A Design for Effective Support of Inquiry and Collaboration

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Abstract

The Collaboratory Notebook is a shared hypermedia database designed to provide a scaffold for students as they learn to conduct collaborative, open-ended investigations. Through its structure, the software provides students with a genre for communication about scientific inquiry. In this paper, we examine the design goals for the Collaboratory Notebook in the context of an example of its use. We analyze Notebook use through student characteristics including gender, previous experience with technology, and attitudes and beliefs about science.

Keywords — educational groupware, collaborative hypermedia, inquiry-based learning

1. Introduction

Student participation in collaborative, open-ended inquiry is a central goal of many current science education reform efforts. Collaborative inquiry is considered desirable, in part, because it reflects the authentic practice of science by scientists. However most students in high school science classes have little experience conducting open-ended investigations either alone or in groups. To provide a scaffold for students as they learn to conduct collaborative inquiry, we have developed a shared multimedia database application called the Collaboratory Notebook. The software has been designed with the explicit goal of supporting both collaboration and scientific inquiry. It has been created by the Learning Through Collaborative Visualization (CoVis) Project as part of an investigation into the use of advanced computing and networking technologies to support project-based science learning in a widely-distributed community of high school students, teachers and scientists [1, 2]

2. Genres of Inquiry

Studies in the sociology of science (e.g. [3, 4]) have shown that the medium of communication shared by the members of a scientific community greatly influences the development and maintenance of shared standards for work. Over time, the development of common structures for the presentation of research in the shared medium (that is, the genres of communication) serves the community by embodying, and subtly enforcing, its standards and values for research.

> *A genre consists of something beyond simple similarity of formal characteristics among a number of texts. A genre is a socially recognized, repeated strategy for achieving similar goals in situations socially perceived as being similar....The formal features that are shared by the corpus of texts in a genre...are the linguistic/symbolic solution to a problem in social interaction.* [4, p. 62],

As Bazerman[4] suggests, the standards of a genre can make an investigator's job easier by clarifying the way that a particular community will receive new work. This makes genres a potent instrument for instruction, and indeed the formal features of genres like research reports are often used for teaching. There is some reasonable doubt, however, as to the wisdom of "teaching" students genres, at least in the most didactic sense [5, 6].

No doubt, the process by which students acquire a written genre is a complex one, and this complexity is not due just to the need for them to acquire new vocabulary and to learn to put it together. Because composition is a form of social interaction, learning to compose within a genre is a process of socialization.

> *The student has to appropriate (or be appropriated by) a specialized discourse, and he has to do this as though he were easily and comfortably one with his audience, as though he were a member of the academy or an historian or an anthropologist or an economist; ...He must learn to speak our language. Or he must dare to speak it or to carry off the bluff, since speaking and writing will most certainly be required long before the skill is "learned." And this, understandably, causes problems.* [7, p. 135]

Of course, it is better if the student does not need to entirely bluff his or her way into a community. Having a valid mission, or a purpose for writing, helps. Our approach to the design and use of the Collaboratory Notebook reflects this thinking. In effect, the software

embodies a genre that reflects sensible standards for investigation. When employed in the course of students' working on legitimate scientific problems, the Collaboratory Notebook is designed to support the acquisition of the genre of investigative writing.

3. Supporting Collaboration and Inquiry

In our development of the Collaboratory Notebook, we have sought to provide students with an electronic medium to support both inquiry and collaboration. The key to facilitating these scientific practices is the genre of communication embodied by the software. The software provides support for collaboration in the form of a networked database, accessible from anywhere on the Internet, in which individuals can share their ideas and actions with others.

The Collaboratory Notebook provides support for inquiry through a structured user-interface based on a task model of open-ended inquiry. Built loosely on the metaphor of a scientist's notebook, the Collaboratory Notebook allows a user or group of users to create a shared workspace called a *notebook*. Within a notebook users create pages that may be linked together through hypermedia links indicating the semantic relationships between them. Every page in a notebook is assigned a page type by its author(s). The page types, influenced by prior work, such as CSILE [8] and Project INQUIRE [9]. reflect a simple but flexible task model of scientific inquiry

The eight page types include questions, conjectures, evidence for, evidence against, plans, steps in plans, and commentaries. Pages may contain text alone, a graphic accompanied by text, or an "attached" document of any type. The hypermedia links enable users to connect pages together according to the relationships between them. For example, students may connect conjectures to the questions they respond to and evidence to conjectures they support or contradict. These page types and the links that may be used to connect them define the genre supported by the Collaboratory Notebook.
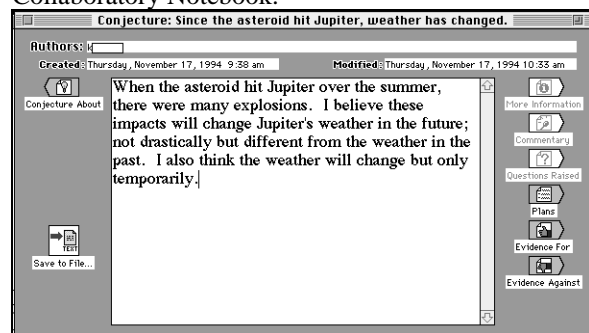

Figure 1. *A* Conjecture *page. Links to other pages are represented by the buttons on the left and right side of the text.*

The genre defined by the page labels and links is designed to provide students with a framework for conducting and communicating about the inquiry process that encourages them to be systematic and reflective. The Collaboratory Notebook has been designed as a scaffold in the metaphorical sense, in that it provides students with a structure for their activities designed to reduce their need to focus on the challenges of organization so that they may focus more on the content of their activities.
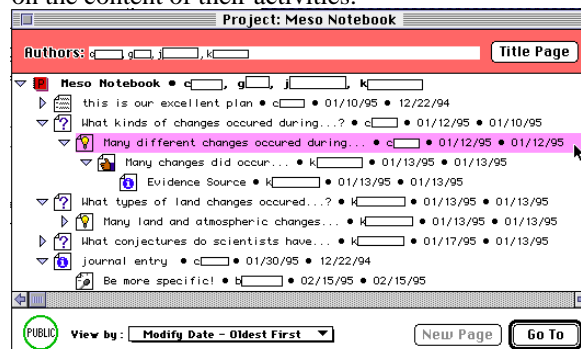

Figure 2. *A notebook table of contents. Page types are indicated by icons; links are indicated by indentation.*

In use, the page-types and the links play two additional important roles in scaffolding students' activities. The way the interface presents pages is designed to suggest appropriate next steps to the user. For example, when looking at a conjecture page, a user sees interface buttons that include those labeled *evidence for*, *evidence against*, and *plans.* These interface elements implicitly suggest to the user that he or she follow up the current conjecture with evidence relevant to the conjecture or a plan for acquiring that evidence. Second, the set of page and link types support the development of conventions within a community about the semantics of each page and link type. These conventions define a genre that provides both writers and readers with expectations about the relationships among pages and inquiry activities that ease the process of navigating through the hypermedia database—in sharp contrast to currently popular hypermedia environments such as the world-wide web and conferencing software that have links that are either untyped or customizable by individual users.

4. The Collaboratory Notebook in Use

The Collaboratory Notebook has been used to support a variety of activities by members of the CoVis community and others. In CoVis classrooms, the Notebook has been used as a facility for maintaining a record of students' thought processes and activities through extended investigations, as a forum for expressing and refining student research proposals, and as a medium for conducting community "knowledge building" [10] activities. Outside of the CoVis community, the Collaboratory Notebook has been used as a medium for sharing data and analyses from field work in an undergraduate ecology class, and as a supplement to in-person discussions in a medical school problem-based learning curriculum.

A primary characteristic of nearly all of these activities has been the role of the Collaboratory Notebook in allowing teachers to monitor and provide timely feedback on their students' work. In a small number of these activities, members of the scientific community outside the school have played a mentoring role, providing students with guidance and probing questions to assist the inquiry process. From a pedagogical standpoint, these uses of the software to monitor and guide students in the course of their work, indicate a role for the Collaboratory Notebook in supporting an increased attention to the students' process of learning as opposed to the traditional emphasis on final products. This form of collaboration where students and adults shape a students' work together stands in contrast to the conventional assessment dynamic where an adult simply evaluates students' work when it is completed.

5. A Study of Notebook Use

We turn now to an evaluation of the software's design. Elsewhere in these proceedings [11], we describe an activity conducted in a ninth grade classroom, in which students used the Collaboratory Notebook in the course of conducting open-ended research projects on climate. In this section, we present an analysis of those students' use of the Collaboratory Notebook in terms of user characteristicsthat designed to identify ways to make the software useful for more learners.

In our analysis we focus on three features of students' notebooks: their size, diversity, and linking. *Size* is a rough measurement of overall effort, measured by the number of pages and words contained in a complete notebook. *Diversity* is a measure of the number of different page types. *Linking* characterizes the connectedness of pages in clusters or trees. It is computed as the average number of links per page (branching factor), the average connected cluster size of linked pages, and the average depth of a page in a linked chain.

In the analysis that follows we use regression models to account for variability in the size, diversity, and linking in students' notebooks. The user characteristics we considered in these regression models were: (1) gender; (2) typing skills; (3) previous experience with computing for specific purposes; (4) writing apprehension; and (5) attitudes and beliefs towards science and science class. These data were collected through surveys administered in the first month of the school year.

We consider gender because there is evidence [12-14] that some applications, for instance, certain types of games, are appropriated by boys more readily than by girls. It was our hope that communication-centered applications like the Collaboratory Notebook would not be used differentially by boys and girls. Typing, and the use of specific computer applications, such as word processors and on-line services, were considered in order to examine the importance of prior experience

and prerequisite skills. Finally, we assessed students writing apprehension in relation to their Notebook usage because of the possibility that discomfort with writing might reduce the size or number of pages written by students in their notebooks. We used The Writing Apprehension Test (WAT) [15], a measure that is designed to judge an individual's degree of comfort with written communication.

We developed regression equations for notebook size measured in total number of pages, diversity in use of page links, and the branching factor of Notebook pages respectively. Our strategy for developing regression equations was based on reliable, simple correlations between the dependent measures of notebook structure and use described above and independent measures of user characteristics. None of the other outcome measures we examined (i.e., words per page, average cluster size, average depth) had reliable simple correlation measures with the independent variables listed above. The regression equations accounted for variance (R^2) in the outcome measures in the range of ~12% to ~25%.

Notebook size. The regression equation for the number of total pages accounted for 22% of the variance. The only reliable coefficient in that equation was the use of on-line chat or discussion groups (t (33)= 2.10, p < .05) measured by responses to the question, "How much experience do you have using computers for using on-line chat or discussion groups?". We explain this result by the fact that students who have significant experience contributing to on-line interactive forums would feel more comfortable contributing to an on-line project notebook and would therefore be more prolific.

Diversity. The equation for diversity accounted for 25.4% of the variability in the number of page types that students used. Again, reported skill at using on-line chat or discussion groups was a reliable coefficient (t (32) =2.42, p<.05). In addition, students enjoyment of their science class was a reliable coefficient (t(32)=2.34, p=.03) measured by their answer to the question; "I enjoy classes in science." It would be reasonable to assume that students who enjoy science class in general are much more willing to explore the various features of the Notebook which are geared towards scientific inquiry.

Linking. The Branching Factor equation accounted for 12.7% of the variance in the number of links per page in students' notebooks. Here too, a measure of attitude toward science was the only reliable coefficient (t (33) = 2.19, p< .05) in the regression equation. In this case, answers to the question "I do very well in my science classes" were positively correlated with richer Notebook graph structure.

These results are interesting both for the correlations that were significant and those that weren't. Many of the user characteristics that could

have significant implications for the design of the software or that have been shown to correlate with the use of computers or with performance in science classes failed to show significant correlations with measures of Notebook use. For example, gender, typing skills, use of word processors and other computer applications besides on-line interactive forums, and writing apprehension did not reliably predict any of the outcome measures of notebook size, diversity, or linking.

On the other hand, attitudes towards science and experience with on-line interactive applications did reliably predict notebook use. In particular, experience with on-line interactive software correlates positively with notebook size, which can be explained by these students' comfort with expressing themselves in a computer-based communications medium. In addition, positive attitudes about science correlate with students' use of the structural features of the notebook, i.e. diversity and linking. This can be explained by the fact that students who enjoy science and have been successful in previous science classes may be more accustomed to organizing their thoughts and activities according to the genre of scientific communication as embodied by the Collaboratory Notebook.

6. Conclusion

The Collaboratory Notebook has been designed to scaffold students as they learn to conduct open-ended inquiries in a collaborative context. In essence, it provides students with a genre for recording and communicating the scientific inquiry process. In the early analysis of use reported here, we observed that students with more positive attitudes about science and more experience using on-line communications media took better advantage of the features of the environment. However, many student characteristics that could have presented obstacles to use did not appear to do so. These early findings will pave the way for more in-depth studies of the effectiveness of the genre provided by the Collaboratory Notebook for supporting collaboration and inquiry among learners.

Acknowledgment

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