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Developing Historical Thinking in Large Lecture Classrooms Through PBL Inquiry Supported with Synergistic Scaffolding

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ABSTRACT

As problem-based learning (PBL) has gained popularity across disciplines, its move from small medical-school inquiry groups into large-class undergraduate inquiry has led to an increasing need to understand the elements of successful PBL implementations in large classrooms. In this study, we investigated how PBL was appropriated among students to develop historical thinking skills in a 96-person introductory undergraduate history survey course. The video analysis demonstrated that students initially found the appropriation of PBL routines and norms to be challenging. However, instructor interaction with both the students and representational tools in a large classroom provided multiple co-occurring and dynamic supports. This synergistic scaffolding structured around representational tools was instrumental in a semester-long intervention in which we supported student learning of historical thinking skills by encouraging appropriation of the activities that govern PBL.

Keywords: PBL in large classrooms, history PBL, developing historical thinking skills, synergistic scaffolding, representation tools

Introduction

Problem-based learning (PBL) situates collaborative learning in an inquiry task focused on self-directed research. A PBL activity assumes that students should engage in analyzing an ill-structured question; identifying and resolving knowledge deficiencies; searching for evidence related to the question; developing evidence-based argumentation; and evaluating and justifying their proposed arguments (Hmelo-Silver, 2004). In PBL, one type of authentic problem has clear real-world applications; for example, students may engage in a STEM inquiry about whether a community should permit genetically modified food to be sold (Belland et al., 2008). The other is less commonly observed in the PBL literature and orients toward authentic disciplinary questions that might not be practical but are nonetheless ill-structured and raise issues that scholars in a discipline find important (e.g., Hmelo-Silver et al., 2007). Social studies and humanities share the systematic weighing of evidence as part of a logical problem-solving approach (Barton & Levstik, 2004; VanSledright, 2002), but the instructional model of PBL in higher education humanities environments, and particularly in the large lecture classrooms that dominate introductory higher-ed humanities courses, has been less well-studied.

In teaching their students, most academic historians describe the disciplinary norms that contribute to the production of historical monographs as inquiry. On the other hand, broadly held epistemological assumptions about

history as a discipline tend toward a pre-existing construct of history as a settled linear stream of events described simply and famously as "one damn thing after another" (Staff, 1968). The large lecture format that dominates most undergraduate students' experience with the discipline of history, a model that Saye and Brush (2002) label "expository," compounds the gap between an expert view of history as negotiated and a novice view of history as concrete knowledge about a linear timeline passed from expert to novice with little inquiry. Undergraduate students thus tend to see both history teachers and historical primary sources as serving up established facts that exist to be received and not questioned (Wineburg et al., 2018). As a consequence, students undertaking traditional assessments like essay tests, which include ill-structured problems with more than one possible solution, struggle to identify their role in crafting a more or less suitable answer to an open-ended historical question that accommodates many expert opinions (Saye & Brush, 2002; Hung et al., 2000). Compounding novice impressions of history as a "settled" discipline is a tendency in early-career undergraduates to see knowledge formation as simplistic, which is in line with Perry's (1970) and Baxter Magolda's (1992) dualism. This developmental model of knowledge construction aligns with social-studies-specific developmental stages (Kuhn, 1999; Newmann, 1991).

However, PBL's inquiry cycle and systematic approach to handling the complexity of ill-structured questions can help bridge the novice-expert historian gap. PBL supports a progression from simple to complex stages of knowledge formation, a path through which students move as they gain expertise in historical disciplinary practices. As research on higher education historical thinking has developed, a variety of competing standards and approaches have been developed to define the self-regulated inquiry processes that describe historical disciplinary norms (Poitras & Lajoie, 2013). Generally speaking, the literature on the history of higher education broadly sketches a process in which students produce historical arguments about change over time by drawing on corroborating and competing accounts in historical texts (or primary sources). Then, the students navigate those accounts by placing them into a historical context drawn from the arguments made by other historians (Craig et al., 2017; Shopkow et al., 2012; Grim, 2004; Saye & Brush, 2002; Wineburg, 1991, 2001). The governing body of academic historians, the American Historical Association (AHA) (2016), developed its 2016 History Discipline Core (HDC), which lays out six core competencies for students drawn from its constituents. We have adopted these competencies as a middle ground between the educational research and the practical guides on which history professors draw for their own teaching practice. The most relevant core competency in history is focused on crafting historical narratives. Answering substantive open-ended questions require historians to integrate a number of research strategies, including adopting the lens of a particular historical methodology (e.g., social, cultural, economic, intellectual history) through which they understand history as a way of honing their research strategies in order to argue for a particular narrative of change and continuity over time (Sewell, 2005).

Our study thus focuses on two parallel but related structures that extend our understanding of practices in large-classroom environments with low student-to-teacher ratios (Puntambekar & Hubscher, 2005). The first question asks whether it is possible to scaffold students in the writing and revision of college-level historical argumentation, in which students are responsible for structuring their own arguments and evidentiary claims with instructor support that is generally provided one-on-one by using PBL (Saye & Brush, 2002). The second question addresses the gap between well-understood small-classroom PBL practices and the large classroom environment (with an eye to the physical features of the classroom in which our intervention was situated) and its role in supporting the implementation.

To understand these questions, we focused on investigating interactions between the instructor and students as they used shared representational tools during PBL activities designed to support historical thinking in a large classroom setting. We examined how multiple forms of scaffolding function in a synergistic and contingent way to support teaching and learning concurrently. The scaffolding designs that supported the PBL activity enactment in this context were rooted in disciplinary norms, such as building and contextualizing historical knowledge in support of an argument about causality to encourage student appropriation of those historical disciplinary norms through the use of PBL. Our goal was to explore the necessary balance between arms-length instructional practices with the one-on-one interactions in which the scaffolding is usually provided, as we adapted PBL practices to the development of argumentation skills in a large humanities classroom.

Instructional Framework: Problem Based Learning for Large History Classrooms (PBL-LHC)

Our instructional framework for PBL in large history classrooms, Problem-Based Learning for Large History Classrooms (PBL-LHC) (See Figure 1), demonstrates how PBL scaffolding can shepherd students from one phase of the Baxter-Magolda-Perry expertise spectrum to the next phase. This scaffolding acts within the framework of one or more historical schools of thought and takes into account the disciplinary norms that govern the complex, ambiguous nature of historical research.

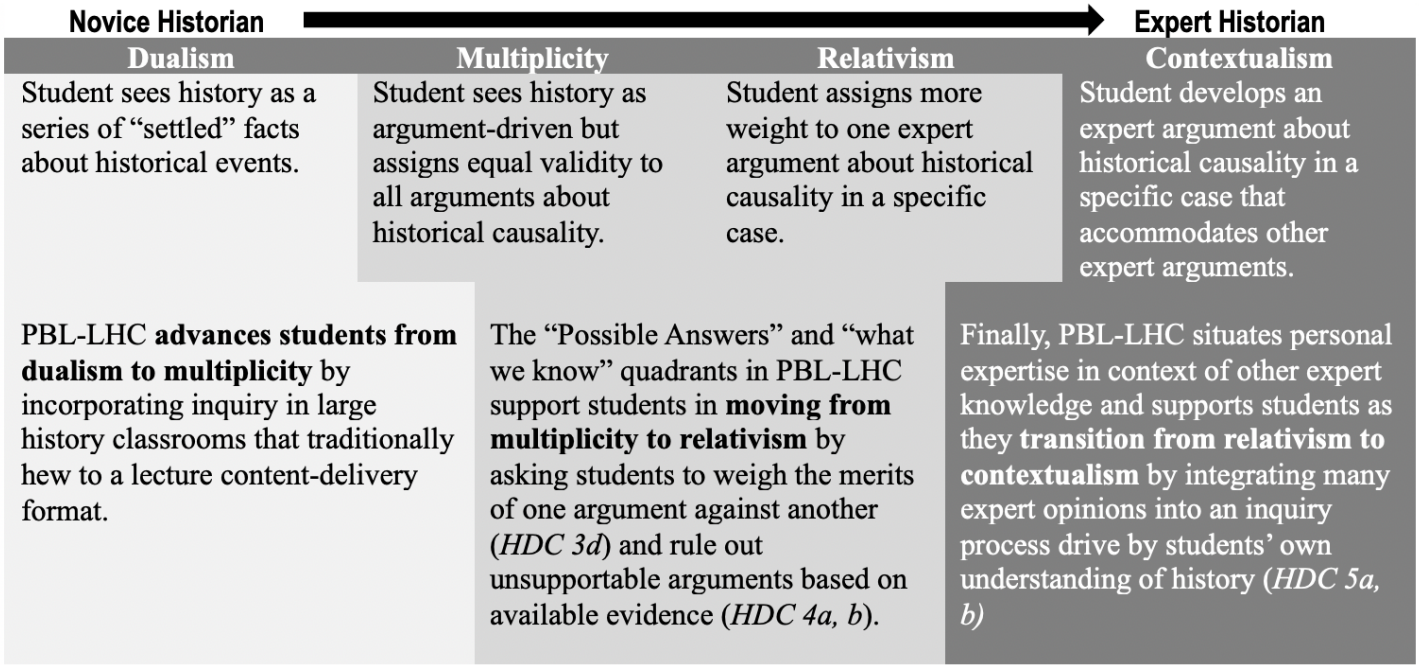

Figure 1. PBL-LHC Framework. Adopted from Baxter-Magolda-Perry expertise spectrum (1970)

Several affordances in the PBL-LHC process support the progression from the dualism of a novice historian to the contextualism of an expert historian particularly well. First, many PBL activities are centered around a common shared visual representation element divided into four columns: Facts, Ideas, Learning Issues, and Action Plan (Hmelo-Silver & Eberbach, 2012). The labels on these columns communicate an epistemological shift from dualism and settled-narrative history toward history that is a blend of ill-structured problem solving. This structure affords collaborative knowledge-building through inquiry, and explicit harnessing of concrete details to support evidence-based opinion for the discipline of history. While technology affords some advantages in shared knowledge co-construction (Lu & Lajoie, 2008), shared representations that use whiteboards require minimal expertise on the part of the instructor, minimal training for students and classrooms with limited technology, which lowers the barrier to entry for their use in large classroom environments.

Second, each of the columns, and the interplay between information in the columns, has been adapted to provide several affordances that guide novice historians away from dualism and toward contextualism. Our title adaptations in each quadrant represent specific elements of history problem-solving drawn from the AHA's (2016) 2016 History Discipline Core. These adaptations were designed to help the collaborative groups organize and manage their ideas in a representational space that walks students through the stages of expertise documented in our PBL-LHC. Each element is parsed from either specific course content or argumentation elements from their own inquiry process and placed into each of these quadrants. Similarly, the change from a columnar PBL visual representation to a quadrant-based visual representation places all of the quadrants in visual proximity to each other. Data visualization researchers note that relative proximity has a semantic distance effect: viewers assume that relative visual closeness or distance also means relative relationships or lack thereof (Iliinsky & Steele, 2011). The linear structure of columnar organization in PBL semantically distanced the last "next steps" column from the first "potential hypotheses" column. This distance has value in a clinical medical setting, in which a researcher may need to physically enact treatment before revising their hypotheses. In historical research, items in the "Research Agenda" quadrant might help immediately identify elements that are easily moved from "what we don't know" to "what we know"—which therefore change the potential value of one or more hypotheses—without students needing to undertake that research on the spot.

The structure of the quadrants then scaffolds students as they brainstorm, divide the results of that brainstorming discussion into meaningful categories, and apply the information in those categories in a more systematic way to the ill-structured question. Additionally, the systematic nature

of quadrants in a PBL-LHC shared representational space communicates an agreed-upon set of norms and categories with which students can assess and rank the answers to an ill-structured problem.

Finally, PBL-LHC quadrants support novice historians as they lay claim to their own expertise by providing a format in which their own expertise is reformulated within the context of a community of novice and expert history practitioners. In many large lecture-based history classrooms, students are assigned argumentative evidence-driven essays, but the dialogue around argument restructuring and evidence bases occurs only with the instructor. In general, the collaborative elements of PBL broaden the audience of a history argument from instructor-only to a community of students and instructors whose expertise plays a role in the construction of knowledge. In the initial stages of PBL, students negotiate the interplay between the PBL columns with each other; their interactions in this shared representational space require them to evaluate other student-contributed hypotheses, evidence and gaps in evidence. The evaluation of this collaboratively generated information for its application to their ill-structured question helps students move quickly past the "multiplicity" stage of knowledge formation, in which any argument is equally valid. Progression through the PBL activity further requires students to examine simultaneously the underlying factors that shape their ill-structured problems. Students must also identify gaps in their own knowledge based on the information provided by expert historians (their instructor and other historians' secondary-source research) and negotiate an answer with their classmates using the resources they draw from a larger collection of historical primary and secondary sources to which they have access (Saye & Brush, 2002, 2007). Finally, the collaborative nature of PBL with its shared visual representation and instructor scaffolding, helps students evaluate the relative merit of their arguments in the context of contributions from their instructor, their classmates and many other expert arguments (Hmelo-Silver & Eberbach, 2012).

Accommodating Large Classroom Issues in of PBL for History Classrooms

Regardless of the nature of the problems, the crucial element of the PBL is an instructor's timely and contingent support (Puntambekar, 2015), an element which is generally only possible in classrooms with a small instructor-to-student ratio. At the same time, instructors employ multiple forms of scaffolds to support teacher-student interactions in the problem-solving process. However, because typical PBL activities are organized around small, collaborative groups, scaling up this learning activity to a large and heterogeneous group imposes difficulties in providing appropriate support for learners (Hmelo-Silver et al., 2009). While PBL provides a well-structured foundation on which to engage with historical argumentation, the large lecture classroom norm in history education creates its own set of challenges for using the PBL approach in higher-education history classrooms. Most PBL relevant studies originated from observations in a tutor-led and small group setting, usually involving five to nine students in medical and dental schools (Savery, 2006). As class size increases, instructors find it challenging to monitor the progress and interactions of multiple groups (Shipman & Duch, 2001). Thus, instead of serving as a dedicated facilitator for each group, the instructor who acts as a "floating" facilitator is required to have a more finely-honed ability to assess the current state of multiple groups' inquiry progress and provide adjusted feedback (Hmelo-Silver, 2000; Nicholl & Lou, 2012). This role of a floating facilitator is often more demanding than that of the dedicated facilitator who works with only one group (Allen & White, 2001). Though this challenge has been recognized, few studies investigate how to support instructors in the "floating" facilitator role, which is the most feasible for large-enrollment classes.

Student lack of experience with the inquiry approach without direct facilitation in their small groups (Pastirik, 2006) compounds the difficulty inherent in the floating facilitator role. The transition from a traditional lecture-based learning format to a collaborative inquiry format creates significant tension for students, requiring the instructor to reiterate the process and norms of the problem-solving activity in order to help students adjust to new teaching and learning paradigms (Biley, 1999). An instructor managing a PBL-LHC activity with multiple groups of students therefore faces two challenges: (1) students who are transitioning from traditional lecture-based history classrooms into PBL history classrooms lack familiarity with both general principles of PBL; and (2) the specifics of the disciplinary norms of history education.

A few studies have demonstrated the beneficial effects of using the PBL approach in large classrooms, mostly oriented toward the role of student engagement (e.g., Klegeris et al., 2012; Pastirik, 2006; Woods, 1996). These active learning environments provide an alternative to lecture-based instruction, in which students work on a problem or task (Andrews et al., 2011). For example, Klegeris and Hurren (2011) demonstrated high levels of engagement and attendance during undergraduate PBL biochemistry class ranging from 45-85 students. Moreover, Klegeris et al. (2012) demonstrated statistically significant improvement in the generic problem-solving skills in large classrooms ranging from 32-77 students. These results combined with their previous study indicated that the PBL approach not only leads to increased student engagement and attendance but can also

improve students' discipline-specific and generic problem-solving skills. These studies demonstrate that it is feasible to provide the facilitation necessary for successful PBL in large classroom settings (Klegeris et al., 2012).

However, PBL learning effects were more pronounced in higher-level classes with smaller class sizes. Ahlfeldt et al., (2005) studied the relationship between student engagement and understanding based on a student survey. The data came from 56 classrooms at a Midwestern university in the United States, in which each faculty member was trained to use innovative teaching methods such as PBL. Even though the results revealed that students who participated more in the PBL activities reported a better understanding of the course concepts, higher-level courses with smaller class sizes demonstrated higher learning gains.

In addition, Marshall et al., (2014) reported that the PBL class was less enjoyable for students than the lecture class. They compared the impact of two different teaching styles on student mastery of learning objectives in a pharmacotherapy module in large classroom settings. The class enrollment was 136 and 141 for the two years of the study. Even though the students showed higher immediate mastery of learning objectives in the PBL course, students reported that they enjoyed the traditional lecture more, which the authors attribute to the nature of the classroom space itself. They argued that student group work with fixed seating and no extra space in the classroom made a PBL approach more difficult to implement. The authors claimed that a physically spacious classroom that allows group work would encourage these small group break-out activities, increasing the likelihood that PBL would provide a route to increased student engagement and satisfaction in large lecture halls.

Shifting away from lectures to a PBL approach without productive support from an instructor and physically appropriate classroom environment can disrupt collaboration processes in a small group collaboration context. These results indicated various factors in the successful implementation of PBL, such as students' knowledge level, class size, participation, and instructor's contingent support. Especially when the class is large and at a survey course-level, instructors play a crucial role in facilitating the multiple collaborating groups while providing sophisticated scaffolding to successfully support complex problem-solving process.

Synergistic Scaffolding Using Shared Representation

Scaffolding refers to temporary supports that allow students to complete a task they would be unable to perform without help (Wood et al., 1976). For instance, scaffolding is important to help learners manage the complexity of an ill-structured problem and the relevant disciplinary practices, such as sense-making and argument articulation (Quintana et al., 2002). To support these challenges around inquiry, scaffolding must be based on an ongoing diagnosis of the learner's current level of understanding (Puntambekar & Hubscher, 2005). In turn, this ongoing diagnosis will lead to contingent support done in a timely fashion with a careful calibration of the support and approach to the learner's needs (Van de Pol et al., 2010). Different learners not only have different levels of prior knowledge but also develop their own understanding at different speeds. For this reason, contingent scaffolding that is responsive, tailored, and dynamic is critical in the inquiry environment.

However, the notion of scaffolding must be extended beyond individual interactions between instructor and students to artifacts, resources, and other elements of the classroom environment. This expansion maintains ongoing diagnosis of student learning and inquiry processes in a large classroom (Puntambekar & Hubscher, 2005). Some researchers suggest that instructors embed hard scaffolding (pre-designed instructional materials; Saye & Brush, 2002) or distributed scaffolding (incorporating multiple forms of scaffolding that are provided through various means; Tabak, 2004) into problem-solving activities to meet students' different needs (Snir & Smith, 1995). Such scaffolding includes various forms of additional tools, such as written prompts, visualization tools, and computer software, and can be used for promoting peer interactions. These methods make the inquiry process visible and support teacher awareness in a classroom (Belland et al., 2008; Puntambekar & Hubscher, 2005). In this specific study, we scaffolded the inquiry process with shared visual representations that effectively promote collaborative learning discourses and lead to a productive problem-solving behavior (Suthers, 1999). In addition, a PBL-LHC representation provides support for floating instructors as they facilitate across multiple learning activities occurring across multiple groups simultaneously, because it makes the group process and progress visible. In turn, this support advances instructional capacity through formative assessments as facilitators interact both with students and the visual representation tools the students have produced. This method parallels the embedded hard scaffolding with soft scaffolding from Saye and Brush (2002). However, the main premise is to create a low-tech environment with much less guidance than in some of the computer-based collaborative environments that often support PBL (Pea, 2004).

All of these interactions contribute to synergistic scaffolding, a system of multiple co-occurring and interacting supports that includes a set of possible tools and actions and communications (Tabak, 2004). This synergistic scaffolding can be achieved via meaningful interactions among any or all possible actions within the set of interacting supports. Alternatively, the scaffolding can occur through a

demonstration of how these actions and tools can be synergistically coordinated in order to produce the activity (Pea, 2004). The challenge in synergistic scaffolding is to support the dynamic, moment-by-moment reasoning process that leads students to appropriate new psychological tools (Vygotsky, 1978). To support student analysis of disciplinary best practices in history argumentation (e.g., HDC), students must appropriate PBL, or transform PBL as a psychological tool from the social plane of mediated interaction to an individual plane (in the mind) (Vygotsky, 1978). Learning via appropriation requires students to use desired tools (i.e., the course principles and history disciplinary norms) until they understand the history disciplinary practices, voluntarily use those tools, and appreciate them (Cole, 1996). In this study, we investigated how synergistic scaffolding allows an instructor to facilitate effectively the student appropriation of PBL-LHC to support historical thinking during the interactions with the shared-representation artifacts, PBL activities, students, and an instructor in a large history classroom.

Methods

Participants and Context

This study was conducted with 96 undergraduate students in a large survey-level history classroom at a public Midwestern university. Students were divided into 16 groups of five to six students and were seated at oblong tables that created a shared learning space to foster collaboration (see Figure 2). This open active learning space allowed instructors to circulate freely and engage frequently with the students. Each table was equipped with whiteboards and large computer monitors to serve as media for shared representational tools, which supported PBL and were designed to promote disciplinary norms in history education. Five groups volunteered to participate in the research and agreed to be video-recorded.

The intervention took place over three 75-minute class sessions distributed throughout the semester (specifically, weeks 4, 8, and 14 of a 16-week semester). In each of the three sessions, one instructor provided mini-lectures to the entire class, and the instructor and two teaching assistants facilitated group discussions by circling among groups. The classroom was designed to support an active learning environment (see Figure 2) to promote student collaboration. We initially assigned each group to one of several shared representational spaces available in the classroom: whiteboards, poster paper, the shared computer screen with keyboard, and a pencil-enabled iPad projected to the shared monitor. In part, these choices were made based on limited instructional resources for whiteboards and poster paper, but no substantial interactional differences were made between groups using different media for their shared representational space.

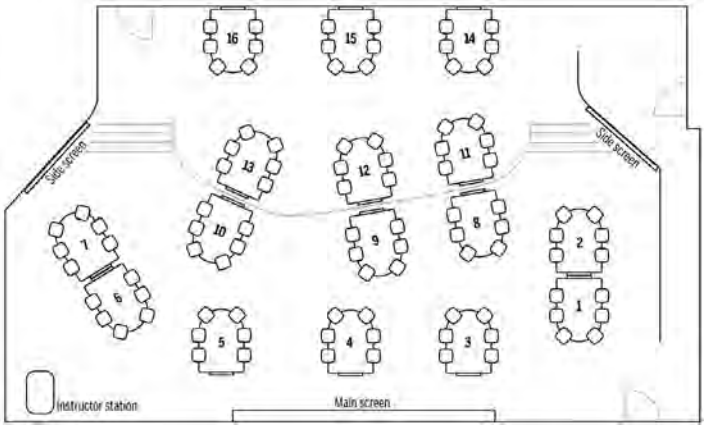

Figure 2. Classroom Layout, including group numbers that are visible to both students and instructor.

PBL Intervention Design and Shared Representations to Support PBL

The driving questions that anchored PBL were provided by the instructor as a subset of historical questions that drove a course focused on historical responses to bubonic plague. In elementary and middle-school social studies, historical encounters centered on bubonic plague mostly focus on the effects of The Black Death in 1345 on medieval Europe's economic and demographic structures. By contrast, academic research on bubonic plague spans social, cultural, religious, and medical-history responses and are centered on plagues in the sixth, fourteenth, sixteenth, nineteenth and twentieth centuries. These more complicated structures in post-secondary history literature are indicative of a vast array of sometimes-competing, sometimes-complementary explanations for historical context and causality drawn from many academic perspectives and many different historical sources.

To help students narrow their frame of reference within all of the potential arguments about public response, the scope of the question for each of the three interventions started with a fairly narrow focus on a single historical school. The questions became iteratively more complex over the course of the semester: 1) "What single element was the most significant factor in the responses to plague in the 6th century Justinianic Plague?"; 2) "What two elements interacted to explain responses to plague in the 14th century?"; and 3) "What single element helps explain plague response in three different outbreaks (6th century, 14th century and 20th century)?" These questions increased in complexity

for two reasons: (1) we wanted to observe students' historical thinking skills as they changed over time and responded to changing course content; and (2) we wanted to capture how students appropriated PBL to develop historical thinking skills. Increasing complexity in the historical question allowed us to better differentiate between increasing the problem-solving-only skills and historical thinking skills.

In the first two interventions, students were shown an example of a history PBL-LHC with adapted titles from a PBL quadrant (Hmelo-Silver & Eberbach, 2012) and asked to copy the quadrant to their local shared representational space. Our PBL-LHC adaptations of these columns and titles are designed to more explicitly communicate the norms of history research within a traditional PBL context are detailed earlier.

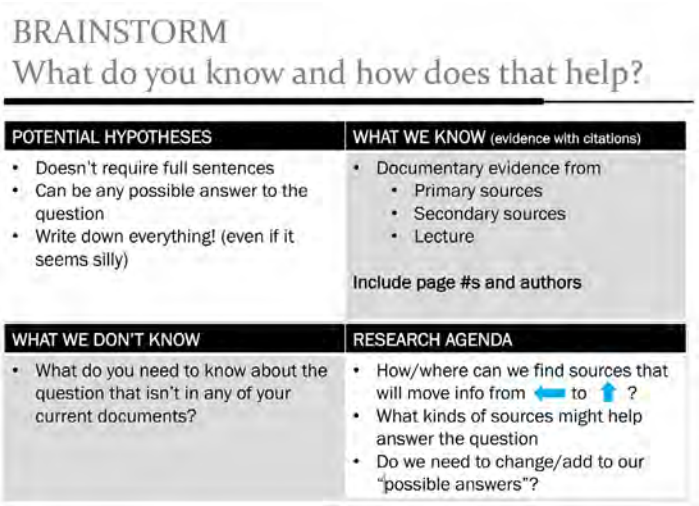

Figure 3. PPT scaffolding for PBL, slide 1

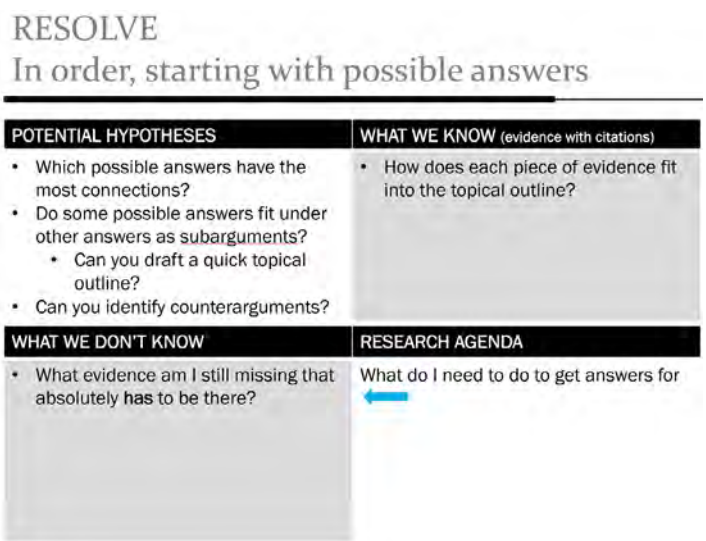

Figure 4. PPT scaffolding for PBL, slide 2

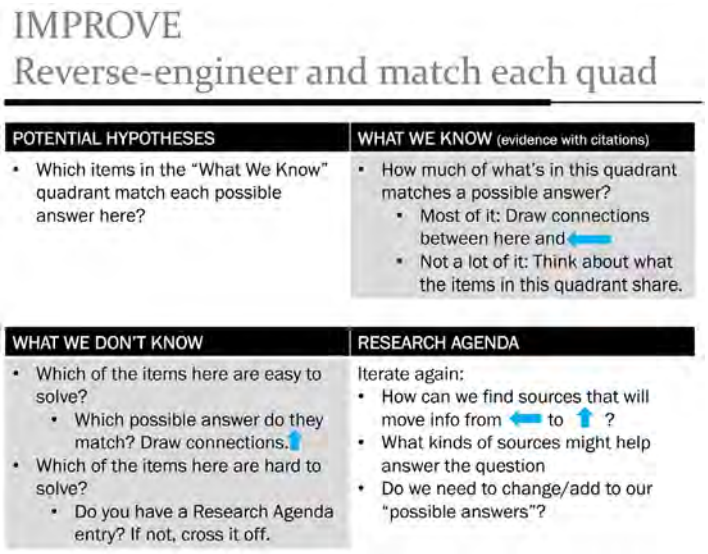

Figure 5. PPT scaffolding for PBL, slide 3

Each 75-minute session was divided into specific types of student interaction with the history PBL quadrants, each of which was designed to further emphasize the norms of the historical discipline. The instructor provided an initial mini-lecture on why PBL provides support for students trying to solve an ill-structured problem—"how to answer a question with no right answer". The mini-lecture was accompanied by guidance on how to undertake a 5-minute structured brainstorming session using the quadrants, and the students received a slide which they could use as a guide (see Figure 3). After five minutes of unguided brainstorming, the instructor began to circulate the room and help students negotiate questions they had about the PBL activity or the information they wanted to enter into the quadrants. After 10 minutes, the instructor presented another 2-minute mini-lecture which directed the students to fill in the PBL quadrants more systematically, using connections between the information they had available and what their next steps were (see Figure 4). Finally, after another 10 minutes of guided work, the instructor used a third 2-minute mini-lecture and reference slide (see Figure 5) that demonstrated how to deduce the best hypothesis using information from the other PBL quadrants.

In the third intervention, students were allowed to structure their own group collaboration. During all three interventions—with the exception of the first five minutes of unsupervised brainstorming—instructors provided support by circulating at will. Students made use of table-mounted microphones to call out their group number and request help if an instructor was not nearby.

Data Collection

Five of 16 groups volunteered to be video recorded. We then narrowed our focus to the groups that represent the different barriers to their PBL processes. In group 8, students started with the evidentiary gathering process but struggled to articulate and organize their evidence to provide a clear answer. In group 13, students developed an initial but unsupportable answer and had to reorient their inquiry. This group had to analyze collaborative problem-solving patterns using multiple scaffolds to develop historical thinking skills, such as use of quadrants and the instructor.

A small tabletop 360-degree camera was placed in each group to capture the whole group interaction; no camera operator was needed for this arrangement. Studies show that when people are intensely involved in what they are doing, the presence of a camera tends to quite rapidly fade out of awareness (Jordan & Henderson, 1995). Additionally, students' artifacts (including final posters, quadrants, and notes) were collected in digital format after each session and were used to triangulate how students' historical thinking skills were developed during the time.

Data Analysis

We employed Interaction Analysis (IA) to investigate learning interactions with each other and with objects in their environment through video (Jordan & Henderson, 1995; Powell et al., 2003). The video-based IA approach can serve as a powerful tool to understand learning, particularly in complex, multi-actor, and tool-mediated learning environments (Jordan & Henderson, 1995). In particular, providing verifiable observation through video technology has been vital in establishing IA for its primary records and on playback capability for the analysis. This analytical approach allowed the researchers to observe learning as a distributed and ongoing social interaction, in which evidence of learning must be studied to understand the ways it occurs moment-to-moment throughout collaboration (Garfinkel, 1967). Thus, the IA approach helped the researchers to gain insights into students' development of historical thinking skills and the instructor provision of contingent scaffolding by interacting with the students and the visual representation tool.

Following the video analysis guidance from Jordan and Henderson (1995) and Powell et al. (2003), our analysis effort was performed in collaborative data sessions rather than individual coding sessions. The research team's intersubjective process of analysis contributed to validity in this qualitative study as data sources were triangulated with the collected artifacts. The researchers analyzed the data through continuous group discussion aiming to construct mutual meanings of the data, as described below. Our first step toward analysis was to generate a video log. The video content listings were indexed by five-minute timestamps, consisting of identifying information and rough summaries of events. The researchers found it useful to grasp a quick overview of the data corpus and locate particular scenes and interactions. At this stage, no attempt was made to provide evenness or consistency in coverage. Then, we identified critical events related to PBL processes, such as development of historical thinking, use of representational tools, and interactions with the instructor. For instance, we looked for observable behaviors that demonstrated any confusion in the PBL process when student groups were discussing what to write under the potential hypothesis section, closely reading their primary sources, asking questions, and explaining their results to the instructor. These clips were transcribed verbatim and analyzed during the multiple data sessions. The transcripts contained annotations for nonverbal behaviors, such as gaze, student's hand gesture, or document writing/drawing, so we could better understand references to the shared representational space of the PBL-LHC quadrants. In the following data sessions, the research team noted interesting moments of each interaction and the specific features of synergistic scaffolding—including the teacher's talk and the usage of representation tools—and discussed how each interacted with each other to support historical thinking based on our framework, PBL-LHC. Through the course of multiple replays of the video segments, our group work revealed finer and finer levels of participants' social interaction with their tools.

Findings

Through synergistic scaffolding rooted in the history PBL quadrants, students in a large-lecture classroom were able to successfully engage in self-regulated historical-argumentation with minimal instructor contact. One representative group, number 8, spent less than 20 minutes engaging in instructor-driven inquiry across the total 225 minutes of the three sessions. Despite minimal instructor contact, students successfully generated multiple hypotheses and narrowed their evidence to provide an answer to an open-ended problem. Here, we present representative interactions in a student group that demonstrated how they drew on minimal instructor support scaffolded by the PBL-LHC representational tool to advance their reasoning.

Connecting PBL Processes to Historical Thinking

The group discussion took place immediately after timely instructor scaffolding based on a concrete example, using the words students actually wrote on the board. After the instructor reviewed the group's whiteboard, she responded to the students' inquiry process by emphasizing that the written

word, "advancement," could be seen as a judgment about the past from a current perspective, rather than an indication that the students had situated their primary sources in a historically contextualized time and place. Excerpt 1 demonstrates how the scaffolding was taken up by the students after the instructor left as they tried to connect three different historical plague outbreaks with a single argument. In this interaction, students struggled to find the right vocabulary to describe their argument without using the word, "advancement."

Excerpt 1 (Group 8 / Week 14)

1. **Michael:** I don't even know how to word it. How you combine the three plagues, I guess. Just like three great plagues? I don't know… Oh my god…
2. **Josh:** (murmuring) *available* medicine… (Michael is typing)
3. **Michael:** (inaudible, but repeating what he is ty ing into the PBL hypothesis quadrant)
4. **Charlie:** We need to name it
5. **Michael:** Yea, I mean at that point, we name them in the actual…
6. **Josh:** …yeah, opening paragraph.
7. (Students all direct their gaze at the PBL hypot esis quadrant)
8. **Michael:** So.. Medicine during three major plagues…
9. **Josh:** Umm, influenced…or…yeah…
10. **Michael:** social change…? Umm, it could be just like societal change?
11. **Josh:** Influenced the social response to change? I mean we don't have to get it ironed out right now. We just need, I mean, I am pretty sure we all know what we are trying to say.
12. (Everyone is staring at the screen silently)
13. **Michael:** Social response...
14. **Josh:** To outbreaks. I don't know
15. (Michael types what Josh just said)
16. **Josh:** Just put next to it, like, "not real". So she doesn't come and say that doesn't make sense. So like we know. We know. We haven't worded it perfectly. You can put "not exact" or something.
17. **Michael:** Yeah, "not complete." (Everyone laughs)

Michael's initial complaint in line 1 that he didn't know how to "combine the three plagues" demonstrated that he had appropriated the underlying PBL norms that required them to synthesize three separate historical contexts and narrow their arguments into one argument (lines 1-5) as well as the value of elaborating the argument in a shared PBL quadrant (line 7). More importantly, this interaction showed that the instructor's scaffolding was taken up by the students properly and was effective, as demonstrated by Josh's comments in line 2, "available" medicine. Then, the students showed they appropriated the vocabulary of historical argument (lines 9-14) and acknowledged the interaction afforded by boundary objects (lines 16-17). Even though it was challenging, the students appeared to regulate their argumentation process, as evidenced by Josh's statement that they should clearly indicate the draft nature of their statement so the instructor "doesn't come and say that doesn't make sense." Here, students acknowledged they would receive ongoing feedback based on what they wrote on the whiteboard. The integration of PBL norms, instructor scaffolding, and representational tools allowed students to advance their reasoning but in a very cautious and mindful way (i.e., using "not complete" wording). This interaction demonstrated how the PBL quadrants supported the instructor evaluation of, and feedback about, the student selection of the vocabulary that would best demonstrate their historical thinking skills. The quadrants also underscored the challenge inherent in student appropriation of discipline norms (e.g., Michael's frustration in his statement, "Oh, my god").

Contingent Support Based on Visual Representational Tools

The visual representations of PBL-LHC quadrants on the whiteboard, computer and iPad surfaced students' reasoning processes, allowing the instructor to assess the current status of the group's inquiry process and adjust the feedback to be more responsive and contingent. In Excerpt 2, the PBL-LHC quadrant made students' thinking immediately visible to the instructor without the instructor interrupting the discussion or making students repeat themselves. In turn, the instructor was able to provide contingent and expert guidance to help the students. This excerpt began with Anna pointing to the whiteboard, and the instructor looking at the whiteboard following the direction of Anna's finger (Figure 7), while they discussed a potential hypothesis.

Excerpt 2 (Group 13 / Week 9)

1. **Anna:** We don't know. We feel like we'd have trouble finding sources.
2. **Instructor:** You will, yes.
3. **Adam:** It sounds like a great idea. But, like, then again is there a lot of evidence to back that up?
4. **Instructor:** There is not. So that's one of the reasons that we talk about the best answer, and not the right answer. This is, it's a fabulous hypothesis, but you would literally have to do, like, tree ring observations, and gerbil population spreads, and a number of other things that are well outside the boundaries of what we do in this class to prove that. Lovely, and I like it a lot, but I would go a different route, ok?

5. **Adam:** Different route as in like, different route for seasons, or different route as in like, social class different route.
6. **Instructor:** I like the social class piece, and you've got plenty to prove that.
7. **Adam:** Ok that's what I thought.
8. **Instructor:** You can already see it over here (poin ing "Social class/Jobs" on the whiteboard). Greed. People who take care of the dead earn substantial salaries. You've already got proof that the plague changed people's social status. So what other elements are happening here? Doctors ... service. Right? Is there an element of, you guys had talked about medical response? Is there an element of social status in how doctors treat patients and can you see that shaped in the primary sources?
9. **Bob:** Alright.
10. **Instructor:** So, now you need to hunt down evidence and figure out how to go get more.
11. **Cathy:** Cool, she just told us what to do.

In this excerpt, students verified their assessment of their PBL-LHC process with the instructor by using their whiteboard as a communication tool (see Figure 8). Anna drew instructor attention to the "what we know" quadrant to indicate difficulty finding sources to support their proposed hypothesis, and Adam restated their problem by asking the instructor, "It sounds like a great idea. But, like, then again is there a lot of evidence to back that up?" (line 3). This interaction showed the students drawing their instructor's attention to a pre-existing issue in their inquiry process—a lack of evidence for their argument to make sure they were on the right track. The instructor's responses throughout this excerpt drew on the students' visual representation of their thinking to validate the students' performance in the inquiry process to date. She began by confirming that the students' concern about lack of evidence was correct and then supported their continued use of PBL-LHC by noting, "…that's one of the reasons that we talk about the best answer, and not the right answer" (line 4)

At this point, the instructor shifted focus to what the students had added in their "Potential Hypothesis" quadrant, an example of responsive and contingent scaffolding that emphasized the successful engagement with disciplinary practice on which the students could build as they moved forward (line 4). In response, students clarified their understanding of the historical thinking in which they were engaged by elaborating the instructor's feedback, such as, "Different route as in like, different route for seasons, or different route as in like, social class different route" (line 5).

Figure 6. Pointing the whiteboard 1

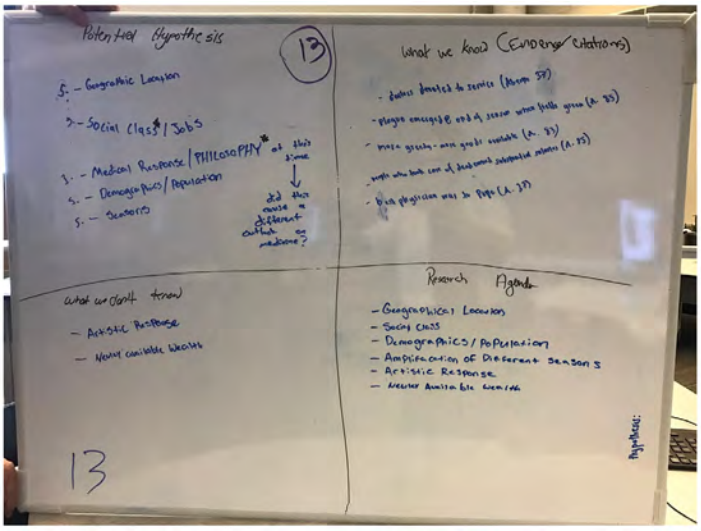

Figure 7. Student's whiteboard 1

Then, the instructor drew student attention to evidence they had already gathered: "You can already see it over here (pointing to "Social class/Jobs" on the whiteboard)" (line 8).

In this way, contingent scaffolding helped students refine their arguments when they were not confident about their inquiry process. By grounding her emphasis on social status in the students' own visual representation, the instructor demonstrated that the students had already engaged disciplinary practices, despite their perception that they were struggling. This kind of interaction prevailed across

the student groups, as demonstrated by a similar interaction within a group that focused on a very different historical argument. In Excerpt 3, we show another interaction which highlights the example of synergistic scaffolding among the instructor, a group of students, and the visual representation to facilitate the problem-solving process.

Excerpt 3 (Group 8 / Week 4)

1. **Instructor:** How are you guys doing?
2. **Josh:** We are doing good. How are you doing?
3. **Julia:** I think we are good.
4. **Instructor:** Ok. The answers are… (looking at the whiteboard and reading) OK, the answers are responding to higher power [that's] striking people down with plague because of war and murder. OK, so divine punisments because of.. (stops and focuses on one corner of the whiteboard)
5. **Tim:** That's our triangle?
6. **Instructor:** WOW! That's so awesome. You guys did a visual version. OK, so divine punishment because of inappropriate geopolitical martial interaction. Plague spreads where there is…
7. **Julia:** War (laughing)
8. **Josh:** That's what I was thinking (inaudible)

In this excerpt, the instructor initiated the conversation by asking how the group felt to diagnose their current status of the PBL process (line 1). Then, the instructor immediately skimmed the whiteboard and quickly assessed the group's status. The exposure of students' inquiry process written on the whiteboard served as a referent for the instructor in her contingent support of the group's historical thinking (line 6). Then, she highlighted the norms of historical argumentation and vocabulary (lines 6). In this group, the students transformed the written information in their PBL-LHC into a triangle diagram that represented their argument that the medieval Christian God spread plague as a way of conveying disapproval about constant war in the Mediterranean (see Figure 8). This is a particularly good example of students integrating

PBL-LHC quadrants with historical thinking and appropriating the results of that integration in an unexpected way. The use of a student-generated visualization—the triangle—within an otherwise text-oriented PBL-LHC quadrant to present a historical argument to the instructor meant two things: (1) the students were able to understand and synthesize the interrelationship among critical factors; and (2) the instructor was able to draw on a very specific representation of current state of student work without witnessing the entire inquiry process. The whiteboard, with its PBL-LHC text plus the triangle, provided a co-constructed reference point that

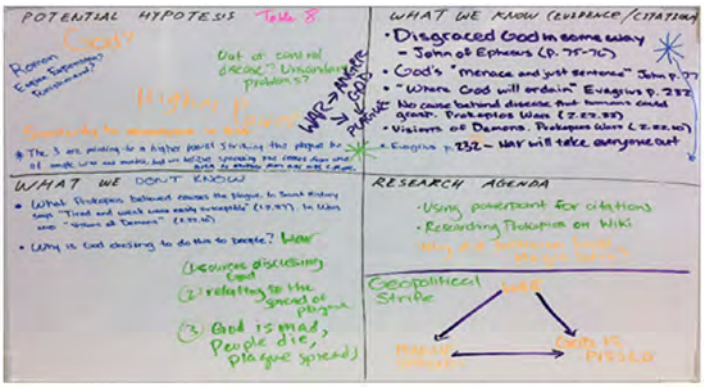

Figure 8. PBL quadrant generated by students at group 8 during PBL encounter 1.

the group members and the instructor used to facilitate jointly a discussion that ultimately affirmed the students' historical thinking.

Students' Gradual Appropriation of the PBL Process

Over the course of the three PBL-LHC sessions, students gradually began to appropriate the norms of PBL-LHC to refine their responses to, and marshal evidence for, increasingly complex questions. At the beginning of the first PBL-LHC session, students struggled to understand several elements of PBL-LHC. Despite accepting the necessity of an ill-structured problem as a foundation for historical thinking, students still struggled with both the ill-structured nature of the historical question and finding appropriate evidence to support the hypotheses they developed. For example, in the first few minutes of the first encounter with PBL, one student asked, "What are we supposed to do?" This question is illustrative of the struggle many students in the classroom faced as they attempted to grapple with the shift from history as a discipline of memorization to a discipline of inquiry. Another student provided an answer to the first student's query: "5 minutes to be confused." The second student echoed a statement the instructor noted in the introduction of PBL, "It is a way to situate students in a messy and complex PBL learning environment. Solving ill-structured problems is difficult at first but will lead to productive solutions eventually."

By the second PBL-LHC encounter, procedural questions about the inquiry process were less frequent and the student-instructor interactions began to focus on the historical content of the ill-structured problem. At the close of the third and final PBL-LHC session, most students were comfortable with PBL-LHC as a process through which they could support their historical thinking. The third session positioned students' argumentation for the production of the last major group assignment of the semester. Instructors announced that students could structure their argument using any

process with which they were comfortable. Twelve of sixteen student groups voluntarily guided their collaborative historical-argumentation inquiry using the structure of the PBL quadrants to categorize their information and explore how the information in the different quadrants related, either on a whiteboard or in PowerPoint. These choices suggest that students appropriated not only the underlying disciplinary norms that required them to synthesize three separate historical contexts into one argument but also the value of elaborating the argument in a shared PBL quadrant format.

Excerpt 4 (Group 8 / Week 14)

1. **Tim:** So we are calling cultural and politics are the same thing?
2. **Josh:** What?
3. **Tim:** Like we are looking for overlap between cu tural and politics?
4. **Josh:** Ah.. I don't think it necessarily overlap? Like
5. **Tim:** One causes the other?
6. **Josh:** Or like political something in a cultural som thing, both arose because of the plague. Like the plague caused these two things either change or act certain way, respond differently.
7. **Julia:** We can do religion as one of the subpoints
8. **Josh:** Yeah…
9. **Tim:** So what group of people is considered "other" for the first plague? As a result of wars?
10. **Josh:** Would it be, non Roman empire?
11. **Tim:** The Roman empire?
12. **Josh:** NON (emphasized speech) Roman empire.
13. **Tim:** Where is
14. **Josh:** Because it was Roman
15. **Julia:** I think anyone who lived in (inaudible) was like Justinian
16. **Josh:** Yea, right before the plague, slash right before Justinian, the Roman empire was right at their peak, so thriving. Then it starts decreasing a little bit …
17. **Tim:** Who raises the wages in second plague? Was it a government body?
18. **Josh:** Umm, it was just a demand thing. Like there were fewer workers so they had to.
19. **Tim:** Which could be political trade for the second one..
20. **Josh:** So like.. It would be like kings and stuff like that would give land to lords who then pay serfs to work it, and so there is like very structured tier system. But as there weren't enough serfs, the lords kind of had to give up some of ground politically. Because they had to pay more to serfs and it became slightly equal so the tier, monarchal type of system kinda fell apart then.
21. **Tim:** So then the lower class kind of was the ta get, right?
22. **Josh:** Yep, like yea that's pretty good. I think we can definitely argue that with facts. If we disagree later on, we can tweak it a little.

In this series of utterances, we see three students engaged in a discussion in which more than one student asks a thoughtful historically contextualized question about their argumentation structure and process (lines 1-8). More than one student provides a response rooted in historical evidence in order to narrow the scope of their argumentation (lines 9-15). More importantly for the inquiry process, students acknowledged they should have evidence to support their argument. At the same time, students expressed an understanding that additional evidence they produce from their historical primary sources may change their argument about historical change and continuity. (line 22). This process is indicative of a general pattern in which students moved from confusion about inquiry in the general use of PBL to a systematic approach in which their familiarity with PBL supported negotiation about the historical argumentation process.

Student appropriation of PBL-LHC to support their historical thinking is particularly visible if we compare artifacts from PBL encounters 1 and 3. Figures 9 and 10 are PBL-LHC quadrants from the same group that were developed during, respectively, PBL-LHC encounter 1 in week 4 of the semester and encounter 3 in week 12 of the semester. Although the artifact from encounter 1 in Figure 8 made active use of the PBL-LHC process to hone collaborative student thinking at group 8, Figure 9 demonstrated the same use of PBL-LHC but with vocabulary and contextual framing that reflected a much more complex historical-thinking approach. In Figure 8, we see generic language like "higher power" and "Roman Empire" appearing in the hypothesis section. A narrowing of student discussion ensued and resulted in a drawing of a triangle that demonstrated that students used the instructor language of "geopolitical strife." This diagram illustrated the linkage of a higher power who is angry over war to the outbreak of plague as a punishment.

In Figure 9, however, the students' language in the hypothesis section of the PBL-LHC quadrant draws on ideas of cultural "otherness" as a connecting point between racial differences, economic class and social status. This "otherness" was drawn from the language from the primary source of history discussing several different plague outbreaks. Group 8's evidence quadrant from encounter 3's PBL-LHC also reflected a more robust understanding of historical context. They implicitly acknowledged the very different historical

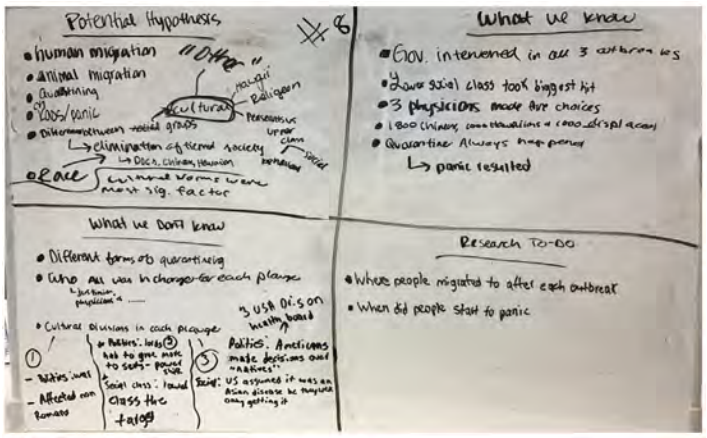

Figure 9. PBL quadrant generated by students at group 8 during PBL encounter 3.

contexts of the outbreaks with which they were working, while still highlighting the similar quarantine patterns of lower social classes. Finally, group 8's more nuanced view of historical patterns with historically contextualized differences was visible in the "what we don't know" quadrant as they compared cultural divisions across each of the three plague outbreaks they studied. This complexity did not have a counterpart in the far simpler thought processes in the "what we know" and "what we don't know" sections from encounter 1, despite the similarity of the instructor's prompt ("one factor that helps explain plague outbreak"). Group 8's use of PBL-LHC to shape their historical argument in encounter 3 demonstrated the role PBL-LHC played in supporting historical thinking across the course. This group voluntarily appropriated PBL-LHC for their own use in encounter 3 despite a prompt that allowed students to use the outlining process they preferred. Twelve of sixteen student groups, including group 8, in the course used the PBL-LHC quadrant voluntarily, suggesting that students found this approach worthwhile.

Discussion

This study demonstrated the promise of implementing PBL in both large classrooms and in humanities inquiry when care is taken to provide synergistic scaffolding. This system of scaffolding can effectively support active learning in a large classroom by using appropriate shared representational tools that do not simply accommodate, but are rooted in and reshaped around, the disciplinary norms of the classroom in question. By co-constructing the elements of a PBL quadrant adapted for historical thinking, students in a large classroom were able to engage in an inquiry-oriented activity by generating multiple hypotheses to answer a central problem. Beyond the size of the classroom, this finding is notable: the co-construction of a PBL-LHC quadrant asked the students to do history, moving away from a passive lecture encounter with the discipline of history and toward a more authentic practice of history. This process involved navigating multiple perspectives, evaluating the reliability of evidences the students built, and experiencing the nature of history, which is interpretive and ill-structured (Monte-Sano, 2012).

This series of inquiry activity in the history classroom can be also contributed to the process of knowledge construction (Scardamalia & Bereiter, 2003) which consists of a range of cognitive processes including the use of problems and questions, interpreting and evaluating new information, sharing, critiquing, and testing ideas at different levels. This effortful, situated, and reflective process can be individual or social in nature (Palincsar, 1998). Moreover, deep learning is often associated with knowledge construction which involves "qualitative changes in the complexity of students' thinking about and conceptualization of context-specific subject matter" (Moore 2002, p. 27). In this study, the PBL-LHC iterations allowed students to experience the knowledge construction process and test their inquiry skills on a set of ill-structured questions that were increasingly complex based in historical schools of thought. This learning process supported students to move from a narrower single historical school of thought to a more authentic, complex and ambiguous historical narrative that accommodated different perspectives and resources to argue. Thus, throughout the course of the inquiry process, student discourse increasingly demonstrated appropriation of vocabulary that drew on historical disciplinary norms, historical complexity and ambiguity, and the synthesis of primary and secondary sources. The iterations also allowed students to connect the historical contexts and events in three different historical plague outbreaks in a single final argument and demonstrate progress toward expertise in historical disciplinary practices. In particular, these disciplinary practices demonstrated a recognized characteristic of the knowledge construction process that contributes to the evolution of ideas by citing and referencing the work of others. In turn, using the disciplinary specific discourse in their own right made the practices evident (Scardamalia & Bereiter, 2003).

At the same time, the types of facilitation were different depending on the complexity of the problem. In the first PBL-LHC encounter, students struggled to understand the inquiry process with the ill-structured problem and struggled to find appropriate evidence to support their hypotheses. In these early stages, the inquiry process was driven by the instructor, who modeled and prompted appropriate historical thinking and inquiry skills. For example, in the beginning of the PBL-LHC activity, the instructor started the class by scaffolding students with a mini-lecture on how PBL-LHC

provides support for students trying to solve an ill-structured problem—"how to answer a question with no right answer". Then, the mini-lecture was accompanied by other slides on how to use the quadrants with specific guidance for a single historical school of thought so that students could refer to a focused example as they worked on their problems. As the intervention continued and student inquiry began to accommodate more complexity, the contingent support shifted away from the direct guidance that a single PowerPoint slide could provide. The support progressed toward a diagnostic interaction that tailored instructor scaffolding to specific student questions that were inspired by the students' own choice of historical school of thought. Despite the increasingly complex questions, the repetition of PBL-LHC with appropriate scaffolding led to positive outcomes. In the later stages of the class, students demonstrated the ability to craft strong hypotheses, locate effective evidence to support these hypotheses and evaluate the validity of a hypothesis without the instructor's explicit support.

The integration of history disciplinary norms into the PBL-LHC visual representation—items as fundamental as the shape of the visual representation that anchored the PBL-LHC or the title of the PBL-LHC quadrants—was a critical consideration in the support of student inquiry strategies as they evolved over time. The representational tools common to PBL served as a boundary object channel for the teacher and students to negotiate shared understanding and to mediate the contingent scaffolding that made enacting PBL-LHC in this large learning space achievable for everyone (Hanney & Savin-Baden, 2013). For students, shared visual representation served as a communication channel to help them regulate and monitor their learning process as a group. Students were able to expose their inquiry processes and historical thinking simultaneously and collaborate more easily with other group members as a result. The process of knowledge co-construction is known to be challenging to follow in small group collaboration settings because it is interwoven with multiple actors in a group (Järvelä et al., 2015; Poitras & Lajoie, 2013). Therefore, collaborative learning requires students to engage in a socially shared regulation (SSRL) to support their learning activities as they produce and maintain their social interaction (Järvelä et al., 2015). In this scenario, the mediating function of the PBL-LHC visual representation demonstrated how the representational tool supported student groups to regulate their inquiry process by providing a structure with which to exchange ideas, negotiate conflicting thoughts, and construct hypotheses (Miao et al., 2000). Moreover, representational tools allowed the instructor to provide more contingent and adaptive scaffolding without interrupting students or asking them to describe their inquiry or historical reasoning in full. We often observed that the instructor stood near (but not at) a student table to read that group's PBL-LHC quadrant in front of the students and provide scaffolding based on the group's current progress. Frequently, both the instructor and the students pointed to specific student-generated elements of the PBL-LHC quadrant so that everyone in that interaction could focus on the same issue more effectively.

The PBL approach aims to promote knowledge co-construction by advancing student reasoning skills to solve a problem and to use systematic process of gathering information and presenting coherent explanations to justify their rationales (Ertmer & Glazewski, 2015). All of these behaviors are indicative of supports that promote productive collaborative problem-solving in small groups using representational tools common to PBL, supporting instructor interaction with students in a large classroom. We argue that this study demonstrates the promise of PBL in both large classrooms and in humanities inquiry when care is taken to provide synergistic scaffolding by establishing norms for group work, structuring the task for learning, modeling the desired collaborating behaviors with the entire class and small groups, and actively monitoring group work with the help of representational tools (Webb et al., 2002).

Conclusion

This study demonstrated ways in which PBL in its PBL-LHC form could be successfully enacted in a large active-learning history classroom. Drawing on inquiry practices to develop historical thinking skills provides a solid foundation for the discipline of history, and PBL-LHC in particular is well-suited to support inquiry in the large classrooms that dominate college-level survey courses on the subject of college history. Even though adapting PBL for use in large classrooms requires a careful integration of history disciplinary norms with the one-on-one scaffolding interactions, the synergistic scaffolding was made possible by visual representation tool of a PBL-LHC quadrant, which supported both elements of that question. First, we can transfer tutor-led and small classroom to practices to a large classroom, as shown in the visual representation that helped offer diagnostic and contingent scaffolding among instructor and students. Second, the visual representation of the PBL-LHC quadrant, especially when adapted to specific history disciplinary norms, both signaled to students that history is an inquiry-based discipline and provided a scaffolding process through which they could represent, modify, and structure their PBL inquiry over an extended period of time.

References

Ahlfeldt, S., Mehta, S., & Sellnow, T. (2005). Measurement and analysis of student engagement in university classes where varying levels of PBL methods of instruction are in use. Higher Education Research & Development, 24(1), 5-20. https://doi.org/10.1080/0729436052000318541

Allen, D. E., & White III, H. B. (2001). Undergraduate group facilitators to meet the challenges of managing multiple PBL groups. The Power of Problem-based Learning: A Practical "How To"For Teaching Undergraduate Courses in Any Discipline, Allen, Sterling, VA.

American Historical Association. (2016). History Discipline Core. Retrieved from https://www.historians.org/teaching-and-learning/tuning-the-history-discipline/2016-history-discipline-core

Andrews, T. M., Leonard, M. J., Colgrove, C. A., & Kalinowski, S. T. (2011). Active learning not associated with student learning in a random sample of college biology courses. CBE—Life Sciences Education, 10(4), 394-405. https://doi.org/10.1187/cbe.11-07-0061

Barton, K. C., & Levstik, L. S. (2004). Teaching history for the common good. Mahwah, NJ: Lawrence Erlbaum Associates.

Baxter Magolda, M. (1992) Knowing and reasoning in college: Gender-related patterns in students' intellectual development. San Francisco: Jossey-Bass.

Belland, B. R., Glazewski, K. D., & Richardson, J. C. (2008). A scaffolding framework to support the construction of evidence-based arguments among middle school students. Educational Technology Research and Development, 56(4), 401-422. DOI 10.1007/s11423-007-9074-1

Biley, F. (1999). Creating tension: undergraduate student nurses' responses to a problem-based learning curriculum. Nurse Education Today, 19(7), 586-591. https://doi.org/10.1054/nedt.1999.0371

Cole, M. (1996). Cultural psychology: A once and future discipline. Cambridge, MA: Belknap Press.

Craig, K., Mahoney, C., & Danish, J. (2017) "Correcting for Presentism in Student Reading of Historical Accounts Through Digital-History Methodologies", in AERA 2017 Annual Meeting Conference Proceedings , San Antonio, TX, April 26-May 1, 2017.

Ertmer, P. A., & Glazewski, K. D. (2015). Essentials for PBL implementation: fostering collaboration, transforming roles, and scaffolding learning. In A. Walker, H. Leary, C. Hmelo-Silver, & P. A. Ertmer (Eds.), Essential Readings in Problem-Based Learning (pp. 89-106). Purdue University Press.

Garfinkel, H. (1967). Studies in ethnomethodology. Englewood Cliffs, NJ: Prentice Hall.

Grim, V., Pace, D., & Shopkow, L. (2004). Learning to use evidence in the study of history. New Directions for Teaching and Learning, 2004(98), 57-65. doi:10.1002/tl.147

Hanney, R., & Savin-Baden, M. (2013). The problem of projects: understanding the theoretical underpinnings of project-led PBL. London Review of Education, 11(1), 7-19. ttp://dx.doi.org/10.1080/14748460.2012.761816Ó2013

Hmelo-Silver, C. E. (2000). Knowledge recycling: Crisscrossing the landscape of educational psychology in a problem-based learning course for preservice teachers. Journal on Excellence in College Teaching, 11, 41-56.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? Educational Psychology Review 16(3). 235-266.

Hmelo-Silver, C. E., & Eberbach, C. (2012). Learning theories and problem-based learning. In Problem-based learning in clinical education (pp. 3-17). Springer, Dordrecht.

Hmelo-Silver, C. E., Derry, S. J., Bitterman, A., & Hatrak, N. (2009). Targeting transfer in a STELLAR PBL course for pre-service teachers. Interdisciplinary Journal of Problem-based Learning, 3(2), 4. https://doi.org/10.7771/1541-5015.1055

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: a response to Kirschner, Sweller, and Clark (2006). Educational psychologist, 42(2), 99-107. https://doi.org/10.1080/00461520701263368

Hung, W., Jonassen, D.H., & Liu, R. (2008). Problem-based learning. In J.M. Spector, J. G. van Merriënboer, M.D. Merrill, & M. Driscoll (Eds.), Handbook of research on educational communications and technology (pp. 1503-1581). 3rd Ed. Mahwah, NJ: Lawrence Erlbaum Associates.

Iliinsky N, & Steele J. (2011). Designing Data Visualizations. O'Reilly Media.

Järvelä, S., Kirschner, P. A., Panadero, E., Malmberg, J., Phielix, C., Jaspers, J., ... & Järvenoja, H. (2015). Enhancing socially shared regulation in collaborative learning groups: designing for CSCL regulation tools. Educational Technology Research and Development, 63(1), 125-142. DOI 10.1007/s11423-014-9358-1

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. The Journal of the Learning Sciences, 4(1), 39-103. https://doi.org/10.1207/s15327809jls0401_2

Klegeris, A., & Hurren, H. (2011). Impact of problem-based learning in a large classroom setting: student perception and problem-solving skills. Advances in Physiology Education, 35(4), 408-415. https://doi.org/10.1152/advan.00046.2011

Klegeris, A., Bahniwal, M., & Hurren, H. (2012). Lack of

Correlation Between Distinct University Student Skill Sets Identified By Using A Panel Of Assessments: A Two Year Study. International Journal of Arts & Sciences, 5(6), 479.

Kuhn, D. (1999). A developmental model of critical thinking. Educational Researcher, 28(2), 16-46. https://doi.org/10.3102/0013189X028002016

Lu, J., & Lajoie, S. P. (2008). Supporting medical decision making with argumentation tools. Contemporary Educational Psychology, 33(3), 425-442. https://doi.org/10.1016/j.cedpsych.2008.05.005

Marshall, L. L., Nykamp, D. L., & Momary, K. M. (2014). Impact of abbreviated lecture with interactive minicases vs traditional lecture on student performance in the large classroom. American Journal of Pharmaceutical Education, 78(10), 189. DOI: https://doi.org/10.5688/ajpe7810189

Miao, Y., Holst, S. J., Holmer, T., Fleschutz, J. M., & Zentel, P. (2000, May). An Activity-Oriented Approach to Visually Structured Knowledge Represenation for Problem-Based Learning in Virtual Learning Environments. In COOP (pp. 303-318).

Monte-Sano, C. (2012). What makes a good history essay? Assessing historical aspects of argumentative writing. Social Education, 76(6), 294-298.

Moore, W. S. (2002). Understanding learning in a postmodern world: Reconsidering the Perry scheme of intellectual and ethical development. In B. K. Hofer & P. R. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 17–36). Mahwah, NJ: Lawrence Erlbaum Associates.

Newmann, F. M. (1991). Classroom thoughtfulness and students' higher order thinking: Common indicators and diverse social studies courses. Theory & Research in Social Education, 19(4), 410-433. https://doi.org/10.1080/00933104.1991.10505649

Nicholl, T. A., & Lou, K. (2012). A model for small-group problem-based learning in a large class facilitated by one instructor. American Journal of Pharmaceutical Education, 76(6), 117. DOI: https://doi.org/10.5688/ajpe766117

Pastirik, P. J. (2006). Using problem-based learning in a large classroom. Nurse education in practice, 6(5), 261-267. https://doi.org/10.1016/j.nepr.2006.02.003

Palincsar, A. S. (1998). Social constructivist perspectives on teaching and learning. Annual Review of Psychology, 49(1), 345-375.

Pea, R. D. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. The journal of the Learning Sciences, 13(3), 423-451. https://doi.org/10.1207/s15327809jls1303_6

Perry, W. G. (1970). Forms of intellectual development in the college years. New York: Holt.

Poitras, E. G., & Lajoie, S. P. (2013). A domain-specific account of self-regulated learning: The cognitive and metacognitive activities involved in learning through historical inquiry. Metacognition and Learning, 8(3), 213-234. DOI 10.1007/s11409-013-9104-9

Powell, A. B., Francisco, J. M., & Maher, C. A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. The Journal of Mathematical Behavior, 22(4), 405-435. https://doi.org/10.1016/j.jmathb.2003.09.002

Puntambekar, S. (2015). Distributing scaffolding across multiple levels: Individuals, small groups, and a class of students. In P. Ertmer (Ed.), Essential readings in problem-based learning (pp. 207–221). Indiana: Purdue University Press.

Puntambekar, S., & Hubscher, R. (2005). Tools for scaffolding students in a complex learning environment: What have we gained and what have we missed? Educational Psychologist, 40(1), 1–12. https://doi.org/10.1207/s15326985ep4001_1

Scardamalia, M., & Bereiter, C. (2003). Knowledge building environments: Extending the limits of the possible in education and knowledge work. Encyclopedia of Distributed Learning, 269-272.

Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Golan, R., Kyza, E., et al. (2002). Evolving a scaffolding design framework for designing educational software. IN P. Bell, R.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. Interdisciplinary Journal of Problem-based Learning, 1(1), 3. https://doi.org/10.7771/1541-5015.1002

Saye, J. W., & Brush, T. (2002). Scaffolding critical reasoning about history and social issues in multimedia-supported learning environments. Educational Technology Research and Development, 50(3), 77-96. https://doi.org/10.1007/BF02505026

Saye, J. W., & Brush, T. (2007). Using technology-enhanced learning environments to support problem-based historical inquiry in secondary school classrooms. Theory & Research in Social Education, 35(2), 196-230. https://doi.org/10.1080/00933104.2007.10473333

Sewell Jr, W. H. (2005). Logics of history: Social theory and social transformation. University of Chicago Press.

Shipman, H. L. and Duch, B. J. (2001). Problem-based learning in large and very large classes. In The Power of ProblemBased Learning: A Practical 'How To' for Teaching Undergraduate Courses in Any Discipline, B. Duch, S. E. Groh, and D. E. Allen, (Eds.) pp. 149–164. Sterling, VA: Stylus Publishing.

Shopkow, L., Díaz, A., Middendorf, J., & Pace, D. (2012).

The History Learning Project "Decodes" a Discipline: The Union of Teaching and Epistemology. In K. McKinney & M. T. Huber (Eds.), The Scholarship of Teaching and Learning In and Across the Disciplines (pp. 93-113). Bloomington, IN: Indiana University Press.

Snir, J., & Smith, C. (1995). Constructing understanding in the science classroom: Integrating laboratory experiments, student and computer models, and class discussion in learning scientific concepts. In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), Software goes to school: Teaching for understanding with new technologies (pp. 233–254). New York: Oxford University Press.

Staff, T. E. (1968, August 30, 1968). What a Year! Time Magazine.

Suthers, D. D. (1999). Representational support for collaborative inquiry. In Proceedings of the 32nd Hawaii International Conference on the System Sciences (HICSS–32) (CD-ROM). Maui, HI: Institute of Electrical and Electronics Engineers (IEEE). Available: http://lilt.ics.hawaii.edu/lilt/papers/1999/Suthers-hicss99.pdf

Tabak, I. (2004). Synergy: A complement to emerging patterns of distributed scaffolding. Journal of the Learning Sciences, 13(3), 2004. https://doi.org/10.1207/s15327809jls1303_3

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. Educational Psychology Review, 22(3), 271-296. https://doi.org/10.1007/s10648-010-9127-6

VanSledright, B. (2002). Confronting history's interpretive paradox while teaching fifth graders to investigate the past. American Educational Research Journal, 39(4), 1089-1115. https://doi.org/10.3102/00028312039004108

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological processes. Harvard University Press, Cambridge.

Webb, N. M., Farivar, S. H., & Mastergeorge, A. M. (2002). Productive helping in cooperative groups. Theory into Practice, 41(1), 13-20. https://doi.org/10.1207/s15430421tip4101_3

Wineburg, S. S. (1991). On the reading of historical texts: Notes on the breach between school and academy. American Educational Research Journal, 28(3), 495-519. https://doi.org/10.3102/00028312028003495

Wineburg, S. S. (2001). Historical thinking and other unnatural acts: Charting the future of teaching the past: Temple University Press.

Wineburg, S., Smith, M., & Breakstone, J. (2018). What Is Learned in College History Classes? Journal of American History, 104(4), 983-993. doi:10.1093/jahist/jax434

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. Journal of Child Psychology and Psychiatry, 17(2), 89-100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x

Woods, D. R. (1996). Problem-based learning for large classes in chemical engineering. New Directions for Teaching and Learning, 1996(68), 91-99. https://doi.org/10.1002/tl.37219966813

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