An Engineering Process for Constructing Scaffolded Work Environments to Support Student Inquiry: A Case Study in History

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Abstract

Inquiry-based curricula encourage students to develop research and collaboration skills by working with evidence and exploring real problems. Students engaging in inquiry projects must be supported in learning the content and work practices of a domain. SWEets, or scaffolded work environments, are one method of providing this support. We present a new software engineering process for designing SWEets for any educational domain and describe the application of this process to the development of Clio, a web-based SWEet for high school history students. The Clio SWEet was piloted in two classroom studies and preliminary data indicate that students were able to use the software to successfully gather and analyze data as part of an inquiry-based classroom curriculum.

1. Introduction: The Need to Support Inquiry

The National Standards for History Education [1] call for students to develop historical thinking skills by engaging in activities such as defining historical questions, gathering evidence, analyzing data, and working with their peers to generate and critique solutions. An inquiry-based curriculum can provide students with opportunities to participate in such investigations, but studies have shown that students need a great deal of support in order to conduct historical inquiry effectively [2]. One way to provide this support is through the use of scaffolded work environments (SWEets), which are suites of software tools designed to support student inquiry within an educational domain. SWEets like Symphony [3] have been successful in supporting inquiry in science classrooms, and this paper describes work to extend the benefits of SWEet technology to the domain of history. Specifically, we present a software engineering methodology for the design of educational SWEets and describe the application of this design process to the creation of Clio, a web-based SWEet for history. Clio was developed in close collaboration with Dr. R. Bain and his group at the University of Michigan School of Education (SoE), who created the curriculum and classroom materials that make use of the Clio SWEet software.

Preliminary results from two classroom trials indicate that students were able to use the Clio software to gather and analyze historical evidence as part of their classroom inquiry projects. Not all of the tools provided by the Clio software were fully utilized during these first trials, and future work will focus on better integration of the SWEet with the classroom curriculum and on providing more professional development for teachers.

2. An Engineering Process for SWEets

Building on the work of Quintana [4], we are developing the software engineering process described here to guide the construction of SWEets to support student inquiry in any domain. This process is informed by the theory of Learner-Centered Design [5], which recognizes learners as novices with unique needs that must be addressed during the software development process, and was used to develop the Clio software. Although we present these steps as an ordered list, they are not intended to be carried out in a linear fashion. Indeed, like many design techniques this software engineering methodology is iterative and involves revisions throughout the lifecycle of the SWEet.

1. *Identify the Learning Objectives*. We first identify what students will learn, what instructional methods will be used, what tasks and activities students will undertake, and what skills students will develop. Clio's pedagogy and curriculum were developed by our SoE colleagues based on Bain's previous work [6] and focus on research problems relevant to students' own experiences.

2. *Identify Expert Strategies*. The next step is to determine what strategies and techniques a professional would employ to complete the various learning objectives. Example inquiry tasks from the Clio curriculum include evaluating the relevance and credibility of sources and corroborating different accounts of the same event. Bain's curriculum team identified specific expert strategies applicable to each of these tasks in Clio.

3. *Identify Student Needs*. Next we evaluate each task and strategy and identify areas where students are likely to have difficulties. The SoE curriculum team identified aspects of the historical inquiry process where students needed support – for example, in order for students to determine the significance and relevance of a source, they needed access to background information about the artifact.

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4. ***Identify Teacher Needs.*** It is also critical to work with teachers to identify where they need assistance to integrate the SWEet into their classrooms. To meet these needs for Clio, the SoE team developed lesson plans and professional development, and all of the developers (both curriculum and software) went into the classroom to demonstrate and troubleshoot the Clio software.

5. ***Identify Classroom Needs.*** When developing SWEets for education, it is critical to understand the classroom limitations that may affect the use of the software. For Clio, these considerations included limited computer hardware and Internet bandwidth and were resolved by developing the software using html and scripts and by minimizing the number of graphics in the web interface.

6. ***Identify Scaffolds and Supports.*** The next step is to determine which needs can be met with educational scaffolds and learner supports (tools assist students in completing tasks that would otherwise be too difficult or complex for novices [7]). To determine how the Clio software could best support these needs, we looked at Bain's experiences with historical inquiry [6] and at SWEets designed to support similar investigations in science, including Model-It [7] and Symphony [3]. The most prominent scaffolds in Clio are the multi-level Strategy Prompts, which support students in analyzing primary source materials. Other supportive tools provided by the Clio software include: Research Problem Folders, which provide persistent workspaces for students to collect information and take notes; Additional Information Sources, which supply additional background and context information for individual artifacts; and the Discussion Forum for online, threaded discussions.

7. ***Design and Implementation.*** The Clio database maintains information for the artifacts, scaffolds, and individual students, and the SWEet interface is built using scripted webpages that format information from the database dynamically in response to users' actions. The flexibility of this database architecture and dynamically controlled interface content allows the Clio software to be quickly modified as the associated curriculum evolves.

8. ***Classroom Trials.*** Early prototyping and classroom testing can help identify unanticipated needs; for example, during the first classroom trials of the Clio SWEet we discovered that students needed more flexible tools for navigating through the historical artifacts in the database.

9. ***Curriculum & Software Revisions.*** Both the Clio curriculum and the SWEet software have been revised based on data from the classroom pilot studies. Examples include adding a Search tool to the interface to help students navigate through the artifact database and creating a process map that hangs in the classroom to remind students of the different steps of the historical inquiry process. This engineering process for SWEets is non-linear, so the redesign and revision of the software should take place throughout the development process.

3. Conclusions and Future Work

Preliminary data gathered from two pilot trials of Clio in high school history classrooms indicate that the software supports students in successfully gathering and analyzing primary source materials and conducting historical investigations. During these first trials, the Clio software was used primarily to gather and analyze historical data. Future trials will explore how the software and curriculum can be more tightly integrated to take advantage of other inquiry tools provided in the SWEet and how we can better support teachers in using the software in their classrooms.

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