

# Visualizing Revision: Leveraging Student-Generated Between-Draft Diagramming Data in Support of Academic Writing Development

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**Abstract** Once writers complete a first draft, they are often encouraged to evaluate their writing and prioritize what to revise. Yet, this process can be both daunting and difficult. This study looks at how students used a semantic concept mapping tool to re-present the content and organization of their initial draft of an informational text. We examine the processes of students at two different schools as they remediated their own texts and how those processes impacted the development of their rhetorical, conceptual, and communicative capacities. Our analysis suggests that students creating visualizations of their completed first drafts scaffolded self-evaluation. The mapping tool aided visualization by converting compositions into discrete persistent visual data elements that represented concepts and connections. This often led to students' meta-awareness of what was missing

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or misaligned in their draft. Our findings have implications for how students approach, educators perceive, and designers support the drafting and revision process.

**Keywords** Revision · Rereading · Writing · Informative writing · Metacognition · Technology · Academic literacy

## 1 Introduction

Writing can function as a communicative medium and an epistemological tool for acquiring knowledge. Recognized as a process that cultivates higher order thinking and disciplinary understanding, writing a coherent academic text is an instance of what learning scientists call “complex performance” (Cope et al. 2013; Kalantzis and Cope 2012). In other words, writing is a time-consuming, non-linear process involving multiple drafts even for those who do it for a living.

The US Common Core State Standards (CCSS) identify two canonical genres for non-fiction writing: information/explanation writing and argument writing. The features of each genre are listed in the standards and outline the range of structural elements commonly used in each (e.g., information texts support concepts by marshaling definitions and facts). These defined features and how they work in concert serve as a developmental target for understanding disciplinary practice. Not surprisingly, despite having an explicit target, the complexity of creating a coherent informational text that demonstrates relevant, interconnected ideas, and uses genre-specific conventions presents significant challenges to middle and high school students (Myhill and Jones 2007).

The struggles many students encounter with writing are compounded once they have what they feel is a credible first draft. The fact that revision is a high-level, cognitively and procedurally challenging part of the writing process (Flower et al. 1986; Hayes and Chenoweth 2006; Lessard-Clouston 1995; McCutchen 2000) may help explain why students rarely embrace work on a second draft as an opportunity to make substantive changes to their text. Instead, they tend to focus on lexical-level issues—spelling, word choice as well as punctuation—declaring their text complete once those issues have been addressed (Beason 1993; Cho and MacArthur 2010). Given the heightened importance of information writing in the CCSS and the lack of progress made in aiding students in overcoming the challenges of revising informational texts despite a range of intervention approaches (Allal et al. 2004), more research-based designed interventions are merited. Specifically, interventions that focus on the process of students evaluating their drafts in an effort to scaffold the identification of missing elements, foreground sections of text that merit reorganization, and revise at both sentence- and paragraph-levels are needed to produce final versions more in line with the conventions of informational writing.

This study examines the impact that a technology-mediated scaffold for visualizing and re-mediating initial drafts had on students’ capacities to evaluate and identify revision opportunities in their texts. We analyze data from two middle-school classrooms where students used a web-based semantic mapping tool as part of their revising process. Students constructed and organized a digital concept map of the genre-related elements in their text. In the findings section, we theorize about how and to what extent this approach supported self-evaluation, meta-cognitive awareness of missing and misaligned elements, a return to source materials, and pathways to more robust second drafts.

## 2 Literature Review

Stretching back to Emig's (1977) assertion that writing is a particular and deliberate mode of learning in which students must plan, record, and reflect on their thoughts, academic writing has increasingly been recognized as a key site for developing higher order thinking and a catalyst for learning through the process of representing disciplinary knowledge. Writing a cohesive information/explanatory text not only constitutes a complex performance, it forms a basis for expressing higher-order thinking, including evidential reasoning (Cetina 1999). Complex performance is a form of learning capable of addressing "the epistemological bases" of a discipline (Grotzer 2009, p. 61). Additionally, it is an endeavor that requires an awareness of what concepts and rhetorical conventions are relevant to a particular task and a continual self-evaluation of how well they are conveyed within a particular text (Negretti 2012).

Experts in a subject domain are typically capable of organizing knowledge into mental schemas and able to make sense of new information by comparing it to their existing schemas (Cope et al. 2011; Gee 2004). When they begin to write, they typically take this knowledge into account, as well as the genre, purpose, and audience of the text (Berkenkotter 1981). Experts know why they are writing and what the writing is meant to accomplish in the world, and this knowledge helps them to map their tasks and ideas (Bereiter and Scardamalia 1987; Flower and Hayes 1981).

As such, writers must engage in multiple simultaneously occurring elements and acts that take an essay from inception to submission. For students who are used to writing in order to be evaluated by their teachers, however, this genre awareness must be taught. Whether working from the CCSS, the National Council for Social Studies Standards, or the National Council of Teachers of English standards, writing processes are often framed as iterative wherein the writer writes and then evaluates her work—in whole and in part—for content, craft, and genre specificity. Writing can include engaging content, outlining, writing, re-reading, evaluating, revisiting sources, re-organizing, adding content, and addressing editorial issues of flow, typos, and unconventional spelling. For informational texts, many secondary school writing curricula emphasize a research phase, a planning and organization phase, a writing phase, and a revision and editing phase. This view of the writing process focuses on cognitive strategies articulated by Flower and Hayes (1981), but focuses writing instruction on form, content, and conventional usage (De La Paz and Graham 2002; Scholes and Comely 1985) rather than on the creation of meaning or narrative flow (Newkirk 2014). As a result, many of the above elements of writing become points of resistance and/or difficulty for many students.

### 2.1 Revision, Metacognition, and Self-Evaluation

Revision is a conscious, ongoing, high-level, cognitively and procedurally demanding part of academic writing (Flower et al. 1986; Hayes and Chenoweth 2006; Lessard-Clouston 1995; McCutchen 2000). It consists of metacognitive processes of reconsidering ideas, organization, and wording, and of detecting problems and opportunities (Hayes 2001). Whether these processes happen during outlining, composition, or rereading, revision is, ideally, a form of "re-mediation" which helps writers see their texts in new ways (Prior and Hengst 2010).

Given the demands writing places on students who are still developing their cognitive capacity and understanding of composition within the confines of a particular genre

(Limpo et al. 2014), the struggle to support students in going beyond lexical or language-level editing toward organizational or content-level transformations of their writing continues largely unmet (Myhill and Jones 2007; Zheng et al. 2014). One significant challenge presented by school curricula that value “coverage” is that teachers rarely have time for students to fully develop their written pieces. Few give substantive feedback on students’ drafts or teach students how to revise, and those who do often focus on English conventions and proofreading techniques (Applebee and Langer 2006; Dyson 2006; Witte 2013). Some teachers ask students to exchange peer feedback, but this technique, too, requires time and explicit instruction: at first, most students focus on the writing’s conformity to assignment characteristics (Beason 1993; Gere and Abbott 1985) or praise their group-mates’ work (Godley et al. 2014; Magnifico et al. 2014). In other words, schooled editing often does not account for learning and re-vision—the ways in which acts of writing and organizing help writers to understand differently (Emig 1977; Sommers 1980).

Classroom writing instructors often support student writing via semiotic scaffolds during the planning process and, as a text progresses, many encourage recursive reading and rewriting of sections or drafts against explicit evaluative criteria (Hillocks 1986). Instructional rubrics aid the formative assessments of many teachers in this way, and they help students receive and generate feedback, as well as understand what teachers value. As such, they increase students’ metacognition and give them a window into teachers’ assessment procedures (Andrade 2001; Spandel 2006), although some teachers must use pre-written or school-level rubrics that may not fit well with all of their assignments (Woodard et al. 2013). Many writing teachers teach students to read model texts metacognitively, examining other writers’ strategies for communicating particular meanings (e.g., Atwell 2014; Kittle 2008). In their cognitive writing process model, Rijlaarsdam and van den Bergh (2006) note that different kinds of writing activities are closely related to each other; for instance, re-structuring and re-reading both seem to be related to idea generation. Writers who re-organize and re-read benefit from these activities. Thus, this model lends some empirical support to more qualitatively- and pedagogically-rooted teacher practices.

## 2.2 Concept Mapping and Writing

Concept maps are another common type of writing scaffold. They aim to help students build external, often graphical, representations of concepts and relationships (Novak and Cañas 2008). As such, concept maps have been useful pre-writing tools since before the advent of digital concept mapping applications (Carroll 1991). Spatial arrays of circles, squares, and triangles connected by directional links provide a powerful representation of complex content knowledge and genre conventions. These tools can be especially useful for describing concepts that are difficult to represent in a linear way (Novak and Cañas 2008; Tergan 2005).

Concept maps as advance organizers were introduced from educational psychology in the 1960s, with the aim of aiding the cognitive process of “subsumption,” in which new ideas reorganize existing schema (Ausubel 1963, 1978; Ausubel et al. 1978). Subsequently, concept mapping was introduced as a technique for metacognition, one that teaches students how to conceptualize their learning (Novak and Gowin 1984). Today, concept mapping is widely employed within educational practice across subjects as a tool for instruction and student learning (Novak 2010) as well as assessment (Rice et al. 1998)—as mapping practices “help the student to understand, internalize and connect concepts through a reflective and critical learning process” (Pinto et al. 2010). Engelmann and

Hesse (2010), too, have found that sharing knowledge through concept map representations effectively supports problem-solving collaboration among diverse groups of learners.

When used in conjunction with writing tasks, concept maps enable students to externalize, visualize and analyze their information/explanatory texts against specific criteria (Driver et al. 2000). Several studies have documented that students' pre-writing concept mapping is correlated with longer, more complex texts (e.g., Sturm and Rankin-Erickson 2002) and summaries (e.g., Alvermann et al. 1984; Boothby and Alvermann 1984). Few concept map interventions seem to have been designed to support transformative revision in later stages of the writing process, although Reynolds and Hart (1990) tested the effectiveness of teaching students to use computers to outline, brainstorm, and cognitively map stories between their first and second draft compositions. They found that the cognitive mapping was the most effective strategy, leading to significant improvement in overall assessments of the second drafts, and hypothesized that the mapping helped students focus on the structure—not the language—of their word-processed compositions.

### 2.3 Technologies for Evaluating and Revising Writing

Many of the studies cited in the sections above employ digital tools such as word processors, internet research and/or communication, and the Cmap concept mapping software. As computers were first integrated into classrooms, research focused on comparing the effects of word processors on writing and revising (Dalton and Hannafin 1987; Dybdahl et al. 1997; Goldberg et al. 2003). Early researchers expected computer technology to help students consider higher-level concerns when writing and revising, but studies show that students using a word processor spend more time and attention on surface features (MacArthur 2006; Reynolds and Hart 1990). The focus on conventions is unsurprising when teachers concentrate their rubrics, evaluations, and instruction on proofreading and other surface features of language (Witte 2013). Regardless, when students write and revise, their process is shaped by the affordances of their writing platforms. As increasingly ubiquitous digital tools align the in-school composition process with out-of-school processes (Olmanson and Abrams 2013) it is important to consider the relationship between writing platforms and the work they support.

Many teachers and theorists have suggested that digital environments' ability to grant students a sense of "real" publication and audience can be critical to encouraging writing and revision (e.g., Allison 2009). At the same time, teacher assignments and feedback systems for student writing affect the kind of comments that students receive from their peers, which in turn dictates revision. As Kline (2015) explains, when teachers write rubrics and provide models to guide student composition and revision, these materials become "rules" that students must follow. Prior (2008) suggests that teachers unwittingly become co-authors of student work in this way. Magnifico et al. (2014) have shown that some students use language directly from teacher rubrics when their mechanism for providing feedback is connected to those rubrics, demonstrating direct co-authorship. The format of peer review—whether teachers ask students to provide global comments at the end of a piece or physically mark up each other's work—affects the proportion of student comments directed towards editing or structural revision, too (Ellis 2011). Still, when students have the opportunity to read and comment on peers' writing, many read this formative assessment back onto their own work in a metacognitive way, making changes that align with feedback that they provided to a fellow classmate (Godley et al. 2014).

In general, however, the literature on revision suggests that students' natural capacity for deep revision is low regardless of the environment. High-level revision processes like

rethinking or rewriting substantial sections of text have been shown to challenge working memory and cognition more generally (Hayes and Chenoweth 2006; McCutchen 2000). As such, students across levels make few global, meaning-changing revisions even if they re-read or add word-level revisions (e.g., correcting writing conventions) and local revisions (e.g., adding examples) (Beason 1993; Cho and MacArthur 2010). As Applebee and Langer (2006) put it, fixing mistakes was the most-cited strategy for revision among both 8th and 12th graders. Even in classes where students do read each other's work and provide feedback, when explicit instruction around peer review and revision does not occur, students in such classes engage in little reorganizing or rewriting of their work.

## 2.4 Concluding the Literature Review

In the preceding sections, we have highlighted several ways students are supported both instructionally and technologically in their development of texts. In addition, we have noted some ways in which classroom writing environments make it difficult for students to internalize multi-draft writing and revision processes or the conventions of academic writing genres. The intervention described in this study was designed to support students by transforming the way they experienced rereading and revision during the between-drafts point in their writing process. As we note above, this is an area of unmet need instructionally speaking and largely unexplored territory in writing research and learning technology design. Thus, in terms of models of technology integration, our intervention, as described in the next section, had the potential to substantially modify if not redefine the way students evaluated and revised their writing (Romrell et al. 2014).

## 3 Description of the Diagramming Tool

Despite the wide use of outlines and concepts maps for generating and organizing their ideas (de Smet et al. 2011), few tools have been developed to aid students in re-mediating their texts at other stages of the writing process (e.g., rereading to revise). Iteratively designed over a 6 month period with this purpose in mind, InfoWriter is a browser-based application that provides student writers a way to re-mediate their linear text as a concept map. As students highlight portions of their draft, InfoWriter converts the highlighted text into nodes that correspond to the expected features of informational writing. The tool thus scaffolds the writer's evaluation of their text as they re-read it. The prototype version of InfoWriter used in this study was integrated as a plugin to an online peer-to-peer writing, feedback, and formative assessment environment called Scholar. A 4 min use case video for InfoWriter—produced by Common Ground Publishing, the developer of InfoWriter—demonstrates how the tool can be used (available here: <http://bit.ly/1Tm5ukh>).

Specifically, the application ingests the most recent version of the student's text and formats it into a text column on the left side of the screen. This leaves an open mapping space on the right side. When a student moves her cursor over the text, a menu of node types appears (see Fig. 1). As mouse/cursor movements often follow eye movement during web navigation and reading, this design decision created an interface that we observed to be functional and supportive (Huang et al. 2011). The node categories align with the US CCSS for Middle School informational writing and include: preview, concept, definition, evidence (fact, statistics, quote), example, opinion, and concluding statement. Highlighting a section of text makes the node types selectable. Users choose the node category that best

Title: Court Case

Subtitle:

Section Heading: Untitled Element

The United States court case known as 'Brown v. Board of Education of Topeka' was decided in the Supreme Court in 1954, but the event that started it took place four years earlier, 1950, in Topeka Kansas (Brown v. Board of Education of Topeka). At this time in history, the early to mid 1900s, things were difficult for people of African American decent. It was shortly after the Plessy v. Ferguson case that had proven unsuccessful to those working toward ending discrimination and segregation toward blacks. The thirteenth amendment had abolished slavery in 1865 and that was soon followed by the fourteenth amendment in 1868, ordering equal civil rights for all citizens of the United States. African Americans included (US Const. amend. XIII, XIV, (amended 1865, 1868)). However, these amendments did not by any means ensure that Black people were treated the same ways white people were. Segregation was a huge part of the American lifestyle and it showed itself very prominently in the school districts. African American children were forced to attend separate schools from white children and these all-black schools were often much less comfortable and privileged.

The story behind this particular court case is about an African American man, Mr. Oliver Brown, and his six-year-old daughter Linda Brown. The Brown family lived in Topeka Kansas, very near to the all white Sumner Elementary School. However, despite the proximity, young Linda Brown was forced to walk a dangerous walk between train tracks in order to get to the bus stop from which she would be taken to the much farther, all black Monroe School (Mauro 243). In 1950, Brown had had enough and he attempted to enroll Linda in Sumner, despite her ethnicity. The school board of Topeka sent Brown away, refusing to allow Linda enrollment. A determined Brown went immediately to the National Association for the Advancement of Colored People (NAACP). With the Association's help, Brown filed suit against the Topeka School Board (Mauro 243).

Many other similar cases were arising at that time, pushing for an end in school segregation. A young African American lawyer of civil rights, Thurgood Marshall, took the issue on his shoulders with the determination to put an end to the separation of schools. Many other cases relating to school segregation followed the Brown case. In 'Briggs v. Elliot', Harry Briggs Jr. and more than sixty other black parents sued the Clarendon County schools to demand equal school facilities' (Mauro, 243). After that came 'Davis v. County School' in Virginia, where some of the highschoolers made a case against the segregation. A similar case to 'Briggs v. Elliot' was brought up in Delaware, and titled 'Gadner v. Belton'. The last case in this series of suits filed against school segregation was called 'Bolling v. Sharpe, filed in Washington D.C (Mauro, 244).

When the 'Brown v. Board of education' case was brought to the Supreme Court, it was met by a vote of 9-0 (votes from Chief Justice Earl Warren and Justices Hugo L. Black, Stanley Reed, Felix Frankfurter, William O. Douglas, Harold H. Burton, Robert Jackson, Sherman Minton, and Tom Clark), a surprising, unanimous vote to desegregate schools and overturn the case 'Plessy v. Ferguson'. When a case is overturned, it means that the verdict of the case is completely changed. The verdict of the Plessy case had been in favor of separation of white and black people in public situations and, after the trying of Brown v. Board of education, the verdict was that segregation in schools and other public places was illegal.

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### Node Types and Descriptions X

Preview	An outline of the main ideas that will be covered in the work, without giving all the details.
Concept	A word or phrase that describes what is the same about a number of things. Earth and Mars are both examples of the concept of planet. Writing about planets might include other concepts such as gravity, solar system formation, and planetary orbits.
Definition	A statement describing the meaning of a concept. For example, a planet is a celestial body moving in orbit around a star.
Evidence:Fact	Fact: Information that is claimed to be true or something that really happened.
Evidence:Statistics	Statistics: Number facts that help describe more than one thing.
Evidence:Quote	Quote: Words that someone has said or written, taken from a book, speech, interview, poem, play, the internet, etc.
Example	One of a number of things, or a part of something, that helps to illustrate a concept.
Opinion	A person's perspective.
Concluding Statement	Tying together the reasons a work has been created to present this information or explanation, including commenting on the importance of the topic, posing a question, looking to the future, or including a personal or widely held opinion about the topic.
Comment	A user's comment or note.

Fig. 1 Initial draft within InfoWriter with the node type selection menu displayed (Esther). To view the figure at its original dimensions go to <http://bit.ly/1Lcl4cL>

fits with their highlighted text (e.g., Concept), and in the blank space, a color-coded node appears (see Fig. 2). In this way, there is minimal amount of effort required to create a node, allowing students to concentrate on selecting the appropriate corresponding category.

Students build their maps by repeating the process of highlighting and converting text into nodes. By clicking on and dragging individual nodes, they can reposition and link them together (e.g., see Fig. 3). When they hover their cursor over a node, the corresponding section of text is highlighted within the draft (see Fig. 3). These features afford students the opportunity to explicitly make connections between related elements in their text and quickly see where each node is in their text without being required to maintain the

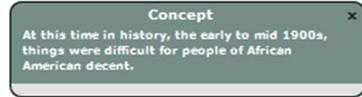
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**Fig. 2** First node created based on the highlighted text (Esther). To view the figure at its original dimensions go to <http://bit.ly/1fdIPrY>

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**Fig. 3** Hovering the cursor over a node highlights the corresponding text (Esther). To view the figure at its original dimensions go to <http://bit.ly/1KTzYq7>

linearity of their text. To see how much of their text they have mapped, students can use the “Show All Highlights” feature.

Students can also create Comment nodes. This feature affords writers the chance to add notes about what is missing or needs more work without leaving the evaluation stage of revision. Later in the mapping process begun in Fig. 3, Esther created a Comment node into which she added the text “Needs historical context that is defensible.”

Finally, as students highlight text and create nodes they are supported in rereading their text via a practice that focuses their attention on the most common elements of a particular genre. The result is a map of their own creation that re-presents both the elements of their text as well as the connections between the elements of the texts.

## 4 Methods

This ethnographic study focused on the extent to which a digital mapping environment supported students in identifying potential changes between drafts of an informational text. We inquire as to how students’ mapping practices facilitated self-identification of conceptual, empirical and rhetorical gaps in their writing. In this section we describe the intervention we designed and the data collection and analytical methods we employed.

### 4.1 Intervention Genesis

Beginning in 2013, members of our research team, in concert with Common Ground Publishing, iteratively designed, developed, and implemented an online text mapping tool called InfoWriter. This between-drafts mapping project came out of a larger project to develop the Scholar writing and assessment platform, a collaboration between the University of Illinois and Common Ground, funded by the Institute of Educational Sciences and the Bill and Melinda Gates Foundation. From questions and conversations regarding supporting the development of academic writing literacies via formative assessment and peer review in Scholar, we considered the pedagogical potential of a between-drafts mapping intervention to be a possible avenue toward the more meaningful revision of student writing. Our goal was to design a support for students in the self-evaluation of their writing, affording them the means to connect portions of their text to explicit elements of the information writing genre. Doing so, we hoped, would lead to better planning and more meaningful changes to their texts. Our inquiry team was made up of researchers, designers, and developers across three institutions who had previously worked together on designing and implementing an online peer review and writing platform called Scholar.

### 4.2 Intervention Protocol

We emailed teachers already using the Scholar environment in their classrooms and asked if they would be interested in participating in a study that extended the platform to include between-drafts mapping. We offered an intervention aimed at scaffolding rereading and eliciting substantive between-draft revisions. Available resources allowed us to work with two responding teachers and their respective students.

Teachers participated in a 2-hour workshop to support information writing using between-drafts mapping. They worked with research team members to integrate the intervention into a writing project that was a part of their existing curriculum and also aligned with the US CCSS.

At both schools sites, research team members introduced the mapping tool to students, providing individual technical assistance as necessary. College Prep Middle School (CPMS) was a school with a 1:1 student–computer ratio. City Middle School (CMS) used a school-wide shared lab space that could be reserved once per week. Students at both schools had the requisite level of computer proficiency necessary for participation in the intervention and used the application with minimal issues.

Previous to this intervention, students at both schools had been introduced to the genre of information writing. During the mapping intervention, students spent one class period witnessing and participating in the mapping of an exemplar text on the US Revolutionary War. Students then spent a class period reading and using the mapping tool to re-present a second exemplar text on either alligators and their disappearing habitat or on an extraordinary person (in this case, Dr. Hawa Abdi).

Eighth graders at CMS had just finished reading a screenplay version of *The Diary of Anne Frank* and had also watched a cinematic version. They were tasked with choosing from a list of Holocaust survivors and writing an informational text that told that person’s story—including their background, how they came to be captured by the Nazis, how they escaped or were rescued, and how their story could inspire people today.

At CPMS, students selected one of two class-discussed court cases (*Plessy v. Ferguson* or *Brown v. Board of Education of Topeka*) and wrote a summary of the case, addressing case history, facts, outcome, and societal impact. This assignment was part of a unit on the history of efforts to extend rights to broader parts of the US population than the laws at the time allowed.

Students spent at least three class periods discussing the assignment’s topic, reading source documents, outlining, and using InfoWriter to compose a first draft. Once students felt they had a completed draft, they used InfoWriter to map it over the course of two class periods. Finally, students revised their draft with the expectation that they would be guided by their just-completed mapping process.

As InfoWriter was a functional beta prototype more than a finished product, it wasn’t seamlessly integrated into the Scholar environment and shared none of its user interface elements. Students had to click on several different links within Scholar before their map-formatted draft would show up in the browser. Some students struggled to get their text ingested properly, and several lost parts of their maps—requiring them to re-map their texts.

### 4.3 Participants, Research Setting, and Data Sources

Data collection took place in the fall of 2013 at two middle schools in Central Illinois using InfoWriter across four sections (two social studies sections at each school). CMS served a population reported as 41.3 % White, 37.5 % Black, 9.2 % Hispanic, 4.1 % Asian, .2 % Native Hawaiian/Pacific Islander, .5 % American Indian, and 6.9 % two or more races. 68.7 % were classified as low-income, and 4.7 as limited-English proficient. While College Prep, a highly academically selective 8th–12th grade school, does not publish its demographic data we observed the two social studies sections to be made up of more than 50 % White students.

Two members of our research team spent 6 days observing intervention-related activities. These activities included introductory sessions on informational writing, creating semantic maps of texts, using the online mapping environment, writing sessions, mapping sessions, and classroom mini-lesson teaching. During these activities we conducted participant observations (Spradley 1980) which we used to help identify potential focal students and create fieldnotes (Emerson 1995).

In the week after students completed their post-mapping draft, the same two members of the research team conducted semi-structured interviews (Weiss 1994; Wolcott 2005) with 23 students who were available and interested in talking about their mapping and writing experiences. From these 23 students, we chose 13 focal students whose maps and mapping processes reflected the range of maps and mapping processes we observed. We interviewed the teachers at the end of the intervention, and analyzed all teacher and student interviews.

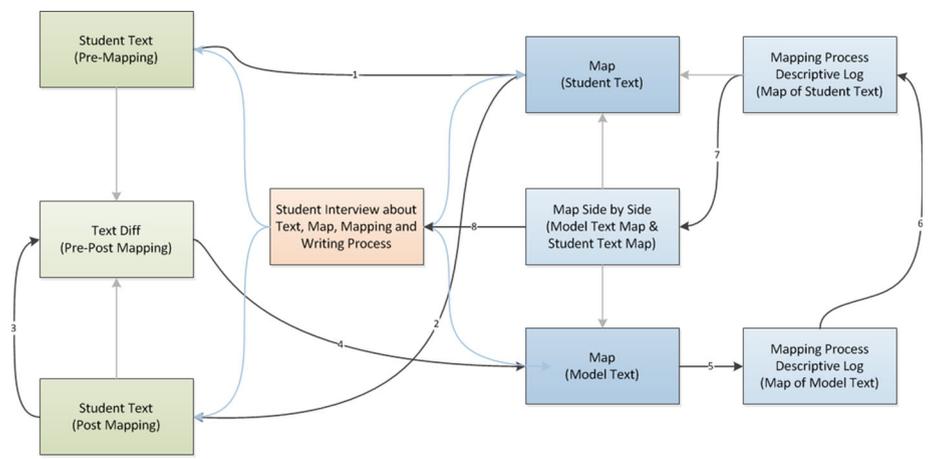
We turned observation data into fieldnotes (Emerson 1995) and interviews into transcripts. From the online application, we extracted pre- and post-mapping drafts, the maps of exemplar texts and student texts, and the time-lapse sequences of map building. We took side-by-side screenshots of the initial draft and revisions made to the subsequent draft. We prepared all these items for individual and cross-artifact analysis.

Over the course of data collection and analysis, we conducted a number of research team debriefings and co-constructed and maintained analytical memos and journals wherein we outlined what we noticed and the connections and meaning we were making.

#### 4.4 Analytical Methods and Procedures

Our analysis of these data required a combination of methods as well as multiple entry points into and pathways through the data. We concentrated on the maps, texts, dialogue, and observations of our 13 participating focal students.

As shown in Fig. 4, we approached the analysis of the data on a per-student basis. We drew from artifact analysis (LeCompte and Preissle 1993; Van Gog 2007) and discourse analysis (Gee 2005) to create a cross-artifact or multi-directional analysis that aligns with recent work on the bi-directional analysis of student writing and revising (Halverson and Magnifico 2013; Magnifico and Halverson 2012). We employed an iterative analytical approach (Anfara et al. 2002) that involved coding elements in each draft, map, note, memo, interview transcript, and fieldnotes. In all, we generated and assigned over 494 different base codes. These codes were subsequently grouped based on code topic and frequency (Fig. 4).



**Fig. 4** Analytical approach beginning with student text and following the *numbered arrows*. To view the figure at its original dimensions go to <http://bit.ly/1JQKjnx>

Procedurally, we first assigned base codes to elements of: (a) a participant's initial draft of their text, (b) the map of the initial draft, (c) the subsequent post-map text, (d) differentiated side-by-side screenshots of their pre- and post-mapping drafts, and (e) the map of the model text. We then turned to the map creation process. Built into the InfoWriter application is a way to step through the students' activity event by event. We used this feature to create descriptive logs of both model text maps and draft text maps, then we coded those logs. Moving forward, we analyzed side-by-side screenshots of the model map and the map of a student's initial draft. We finished by coding the students transcribed interview. We compared what the students said in the interviews to the texts and maps they produced, and we created descriptive and analytical memos based on those multi-directional readings.

Once we had completed the above cycle for each student, we coded the transcribed teacher interviews and grouped the generated base-codes to guide code chunking. This supported participant and artifact-centric theming and theory development (Strauss and Corbin 1998). This artifact-based multi-directional analysis, in concert with code-based iterative analysis, supported our identification of salient elements.

## 5 Data and Findings

In this section, we begin by looking at student perspectives on writing in general and revising in particular. We then look at how the process of mapping texts impacted students' rereading. Following that, we trace how mapping supported the identification of revision opportunities. Finally, we explore the level to which students executed the revisions they identified. Throughout this section, we highlight two students—Peter and Ozgur—as well as include the voices of our other 11 focal students. To afford readers of this article a sense of the mapping process, we created animated gifs for each student's mapping of their own text.

### 5.1 Student Attitudes and Approaches to Traditional Writing and Revising

When asked about how they felt about writing in general, students expressed low degrees of engagement and persistence toward academic writing and revising. Peter said he felt the point of writing was to, “express your feelings, and to learn words,” and described his approach saying, “I don't like plan it out and stuff.” Andrew concurred, explaining that he didn't use an outline to scaffold his writing, he just wrote down what was in his head. When asked about catalysts in his life for writing, Andrew said he only writes, “when the teachers say we have to write.” Others, like Neerja, also articulated a process for writing focused on “getting thoughts down on paper,” but combined that with externally provided scaffolds saying, “I get the rubric and then I'll generally start typing.”

Unsurprisingly, students said they were motivated to reread their text only to decide if they were finished with their first draft. Some took a content orientation, saying they knew it was finished when they felt all the information was included. Others based their evaluation on how it sounded in their head as they reread it. Peter articulated a combination of these saying he knew his was done when it, “sounded good and it had enough stuff.” A few mentioned the presence of smooth transitions between different sections as a marker of having a complete draft.

When reflecting on their approach to revising, participants described themselves as reluctant editors and novice evaluators of their own texts. Ray said, “I find writing it the

first time to be very easy for me, but then rereading it and then revising is something that I've never really liked." Andrew described revising as, "almost a puzzle" and Neerja said that evaluating her own writing was challenging because, "you're just reading it and you kind of don't know exactly what it is." Beck echoed Neerja's pessimism about the difficulties of basing revisions off of unscaffolded rereading saying, "if you're just reading you don't really catch things." Ozgur was pragmatic about revising saying, "it's tedious, but it's very useful."

In describing the purpose of revising writing, students tended to position editing as the primary goal of revision. Aspen articulated her process, explaining, "I just fixed a couple typos that I found and fixed my in-text citation and then I was kind of done with it." Esther described revision as cleaning up her text, saying she found, "a lot of the little, random facts that I'd just added in and are like extra words that I felt when I was writing made it sound better, but actually made it a little bit less lucid."

## 5.2 Mapping as Mediating Student ReReading

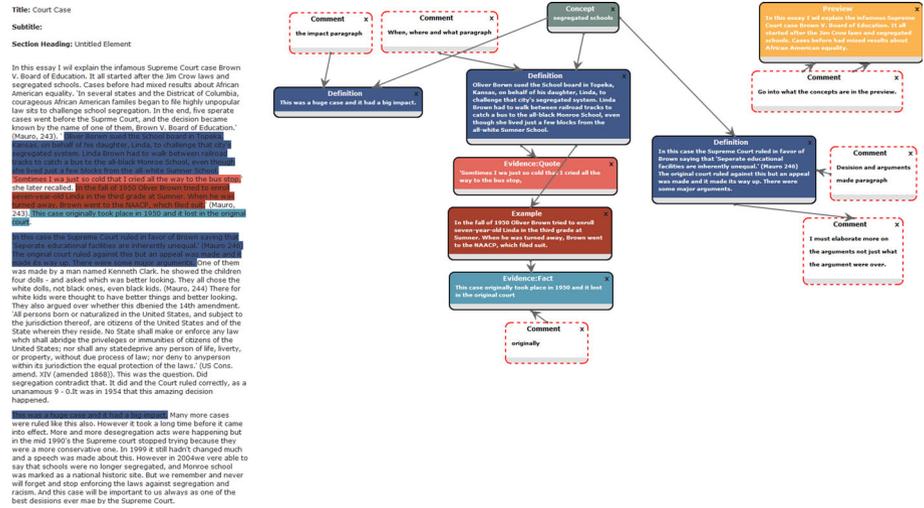
As students stated and we observed, the application's node menu (see Fig. 1) acted as a scaffold for searching through students' own texts. "I was trying to find examples of all the different kinds of evidence and all that stuff," said Ozgur. Aspen described how the mapping process and access to the node type list influenced her approach: "when I was mapping [my text] I had to look for stuff and examples of each [node type]." Other students interpreted the node type list as a list of expected elements. Christopher said, "I tried to think what would be a good evidence fact; what would be a good quote; what would be a good opinion." At times, this node-centric re-reading helped students better understand the organization of their writing. "Well I found a fact and I was trying to find an example and some more evidence to back-up the fact and I realized I put the evidence to back-up the fact after I'd written another fact and the little example," said Ozgur.

After writing a draft about Holocaust survivor Joseph Heinrich, Peter spent 30 min mapping his text using InfoWriter (animated gif: <http://bit.ly/1JJ9g4j>). Peter began by adding a Comment node with the phrase "need description of him" followed by the creation of six Evidence nodes and three Statistics nodes. He then added several additional Comment nodes including one with text from his draft and many more Evidence nodes. Next he organized the nodes and added links between nodes. During this period of extensive organization, Peter added a Preview node but no overarching Concept nodes (see Fig. 5).

In the map creation process, we observed how students attended to the visual organization of their remediated work. They generally followed two patterns of node creation. Either they created most of their nodes first and then added links between nodes, or they organized and linked nodes as they created them. These functional concerns translated into reflection. As Logan said, the rereading she was doing in order to map her text made her more of an evaluator and less of an editor, "I'm judging it more because I actually have to think about where the concepts are." Neerja described how mapping her text scaffolded her thinking about organization saying, "[mapping] helped because then I saw how different things connected and if they connected to more than one thing or the order in which things happened, [or] if they were not in order." Christopher noted the way this type of remediated rereading supported him in thinking about organization, saying "it showed how A, B and C all connect together."

During and after completing their maps, students evaluated the content knowledge reflected in their texts. They positioned texts they had just written as being difficult to penetrate through rereading but more accessible via the intervention. "I think [mapping my





**Fig. 6** Ozgur’s map of his own text. To view the figure at its original dimensions go to <http://bit.ly/1C9qyZH>

and I was wondering, ‘does my teacher want me to put more of those in?’” Looking at her map helped Esther realize she didn’t include an introduction in her text while Logan’s map helped her notice a lack of supporting node types saying, “I see I don’t have any quotes and I think ‘oh I should go find a quote and add it in,’ or ‘I don’t have any examples.’” Logan called the intervention as a whole helpful, saying, “I just find it useful for finding what I was missing in my papers and what I could add.”

In comparing the intervention to ways he revised in the past, Brad said, “[using the mapping tool] is a lot easier than some of the other [approaches to revision] we’ve learned before—of going back manually looking for each part and just seeing what you missed.”

### 5.3 Mapping Helped Identify and Document Revision Opportunities

Brad described how his map made it, “easy to go back and see what you need to add to your draft.” One way students noted their thoughts about and plan for their next draft was through the editable Comment nodes. Sometimes they signaled an evaluative meta-awareness of their text. Esther said, “when I found a problem I put a comment about it.” Ozgur’s comment nodes were mainly geared toward flow; he explained saying, “I used a lot of comments because it wasn’t as coherent as I would have liked it to be.”

These student-generated Comment nodes were often explicit signals that a student had identified revision opportunities in her text. According to the Comment nodes Peter created (see Fig. 5), he planned on adding: a more detailed description of Joseph Heinrich, a preview, a conclusion, and more details in general. He also created a Comment node reminding himself to add text already included in his first draft.

Most participating students used Comment nodes as a note to themselves about what needed to be done in their next draft (see Table 1). Ray said, “sometimes I’ll forget things so what I did was use the comments sort of as a memo to say ‘okay this is why I did not like what I wrote, I might do this later.’” Neerja, Ray, and others leveraged the commenting feature to reduce the complexity of the revising process, Ray explaining that, “I

**Table 1** Tally of comment node use across students

Comment node and map implication	Editing	Non-actionable	Organizing	Adding content
Total	2	12	16	28

thought it was good for me to note what I wanted to do without having to do it right away; that helped me think of exactly what I was going to do to improve the passages that I marked.” Neerja said she edited her Comment node text in her map to keep track of her progress as she worked on her next draft, “I added a Comment note so that I saw that it was there and after I’d finished it, I put it in parentheses so I knew that I did it.”

The Comment nodes Ozgur created (see Fig. 6), showed that he planned to add a preview of the main concepts included in his paper to his introduction. He also created a Comment node to expand upon the different arguments that came up in *Brown versus the Board of Education*. Additionally he used three Comment nodes to identify the type of paragraph a particular Definition node represented, and one Comment node as a reminder to fix a lexical issue in his text.

### 5.4 Revision Patterns in Second Drafts

Participants used the mapping process as a gateway to add content and adjust the organization of their texts. Esther spoke of how she added a stronger conclusion to her second draft, expanded particular ideas, and identified how reorganizing her paper under a single unifying theme would make it more coherent. Several students described returning to source material in order to locate and include concepts, details, evidence, and definitions they felt were missing.

A comparison of Ozgur’s first draft and his post-mapping draft show that he followed through on his Comment node about adding details which explain the court’s decision in more depth (see Fig. 7). In our interview with him he said, “in the long run [mapping my text] helped me learn more about the [court] case because I figured out that I needed to



**Fig. 7** Ozgur’s first draft (left) and his post-mapping draft (right). To view the figure at its original dimensions go to <http://bit.ly/IO1540g>

have more information, so I went and researched and found more information and learned more about it.” Ozgur also mentioned that he, “[noticed] I needed a quote for this and so I went and added in a quote.”

While Esther, Beck, Ray, and Ozgur made significant revisions to their texts, the others did not (e.g., Aspen, Andrew, and Christopher). Despite evidence of meta-awareness about areas of need in their texts—expressed via Comment nodes and map organizations—some students simply carried out their normal editing-as-revising process (e.g., Peter, John). Instead of rewriting and adding content or adjusting the organization of their text sections, they left the texts largely intact with revisions consisting of fixing spelling, typos, and wording with the occasional addition of a few lines to the beginning or end of their text (see Table 2).

A comparison of Peter’s first draft with his second draft written post-mapping shows a number of changes (see Fig. 8). However, these changes did not combine to transform his text. While he did follow through on his plans (articulated in two Comment nodes) to add to his conclusion and introduction, what he added could best be described as vague generalities, an opinion, and a minor change in punctuation.

Peter was one of nine focal students whose Comment nodes and map organizations reflected ideas and plans that could reasonably lead to meaningful revision. Cross-referencing student maps and Comment nodes with their post-mapping draft changes show that all four students who made substantial revisions came from this pool of nine focal students. Like Peter, there were four other students who formulated plans to transform their texts but did not or could not follow through.

In his interview, Brad said that sometimes during his revision process he identifies something that needs attention but then forgets to, decides not to, or is not equipped to address the issues he identified. In stating, “I might do this later,” Ray, talking about the comment nodes he created, hints at his feelings about how loosely the rereading and mapping process was coupled with the revising process. While the mapping tool scaffolded the act of identifying issues within a draft to the extent that 11 of 13 focal students used the Comment nodes to mark sections for revision, applying those insights proved elusive.

**Table 2** Changes made to drafts after mapping tallied by frequency and number of students implementing

Changes made to draft (post-mapping)	Overall frequency	Number of students implementing
Punctuation	36	12
Word choice/lexical changes	11	6
Added citation	8	6
Expanded conclusion	7	6
Spelling	39	5
Sentence level explanation/elaboration	6	5
Expanded preview	5	4
Added content (facts)	3	2
Deleted sentence	2	2
Added content (entire section)	2	1
Added conclusion	1	1
Capitalization	1	1
Reorganization within a paragraph	1	1
No changes	1	1



existing text and used as an aide for re-mediating students' texts to focus the practice of rereading and facilitate substantive revision. The common pedagogical practice of using mapping and mapping software during science, social studies, and pre-writing literacy activities ensured that students were familiar with concept mapping before participating in the study. These understandings of the conventions of mapping transferred without notable issue to a different phase of writing with minimal issues and negligible tool-centric 'training' time. In our observations we found that most of the time spent familiarizing students with the technology was allocated to showing them how to ingest their text into the mapping environment and getting them up to speed with the genre-specific element nodes and how they were related to one another (see Fig. 1).

Creating persistent, flexible, visual, semantic maps based on the features of the target genre helped shape the act of rereading, affording developing writers scaffolded pathways toward transformative revising. Between-drafts mapping enabled students to re-present their writing based on a meaning and genre-focused close rereading of their own text. The experience of mapping their draft supported students in considering what was missing and what they should add, revise, or reorganize. Based on both the maps and the comment nodes students generated, the intervention supported writers in attending to the semantic elements of their texts. Students' positive responses to the mapping experience suggest that using mapping as a scaffold toward transformative revision may be a productive focus. That is, rereading within an environment that creates a persistent visualization of how evidence and argument fit together in a text or to identify what elements may be missing from a text, scaffolds the first part of the revising process. In other words, re-mediating writing via between-drafts-mapping serves as an enabling element in revising. At a different grain-size it also serves to experientially involve students in constructing their understanding of what it means to fully evaluate a text within a particular genre by requiring them to construct a visual map of what their draft looks like—both in terms of content and organization.

We designed the intervention with the expectation that students would use the scaffolded experience of mapping their draft as a way to overcome the high-level cognitive, procedural, and affective challenges related to revision—leading to better evaluations which would precipitate a return to source material and a substantive reworking of initial texts. Our data show participants did create map organizations and comment node notes that could lead to substantive revisions. We see between-drafts semantic mapping for the evaluation of texts as a promising and productive step toward transformative revision.

## 6.2 From Rereading to Revision

Between-drafts mapping supported students in focusing their self-evaluations on genre and content-related elements of their texts. Specifically it supported students in gaining clarity about what to look for, provided scaffolded ways to look, and offered several avenues for capturing the results and making revision-related plans. Yet, navigating the complexities of evaluative rereading via mapping was only supportive enough to help four of the thirteen focal students transform their texts. Despite a technology-supported intervention that led to students identifying opportunities for transformative revision, many revision-related plans and node reorganizations went un-acted upon—suggesting that while the obstacles to transformative revision may begin with rereading, they do not end there.

In their interviews our focal students articulated how the mapping process helped them notice things that were missing in their texts as well as sections that could use reorganization, yet they also stated that they did not feel obligated to return to source material in

order to write new sections. Some talked about the mapping not as an intermediate point in their recursive writing process but rather as a post-writing exercise that was minimally connected to the subsequent surface-level edits they made in their texts. Feeling like one has already crossed the metaphorical finish line may make returning to sources and re-engaging with writing psychologically difficult. Changing this perception may require both a change in classroom writing culture—in terms of expectations about revising being explicitly positioned as inclusive of the acts of research and writing—as well as increased classroom time and tools to help support writing within developing texts.

### 6.3 Implications

This study has yielded insights and paths for future inquiry into revision as well as design considerations for future iterations of the intervention and application.

First, the prospects of identifying meaningful revision candidates based on unscaffolded rereading of one's own text may be unduly challenging for students—especially when working within a genre they are still learning. Too diffuse and iterative for developing writers, rereading as the lone avenue toward substantive revision requires them to mentally keep track of compositional elements, the location of those elements, how they work in concert, and which might be better placed or are missing but deserve to be included. For novice academic writers, parsing, evaluating, and reflecting upon texts via rereading may be the cognitive equivalent of trying to create an evaluative concept map out of smoke-rings.

Second, the experience of using rereading to create persistent, movable, visual markers of the required elements in an academic text holds promise. In creating a menu of node types made up of the expected elements found in informational writing, student rereading is focused not on issues of editing but at the intersection of content understanding and genre awareness. The color-coded student-generated nodes forefront the ideas, concepts, and evidence present and missing in their texts as well as how these are hierarchically linked and organized. Thus, the experience and the resultant maps direct visual and global concerns to a type of evaluation that supports students in reconsidering how they have shaped their message against the expectations of the genre. This research has led to new ways of understanding how visually articulating textual architectures can support domain-related learning as well as increase genre-awareness in academic writing.

Third, participants in our study undertook the process of mapping their texts in a variety of ways suggesting that the non-linear nature of the intervention offered a range of entry points for rereading via mapping. As we observed and the animated GIFs of their map building show, some students added all of one type of node first, others added them as they encountered them, some organized and created links as they added nodes while others waited until they had created most of their nodes before organizing and linking. The process of mapping and the maps themselves afforded students opportunities for scaffolded interaction with the complex, multidirectional networks involved in the development of academic literacy, reasoning, and knowledge representations. Moreover, the design of the InfoWriter application not only afforded a range of gateways into mapping but it did so at a low cost to the student. Building a map involves highlighting text to be included in a node and selecting the corresponding node type from the menu which persists when the student moves her cursor over her text. This near-automation of node creation means that student focus is not on the technocentric aspects of the tool but on understanding the node types and rereading their texts in light these. At different points in the mapping process, students erased some or all of their existing nodes and then added nodes of a different type or with

different text—suggesting students both became more familiar with the node types and were undeterred by the effort required to remake, link, and position their nodes.

Last, the research and pedagogical implications of our study include insights into the targeted re-mediation of student writing, especially early in the writing and revising process. However, as over half of the students had difficulty translating their meta-awareness about needed revisions into subsequent drafts of their texts, researchers and educators might consider ways of extending supports like between-drafts mapping into both the earlier and later stages of revising. Based on our findings, translating student intentions into substantive revisions is likely to require further scaffolds including modeling, mentoring, comparison, direct instruction, and/or the remediating affordances of emerging technologies.

## 6.4 Future Intervention and Application Designs

Our data analysis has informed the future trajectory of the design of the intervention and application. We are interested in exploring the possibility of changing the student experience in a number of ways outlined below. We anticipate that translating plans into actual revisions is most likely to happen within generative ecologies where the practice of making meaningful revisions is familiar, valued, and modeled or explicitly taught. Such an ecology would include multiple entry points into the practice, and scaffolds to support success.

We see conducting future interventions within contexts wherein students identify the academic writing they undertake as personally meaningful and feel they have some level of active agency over their literacy development (Beck 2009). Additionally, the noted disconnect between encouraging student post-mapping meta-awareness about their text and limited levels of follow-through has led us to consider adding a feature that inserts student Comment node contents into the next version of their draft as in-line text, perhaps within brackets (e.g., [[Comment: Expand section to include more statistics.]]), thereby creating landmarks or objects in their text to serve as a reminder of their intent and starting point for their revisions.

Both teachers and student participants voiced interest in using the intervention for peer and teacher diagramming and diagram commenting on writing. This may prove useful for the purposes of formative assessment focused on feedback directed toward the information structure of texts and suggestions for revision when the student is not able to bridge the gap from text to issue identification and from issue identification to resolution.

Students who did not engage the mapping process—creating just a few nodes and no comments—might also benefit from the application of advanced natural language processing (NLP) technologies that could provide feedback and suggestions on the structure of information texts. We have developed this functionality to a proof-of-concept stage as of 2015.

Finally, we plan to prototype and trial versions of the intervention and application for other academic genres such as argument and narrative writing. Additionally, teachers and students expressed an interest in being able to create their own node labels and node definitions for hybrid or specific sub-genres or to address the conceptual structure of specific topics. We are also considering several design changes that support the visualization of texts that exceed 1200 words.

## 7 Conclusion

Supporting students in making meaningful revisions to their academic texts is a difficult if not intractable challenge involving: identifying opportunities for redrafting, understanding how to translate these opportunities into a revised text, and marshalling the will or aligning the writing with a generative need to follow through. In working to better understand the dynamics involved in revision we created a technology-supported intervention that repurposed concept mapping conventions to support writing students in identifying opportunities to make transformative changes to their texts. While not all students in our study consistently translated the work they did in their maps into additional or reorganized writing in their next drafts, our research outlines an approach to scaffolded rereading that supports developing writers in re-mediating their texts in a genre and concept-focused way.

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