure 5. Map showing aggregated clusters of correspondence with FDR coded by whether the correspondent received a response (red = Yes, blue = No). The Philadelphia area sent 205 pieces of correspondence, most of which received a reply.

To explore these newly-formed questions, students will need to draw upon both their primary source analysis skills and their computational thinking skills, and they will find that these two bodies of knowledge reinforce one another. For example, the data definition stage of computational thinking maps perfectly onto contextual analysis of primary source heuristics (author, audience, purpose, etc.). As students integrate other datasets—perhaps there is a difference between Pittsburgh and Philadephia's political party affiliation? Economic cost or benefit relative to FDR's New Deal policies?—they will draw upon their spatial reasoning. In the end, students exit this process with a much more sophisticated understanding of both the historical topic being studied (that is, FDR's communications, politics, and policies during the Great Depression) and the process of historical investigation. Furthermore, by situating this inquiry within the far-reaching of frameworks of computational thinking and spatial reasoning, students' work with these topics may translate outside the social studies classroom and become part of their work in other content areas and daily life.

Social studies teacher education can benefit from this approach. First, the focus on decision-making, whether at the data interpretation or policy level, links social studies to its core mission of citizenship preparation. Second, the integration of spatial reasoning and computational thinking skills link social studies to the STEM fields, providing a curricular home for explicit instruction in skills that are otherwise in the deep background of secondary curricula. In-service teachers can re-vitalize social studies with this approach, and pre-service teachers can enter the profession equipped to radically change the expectations of the social studies curriculum for students, colleagues, and community stakeholders.

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