Net.Create: Network Analysis in Collaborative Co-Construction of Historical Context in a Large Undergraduate Classroom

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Abstract: History educators in large-lecture humanities undergraduate classrooms struggle to support reading comprehension, defined as the ability to simultaneously read a complex text critically, understand the text's details and context, and vet the text's claims. Critical reading of historical texts in particular helps bridge the gap between seeing history as memorization-oriented and seeing it as an inquiry-oriented discipline that reconstructs narrative and context. Net.Create is an open-source, network-analysis software tool paired with activities that support intuitive creation and revision of a network data set and accompanying visualization, and through these representational practices, reading comprehension in humanities classrooms. Findings show that as students draw on details in a historical text to collaboratively construct a larger network, they begin to emphasize context reconstruction over memorization.

Keywords: history, network analysis, representations, activity theory, CSCL

Introduction

History educators in undergraduate classrooms struggle to support reading comprehension, which they define as the ability to read a text critically, develop an understanding of the key historical actors, relationships, and context within a text, and simultaneously vet the reliability of the claims the text makes about them (Shopkow, 2017; Sipress & Voelker, 2011). Critical reading is a challenge for novice history learners when encountering long, complex historical texts. This is also the first major step in historical argumentation (Burke & Andrews, 2008; Martin & Monte-Sano, 2008; Lévesque, 2008) and is therefore important to support learners as they draw on historical texts to engage in critical historical reasoning.

Large-lecture environments in history survey courses and the complexity of historical primary sources create barriers to learning the reasoning practices of professional historians. Lectures encourage students to consume other people's narratives or to see history as memorizing facts (Wineburg, 1991; Jeffrey, 2003; Wineburg, 2018), rather than as an inquiry-oriented discipline in which students can construct their own evidence-based historical narrative (Slotta & Najafi, 2013; Estes, 2007; Calder, 2006). High instructor-to-student ratios makes it even more difficult to provide extended instructor interventions that effectively support historical inquiry (Saye & Brush, 2002). Rather than being limited by the constraints of a large fixed-seating lecture hall, we developed an approach that uses simultaneous data entry and network analysis through network visualizations that actively takes advantage of this physical space.

Net.Create (Craig et al., 2019) is an open-source network-analysis software tool that supports intuitive creation and revision of a network data set and accompanying visualization of a large body of text, and, through these representational practices, reading comprehension in humanities classrooms. Using network creation and visualization tools allows learners to think relationally, and make visual and explicit representations of the historical actors and the events and ties that connect them. As students draw on a historical text to collaboratively construct a network, they engage in knowledge construction using one of the foundational disciplinary tools of the historian: working out the larger historical context that helps explain the immediate events they are examining.

Net.Create and its activities support students as they collaboratively co-construct knowledge about a large corpus of data at both the small and large group level, facilitating discovery, discussion, and recreation of historical context. Supporting deep collaborative engagement helps learners understand what historians do as they apply critical reading to grapple with the complexity of historical primary sources in the construction of historical context (Shopkow, 2017). When students acquire these foundational methods of historical thinking, they are able to make sense of the past from their own perspective. Although students may quickly forget specific historical facts, instructors hope that when students leave a history class, they will take with them an inquiry approach that gives them the tools to ask penetrating questions and provide meaningful answers.

Background and objectives

Our goal in bringing Net.Create into history classrooms was to help students shift from memorization to context reconstruction. In the activities discussed here, students fed individual historical details into Net.Create's shared representational space, which supports simultaneous network data entry and a live visualization. Small groups of students were given short excerpts of a long text, from which they entered data about the people and interactions they found into Net.Create. As they worked, they could see the data being entered by other groups using other excerpts from the same text. This collaborative co-construction put each student-provided detail into a broader historical context. Students then used Net.Create's representation to identify the local significance of a historical detail and to understand the place of that detail in a larger framework constructed by the author of a text.

Our work builds on activity theory (Engeström, 1987), a sociocultural theory of learning (Danish & Gresalfi, 2018) that focuses on how joint, collective activity and its shared object or overall goal shapes individual learning (Wertsch, 1981). Individual activity is mediated, or transformed, by the tools used, rules for collective activity, and the division of labor between the individuals within the group (Engeström, 1987). We aim to leverage this perspective to design for specific mediators of students' activity, and then to analyze if and how students' activity is transformed, and whether this leads to the kinds of learning we hope to achieve.

The researchers thus began the design of Net.Create and the surrounding activities by articulating the gap between historical-thinking learning objectives (Table 1) and the objects (motivations) students brought with them via previous experiences in history classrooms. Our learning objective was for students to build historical context by understanding the complex interactions shaped by the author of a historical text (Wineburg, 1991, 2001). However, students tend to define history as the memorization of names and dates (Barton & Levstik, 2004; Levstik & Barton, 2008; Shopkow, Díaz, Middendorf, & Pace, 2012) — in their words, the "chronological history stuff" (Student 1, Group High1, Day 2) — and they are puzzled when that memorization task is not emphasized. We wanted to re-mediate this engagement with history so that students were more oriented toward understanding the historical context that explains *why* historical figures behaved the way they did, rather than simply memorizing the historical "stuff" and talking about *when* historical figures did what they did.

A key challenge in bridging this gap between memorization and reconstruction of historical context (Craig, 2017) comes when students simultaneously encounter a new detail and need to reconstruct that detail's historical context and significance (Monte-Sano, 2011; Rouet, Britt, Mason, & Perfetti, 1996). By pairing collaborative learning with networks, we were able to show students how individual actors, (nodes or circles that represent people, organizations, etc.) had interactions (edges or lines that show interactions between the nodes) in the context of a larger, aggregated set of complex interactions represented by a visualization that simultaneously exposes local and global context (See Figure 1). In this simplified example drawn from a more complex student-generated network, nodes representing Roman imperial figures like Agrippina, Nero and Claudius are connected not simply to each other but in a triangular interaction that demonstrates their dependency on each other.
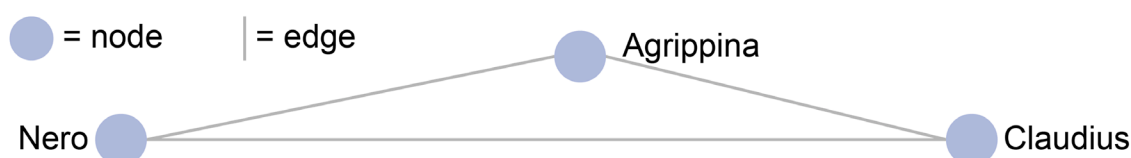
Figure 1. A simplified networks visualization of nodes (individual things) and their connections (edges).

In this way, Net.Create allows students to transform a text into a joint object, in the form of a network visualization, to think with as they attempt to reconstruct a text's detail and historical context at the same time. At the professional level, humanities researchers have used network analysis to address this complexity. For instance, network analysis allows researchers to move between local detail and global context in phenomenon such as the rise of the Medici family in Florence in the 15th century (Padgett and Ansell, 1993) and the ways a century of changing social structures (genealogical and religious patronage relations) of nobility, gentry, and urban bourgeoisie in Norfolk influenced gentry involvement in the English Civil War (Bearman 1993). Reconstructing these specific interactions assists historians as they build their understanding of historical context, demonstrating the facility with which networks position local detail in a global context.

In order to tie the features of Net.Create to learning outcomes, we drew on computer-supported collaborative learning (CSCL) pedagogies that position synchronous activity around a dynamic representation to support knowledge co-construction (Slotta & Najafi, 2013). First, Net.Create facilitates co-construction of ideas by supporting simultaneous multi-user contributions to a single network, a synergy that extends beyond the individual to provide a focus for joint attention (Hmelo-Silver & Barrows, 2008; Suthers, 2006). Second, Net.Create represents detail and historical context in a live visualization, providing students with a meaningful joint task that allows them to display, repair, and refine their ideas (Roschelle, 1992). Finally, collaboration does

not guarantee success, so we characterized the interaction patterns of more and less successful groups (e.g. Barron, 2003; Derry et al., 2006) to design future Net.Create activities to encourage more productive group interactions.

Methods

The Net.Create activities were designed around three activity clusters to help students recreate the historical context in a 60-page historical primary source about the Roman Emperors Nero and Claudius (Tacitus, 2008), which we divided into 1.5-page excerpts. Table 1 maps each of our instructional goals to our desired learning outcomes, the salient Net.Create features, and assessment measures.

Table 1: Instructional goals mapped to learning outcomes, technological features, and data sources

Instructional goals	Learning outcomes	Net.Create Feature(s)	Data collected
1. Practicing *consistent citation* and *accurate historical identification*	Tie network revision to history disciplinary practice of argumentation ("historiography")	Predictive text; Node/Edge tables with fields for citations and significance notes	Student-produced network creation and revision data
2. Using *network concepts and visualizations* to identify *individual significance in a larger context*	See group excerpt in a larger whole, moving seamlessly between local and global context	Simultaneous multi-user data entry	Student-produced network creation and revision data; audio log data; Network-thinking paper score
3. Producing a *network of key players* for the text and *discussing it in groups*	Seeing individuals in a network-analysis-driven historical context	Live visualization of the aggregate network	Historical-thinking paper score

This study was conducted during two 75-minute class sessions in a survey history course at a Midwestern United States university. The 75 students were divided into 25 groups of 3 students in a large lecture hall with tiered stadium seating. Each group was given a laptop to collaboratively use Net.Create. On Day 1 of the study, each student group used a single excerpt from Tacitus to enter new node and edge data into the Net.Create tool. On Day 2 of the study, each group evaluated nodes and edges created by another group on Day 1 and revised the data to improve accuracy and fill gaps. Data entry prompts within Net.Create encouraged the inclusion of citations and notes on historical significance for each node and edge. These text notes on historical significance provided additional annotation for reference and contextualization of historical actors and the relationships between them.

Data sources included screen-captured recordings of Net.Create use, audio of small-group collaborations, software log data, and student papers. These data sources helped us determine the relationships between groups' average performance on their final papers and the ways that groups interacted with the Net.Create tool during class. The study adopted a mixed methods approach (Creswell & Clark, 2017). We began by quantifying students' final paper performance, and then used these results to inform subsequent analysis about how group interactions with Net.Create supported these outcomes (See Table 2). The paper assignment asked students to reconstruct the early Roman Imperial historical context according to Tacitus. The course instructor scored these papers out of 70 points. The research team coded separately for the presence of historical thinking and network thinking practices.

Table 2: Methods used for analysis mapped to key data sources

Source	Coding Schema	Notes
Log data	*Determining the quality of entries (Historical significance):* Written annotations in the significance field were coded on a Likert scale (1-5). 1 = no attempt at explaining the historical significance of the node/edge; 5 = a well-constructed explanation of significance that includes the specific situational context of related nodes and edges.	Two historians rated 10% of the entries and negotiated any differences to 100% agreement before coding the rest of the corpus
Student papers	*Instructor grades:* standard A-F grading scale out of a possible 70 points.	For all but the instructor grades, three members of the research team rated

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	Historical sourcing: Did the student recognize that the historical account in the Annals was driven by Tacitus's perspective? Coded on a qualitative scale (no, sort of, yes) based on whether the student drew on information only from Net.Create significance fields or added additional information from Tacitus not contained in Net.Create notes. *Historical context (2 questions):* Coded on a Likert scale (never, seldom, occasionally, often, or consistently). • *Attempted* to reconstruct broad historical context • *Accurately* reconstructed broad historical context *Close reading (2 questions):* Coded on a Likert scale (never, seldom, occasionally, often, or consistently). • Accurately identified historical actors • Accurately placed historical actors in their individual context	10% of the entries and negotiated any differences to 100% agreement before coding the rest of the corpus.
Audio & screen-capture recordings	Interactional analysis of groups selected based on weak/strong log-data and paper scores.	

Log data allow us to measure the *quantity* and *quality* of Net.Create tool use. *Quantity* is the number of interactions that students had with the Net.Create tool (captured in detailed server logs). *Quality* is the average rating that two trained historians gave to students' node and edge entries in the historical significance field (which allowed students to annotate nodes and edges with historical details). Spearman's correlations exposed the relationships between quantity and quality of Net.Create interactions and accurate reconstruction of historical context in student papers. One correlation looked at the quantity of interactions (total node/edge creation/revision) and their final paper scores. Another correlation compared the quality of notations with Net.Create to final paper scores, using the ratings trained historians gave to students' historical significance annotations (see Table 2).

We used log data to map event timelines for groups that were particularly good or particularly bad at reconstructing the historical context of the data they entered, defined by the quality ratings that historians gave to the students' significance-field entries. We also compared the entry processes of groups that did better or worse on the final paper, to see whether these differences in scores might be related to the groups' Net.Create data-entry processes. For example, some groups entered many nodes with shallow historical-significance explanations, while others spent more time creating and revising each node and edge, with fewer resulting entries but higher quality connections to the broader historical context. To triangulate log data and analyze the impact of Net.Create features on group collaboration, we conducted interaction analysis (Jordan & Henderson, 1995) on a subset of the video and audio data. We selected three high-scoring and three low-scoring groups based on final paper scores for focused qualitative analysis. This data exposed the collaborative practices of students as they entered data into Net.Create and helped us explore how patterns of behavior in groups with fewer entries in Net.Create might account for performance on their final papers. Excerpts selected to demonstrate these differences represent broad patterns in interactions that we saw across the high scoring and low scoring groups, respectively.

Findings

We began our exploration into the data by looking first at quantitative comparisons of group success, to see if student paper scores and log data could give us insight into which interactions with Net.Create were productive for learning. We found that the *quality* of data entries and revisions into Net.Create mattered more for success on the final papers than mere *quantity* of interactions with Net.Create. Statistical analysis of the log data revealed that groups who added and revised the most nodes and edges in Net.Create did not necessarily score higher on their final paper. A Spearman's correlation revealed no significant tie between the *quantity* of interactions with Net.Create and performance on the final paper (r_s= 0.11, *n*=15, *p* (2-tailed) = 0.69). There was, however, a moderate, positive correlation between their average *quality* ratings for their historical significance entries in Net.Create and average scores on the final paper (r_s= .0.53, *n* = 15, *p* (2-tailed) < .05). This suggests that students who were most successful at reconstructing historical context in their final papers tended to belong to groups that spent more time constructing more sophisticated explanations of why certain nodes and edges were significant.

To uncover more detail about what exactly these groups were doing differently that might contribute to their success, we selected three high-scoring groups (High1, High2, and High3) and three low-scoring groups (Low1, Low2, Low3) based on final paper scores, and mapped out timelines of their interactions with Net.Create based on log data. Mapping this log data into timeline representations revealed two divergent methods of entering and revising data. Low-scoring groups tended to enter many nodes and edges in quick succession; on the other hand, high-scoring groups took more time editing fewer entries and made multiple passes at revision for the same entries. These differences can be seen in Figures 2 and 3. Segment lengths represent the amount of time that students spent on that activity, rounded to the nearest half-minute; segment lengths ranged from 30 seconds (e.g., Figure 2, row 2, segment 3) to five minutes (e.g., Figure 3, row 2, segment 5).
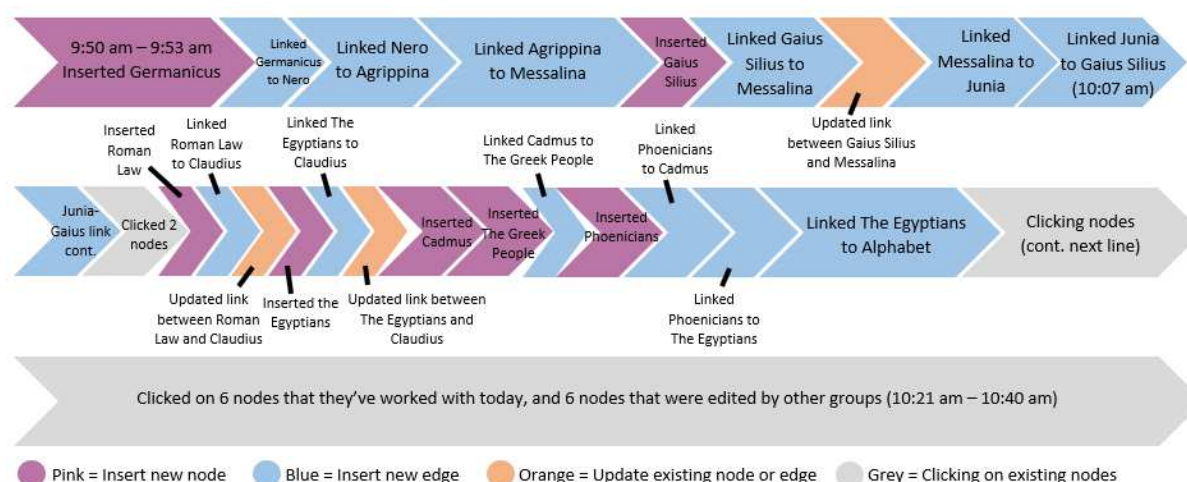
Figure 2. Group Low1's data entry timeline for Day 1. The average quality rating for their significance entries on this day was 2.77/5.
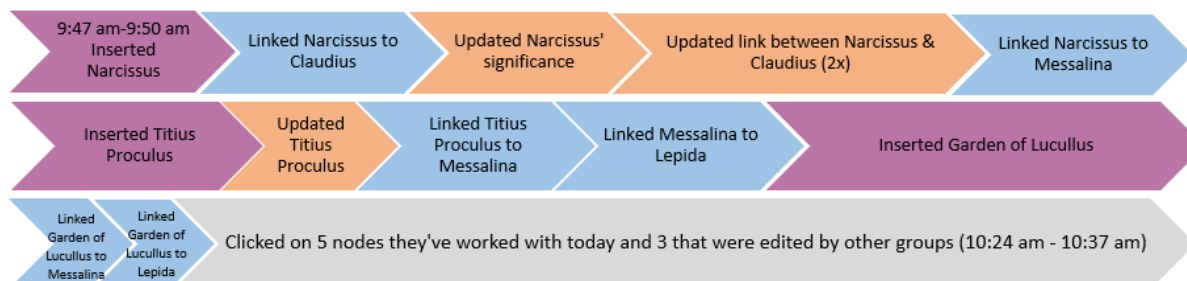
Figure 3. Group High1's data entry timeline for Day 1. The average quality rating for their significance entries on this day was 3.95/5.

As Group Low1's timeline shows (Figure 2), they spent a significant amount of time linking nodes to other nodes, which is an essential first step in building a reconstruction of historical context through network analysis. Mapping the connections between nodes, noticing which nodes were missing and needed to be added, and adding additional relationships between key nodes allowed students to put the details from their chapter of the text into the larger context of the historical time period. Low scoring groups also benefited from activities on Day 2 that explicitly prompted groups to revise and expand on the significance entries that their peers had created. For example, the Low2 group began Day 2 by critiquing how few significance notes had been added by the group who had their excerpt on Day 1. Group Low2 revised these entries to add significance, which required them to use citations to engage in reconstruction of historical context. When given such opportunities to conduct revisions on Day 2, we found that groups across the board improved their explanations of the larger context of individual nodes and edges, with an average rating across groups of 2.00/5 on Day 1 and 3.67/5 on Day 2. The process of adding to and revising the significance field in Net.Create (for their own and others' entries) helped students to improve how they explained the larger context in which individual nodes were situated. Our hypothesis is that the tool design supports both low and high performing groups at their level, offering each group opportunities to

complete both basic data entry and more advanced revisions of nodes and edges as they develop a deeper understanding of the historical context in which the network is situated.

This deeper understanding of context became visible in conversation for the higher scoring groups, when we moved from analyzing log data to exploring the interactions between group members in classroom video data. Figure 4 demonstrates how Group High1 on Day 2 used Net.Create's edge-type feature to situate more nuanced encounters with details in their historical context, a practice that better supported success on the final paper.

#	Speaker	Utterance
1	Joe:	*[Reads from screen]* "Murder of Agrippina. Significance: Penalty for crime she committed." I mean, come on. *[sigh]* But. We can link it to political murder.
2	Ben:	Yeah, I think so.
3	Joe:	We haven't done that yet, no. Add new edge.
4	Ben:	I mean, they're not wrong, but—
5	Joe:	Yeah, but what help is that gonna be to somebody, you know, wanting to see what the motive of Agrippina was? Okay. *[selects edge-type menu]* "Participates in", "is a group member of". *[pause]* "Participates in," I guess….
6	Ted:	It's like marginally better than saying she died…*[inaudible]*.
7	Joe:	Wait, they didn't even have a citation.
8	Ted:	What are you looking for?
9	Joe:	Yeah, the citation where Agrippina gets murdered. 'Cause it would be really fun to have that. *[reads]* "Nero was in a panic, eager to kill his mother." *[inaudible]* OK, we're close. Book 14. Agrippina heard the plot. OK. The botched murder attempt *[pause]* Like the greatest story of all time. I think 14.9. I mean, really, it goes on and on for several chapters.
10	Ben:	There'll be another group.
11	Joe:	Yeah, yeah, I figured I'd just…. *[types into "Significance" field: "Murders his politically ambitious mother, who tried to institute joint rule and was protected by Praetorian Guard."]*

Links to Instructional Goals

Line 1: Students use Net.Create visualization and significance fields to support accurate historical identification.

Line 5: Students use Net.Create edge-type menu to support discussion about how local actor relates to larger network/historical context.

Lines 7-9: Students use Net.Create citation field to critique previous work ("historiography"), revisit text, and resituate individual in historical context.

Line 10: Students acknowledge small-group/whole-class joint task.

Line 11: Students tie 4 details together in Net.Create significance field to reconstruct historical context.

Figure 4. Excerpt of Group High1's discussion on Day 2 (with Net.Create screen capture), linking students' comments to key instructional goals.

As Group High1 edits the significance for the "Murder of Aggripina" node, they discuss how the previous group's entry for this node does not explain the importance of this event in enough depth. Ben and Joe jointly explain that while the group was factually accurate (line 4), the explanation of significance does not give a reader of the network sufficient information about why Aggripina was murdered and what the motives were that led to her death (line 5). The group then returns to the text to fill in a more detailed explanation of why this political murder was historically significant. This collaborative process of critiquing and revising edges in Net.Create helped to prepare these higher performing groups for success on the final paper, because they were critically reading a primary source text, critiquing other historians' reading of that text, and building an understanding of how different historical actors influenced one another in the context of the time period. These skills, separately and in combination, are key building blocks that support the historical argumentation and creation of historical narratives that history instructors aim to teach in undergraduate classrooms.

The differences in Net.Create tool use, student use of Tacitus, and interactions with classmates reveal how differences a group's approach to data entry processes can be explored both through log data and through the details of video data. This allowed us to triangulate the collaborative processes that support groups in building more complex reconstructions of the historical context that they read about in class through Net.Create.

Discussion

Groups interacting with Net.Create were able to produce a shared network visualizing the historical significance of people, places, and events from Tacitus' history. However, the value of collaboratively producing this network went beyond simply having a shared visualization to reference. As students created the nodes and edges of the network, Net.Create's shared data and network visualization led them to engage in rich discussions about how to determine which elements of the historical text were relevant to document. This helped the students to move between local and global context to accurately reconstruct the larger historical significance of individuals, a process that is often a struggle for novice historians.

Students who were less successful in the class based on their paper grades, and whose historical-inquiry practices needed the most support, also saw benefits from the Net.Create intervention. Adding nodes to the network (i.e. names of people, places, and events) was still a starting point to understanding Tacitus' history. For example, while Group Low2 didn't focus on significance in their first pass at the network, they appear to have oriented toward this on the second day and were quite critical of the lack of significance that was previously entered. The activity design that asked students to revise peer entries supported them as they began focusing on documenting the Roman imperial context in Tacitus' history in exactly the kinds of ways that we had hoped. Citing and utilizing pre-existing citations for individuals and small-scale interactions drawn from a complex historical text, provided the foundation for an important first step in the practice of historical thinking, and a goal of future work will be to further develop this through a longer intervention.

Net.Create also supported the inquiry practices of more successful students; it acted as a mediating tool to help them shift away from memorization and toward the active construction of knowledge that underpins the reconstruction of historical significance. When students were tasked with explaining how various historical actors were connected using edge types, they didn't simply regurgitate the relationships they had read about. Rather, they engaged in rich conversations about how the individual nodes fit into the larger historical context. They did this by using the network visualization incorporated into Net.Create to explore those relationships while also revisiting and revising the ideas based on referencing the primary source text. This is the exact kind of historical practice we had hoped to encourage, as it builds on both traditional historical practices of constructing historical context through iterative referencing of sources (Shopkow, 2017) and more recent digital history practices of using computational representations such as Net.Create to help visualize, connect, and refine those relationships.

Conclusion

The features of Net.Create were designed to leverage a common barrier to collaborative learning recognized in history pedagogy: a large lecture hall with many students. Net.Create builds on these features of a history classroom to support the historiographic practices of citation and revision and help students embed local historical actors into a larger historical context. Many students began the long process of shifting away from memorization and toward reconstructing historical context, and the instructor and one Net.Create team member (with a combined decade of undergraduate history instruction) noted how effective Net.Create was as a mediating tool, pushing even weaker students to engage in the first steps of building historical-context reconstruction skills. Our goal is to use the collaborative patterns of successful groups in this study as a way to redesign and orchestrate future Net.Create activities that help students move even further along the continuum between memorization of historical "fact" and collaborative co-construction of historical context.

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