Supporting Interaction Outside of Class: Anchored Discussions vs. Discussion Boards

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ABSTRACT

Newsgroups and online discussion boards have long been used to supplement class discussions. We describe a study comparing the use of two systems, WebAnn and EPost, to support class discussion of technical papers in a graduate course. WebAnn is a shared annotation system that supports anchored discussions on web pages, and allows users to easily associate comments with a particular paragraph, phrase, or word in the paper being discussed. EPost is a high-quality conventional discussion board system. In our study, students contributed almost twice as much to the online discussion using WebAnn. WebAnn also encouraged a different discussion style, focused on specific points in the paper. We expected WebAnn discussions to serve as a starting point for in-depth discussions in the classroom; but in fact, online discussions often competed with classroom discussions. We conclude with implications of the study for technology design and the process of its use.

Keywords

Annotations, online discussion forums, computer-mediated communication, educational technology

INTRODUCTION

Students and instructors are spending more time online. Many see this as a significant opportunity to encourage more educational interaction outside the classroom. Tools that support asynchronous collaboration hold potential as a convenient, flexible means of doing just that. Various systems, for instance online discussion boards, have long supplemented class discussions, but their use typically has been limited and optional, because not all students were assumed to have access to a system or the skills to use it. Today these restrictions are fading away, and we can harness the increasing ubiquity of online access and tools to promote educational discussion beyond the classroom door. But what is the best way to proceed?

Tools that support asynchronous collaboration allow discussion to happen when and where it is convenient, and help link what goes on outside of class while students do homework to what goes on in class. For instance, students can begin to discuss a reading assignment *while they are reading it,* instead of taking notes and waiting until they get to the classroom to express their reactions.

Online discussion boards have supported this in the past, but discussion board posts are divorced from the context of the assignment. To contribute a comment or question students must manually reconstruct the context of their remark before making it. That is, they must identify not only the paper or document being discussed, but perhaps also the section, paragraph, sentence, or word. Only after this is done can a discussion thread ensue. Further, the resulting discussion will not be readily available to other students as they read the paper.

Our shared annotation system, WebAnn, takes a different approach. It supports fine-grained annotation of web pages, so that students' remarks can be made and seen in the context that inspired them. Furthermore, annotations are shared, and can serve as anchors for threaded discussions. In this way, discussions around class material outside of class are captured for all to see, *and* they are directly linked to the materials—and the precise location within the materials—that they reference. This paper presents a study we conducted to evaluate the efficacy of WebAnn for supporting ongoing discussion outside of class.

The process of use that we envision for WebAnn is as follows. A student reads a paper on-line, and can at any point identify some text and type in a comment or question. This annotation then appears alongside in a separate frame with a visual indication of the associated text. It can either be a personal note or an entry in a public class discussion. The student will also see annotations left in the class discussion by previous readers, and can reply to those. With this facility questions can be asked or answered, opinions made known, issues identified, and discussions started. Using the WebAnn system, students can more easily participate in discussions of class materials, and discussion outside the classroom will flourish.

At least, that was the theory. To put our hypothesis to the test, we conducted a study in a graduate university course comparing WebAnn with EPost, a high quality discussion board system (EPost, 2001). The course focused on lectures and discussions of published research papers, and student assignments included making comments on the readings using the two systems. The study provided many insights into the value and appropriate uses of tools for support of discussion outside the classroom. For a variety of reasons, including access and the granularity of the discussion, student preference

appears to slightly favor EPost. However, students contributed almost twice as much to the discussion using WebAnn. The nature of the class discussion was affected in ways not anticipated by the class or instructor. Based on our results we identified enhancements that will improve WebAnn, as well as important considerations for the process of using it.

The remainder of the paper is organized as follows. The next section briefly reviews related work. Then we describe the salient features of the WebAnn and EPost systems. We then outline the study we conducted to assess the efficacy of WebAnn in promoting discussion outside of class, and present the results. Finally, we discuss some of the implications of our findings, and provide some concluding remarks.

RELATED WORK

In this section we focus primarily on systems studied in an educational context. Word processors and co-authoring tools have gradually added commenting and revision features, although they are not yet as convenient as pen and paper. WebAnn incorporates some features of these systems. Like the commenting feature in Word, WebAnn allows comments to be attached to specific words or passages and it supports the viewing of the annotations and the original document in a single window. In contrast, CaMILE (Guzdial & Turns, 2000), Col•laboració (Col•laboració, 2001), and CoNote (Davis & Huttenlocher, 1995) support coarser granularities of context, with anchors to a threaded discussion of an entire web page or a section of a page or document. The first displays comments below the text, the second embeds a link to the discussion in the page, and the third is a discussion board in which a thread contains a link to the object being discussed. As our study indicates, tradeoffs affect design decisions regarding annotation granularity and presentation of source material. One solution may not be ideal for every setting. WebAnn allows us to explore the way people respond to the ability to identify precisely the context for a comment.

The intended user of annotation systems varies. Many systems that provide anchored comments or discussions, such as Quilt (Leland et. al, 1988), Prep (Neuwirth et. al, 1990) and Col•laboració, are intended to support co-authoring. The authoring and editing process is also a principal focus of commenting with Word (Cadiz et. al, 2000), which in its most recent versions supports anchored discussion threads. While WebAnn could be used for authoring and editing, in this paper we focus on its use for commenting.

In the educational context, bulletin boards and chats and other real-time communication systems have been used in distance education and to supplement face-to-face classes. In contrast to our study, studies of anchored online annotation systems have primarily focused on editing and commenting on student or instructor work. Hewitt and Teplovs (1999) is a nice study of the use of one such discussion board, CSILE, across many courses. In a study of CoNote (Davis & Huttenlocher, 1995), students were required to use the system to comment on project sites constructed by 3 others sets of students. CaMILE (Guzdial & Turns, 2000) was used to discuss short descriptions of assignments and review outlines for exams. The Collaboratory Notebook / CoVis system (O'Neill et. al, 1995) includes student-created notebooks on which instructors commented, as well as discussion boards.

One exception is CLARE (Wan & Johnson, 1994), in which a tool is used collaboratively to analyze scientific papers online through the creation of a highly structured hypertext of labeled annotations describing portions of the text as problems, claims, evidence, theory, concepts, and so forth. It also allows more general annotations categorized as critiques, suggestions, and questions. The interface and process of use of CLARE is very different from that of WebAnn: it is not first and foremost a discussion. Students first privately analyze the text, then view each other's analyses, at which point they can comment by creating new links. Threads are not presented visually. However, CLARE resembles WebAnn in the way that it anchors annotations on online representations of core course content.

Anchoring and context in education are used in a different sense in the anchored instruction paradigm developed by the CTGV group (CTGV, 1993). They discuss using materials such as videos to anchor assignments in the context of students' daily lives. We focus on anchoring discussions in the context of the text being discussed.

DISCUSSION SYSTEMS

In this section, we describe WebAnn, the online discussion system we implemented, and EPost, a discussion board that is part of the UW Catalyst toolkit.

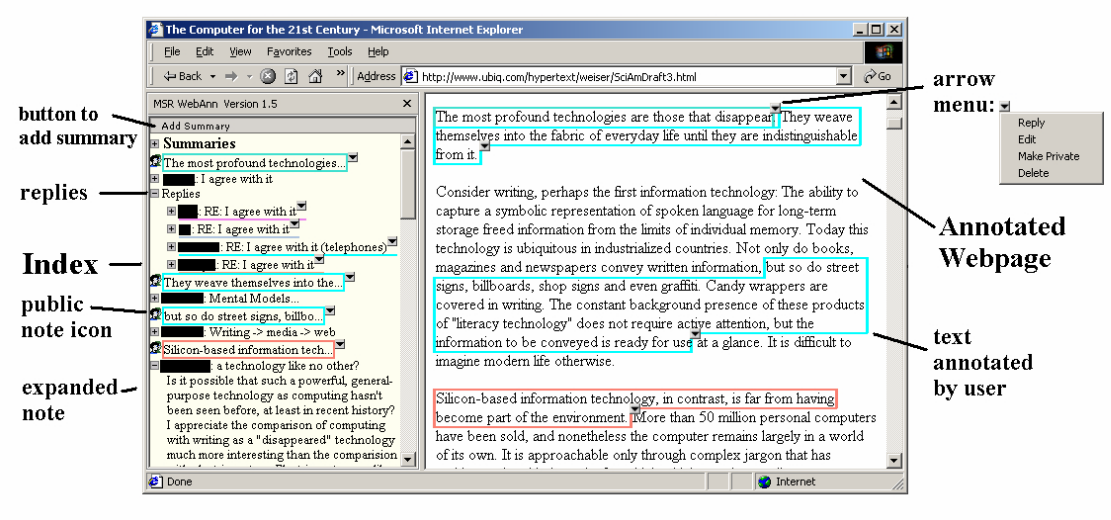

Figure 1: WebAnn interface embedded in Internet Explorer. On the right is the webpage being annotated, on the left is the index of notes and replies. Student names are blacked out to provide anonymity.

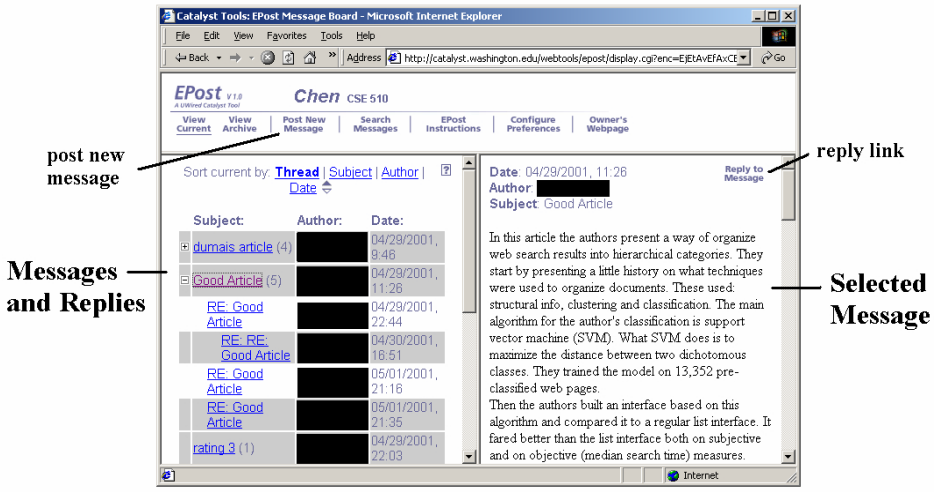

Figure 2: EPost, a threaded discussion board from the UW Catalyst toolkit. The left pane is the index of posts and replies. The right pane is the text of the selected message. Student names are again blacked out.

WebAnn

WebAnn allows text annotation on any web page. It is designed to support shared persistent threaded discussions that occur in a precise context. WebAnn is embedded in Microsoft Internet Explorer, and can be easily installed on any computer running Windows 2000. As shown in Figure 1, the web page being annotated is displayed on the right, and discussions on the page are shown in the index window on the left. WebAnn is adapted from an earlier system we built to experiment with robust annotations on web pages (Brush et. al, 2001).

To create a new note, a user selects the text to be annotated and chooses to “Add a Note” from a popup menu. A dialog box appears, into which the user types the note. The user can optionally make the note private. The new note is added to the index, and the text to which it corresponds in the page is outlined with a color unique to that user. Annotations are automatically made persistent in an internet-based annotation store.

Once an annotation has been created, it is available as a navigational aid in both the index and the page, so that clicking on it in the index, for instance, scrolls the web page until the outlined text is in view. Later on, the user can go back and edit or delete his or her notes (provided they do not have replies). To add a global note that applies to the entire web page, the user clicks the “Add Summary” button and follows the same procedure.

Threaded discussions grow when users reply to existing notes. To reply to a note, a user clicks the arrow menu next to the note (either in the index or the web page) and chooses “Reply.” Replies are added to the index directly below the original note.

EPost

EPost, a University of Washington (UW) "Catalyst" tool (EPost, 2001), is a high-quality web-based threaded discussion board similar to a traditional newsgroup browser. EPost discussion boards are widely used at UW, and can be accessed using any HTML browser.

As shown in Figure 2, the left side of the EPost interface lists the original messages and replies, while the contents of the selected message is displayed on the right. To post a message, the user clicks on the "Post New Message" link at the top left, and to reply on the "Reply to Message" link. EPost supports several useful features, including filtering and notification options. For the class we studied, an EPost discussion board was created for each reviewed paper.

STUDY

To examine the tradeoffs between discussions anchored in-context and traditional discussion boards, we compared the use of WebAnn and EPost in a graduate-level Human-Computer Interaction (HCI) class taught at University of Washington during Spring Quarter, 2001. Two of the authors, Alan Borning and A.J. Brush, taught the course and served as teaching assistant (TA). In general, we wanted to assess the efficacy of WebAnn for promoting discussion outside of class and to see how this affected subsequent discussion in class. Would the use of WebAnn increase the overall amount and quality of discussion and participation? Other studies have found that anchored discussions lead to longer threads and greater participation (Guzdial & Turns, 2000). Beyond this, would WebAnn engage students more by encouraging more specific and pointed comments and stimulate more engaging discussion in class? We expected that the online and in-class discussions would be complementary, since the online discussion could be used to inform the in-class discussion.

Study Design

During the class students were assigned to read 2 or 3 papers per week as homework. For each paper, students wrote a brief review with two parts: a summary and some personal reactions to the paper. Students were also required to respond to at least one other student's comments for each paper. The total length of each review was expected to be equivalent to two or three paragraphs, and students could skip up to five reviews during the quarter. Reviews were 25% of a student's course grade, and it was expected that all students would receive full credit for them. Previous offerings of the course were similar, except for the requirement to post a reply to another student's comment.

This assignment format is a particularly good one for discussion systems such as WebAnn and EPost. To submit paper reviews using EPost, students posted a message containing both their summary and comments, and then replied to other students' posts. With WebAnn, students used the "Add Summary" button for the summary, and then anchored their comments and reactions throughout the paper by adding note annotations and at least one reply.

The class met Mondays and Wednesdays for 80 minutes. Student reviews were due on Tuesday at noon, and responses were due before class on Wednesday. We planned to make the reviews and responses due before the Monday class, but the inability of some students to access WebAnn from home forced the later due dates. Six women and five men enrolled in the class. Four students were from Computer Science; the others were from the Information School, Psychology, and Medical Informatics. One student was an employee of the UW library system.

The class alternated between using EPost and WebAnn in two-week blocks. During the 10 week quarter, students spent at least 4 weeks using each system, with an extra week on EPost at the beginning of the quarter and a final week of presentations when there were no paper reviews. On WebAnn weeks all papers were available in html to enable online annotation.

We fixed basic WebAnn problems and released two new versions during the first two weeks of its use, focused on improved annotation loading and rendering speed. For the final two weeks of WebAnn use, we introduced a version supporting direct editing of annotations (rather than having to manually delete and re-create a note to change it).

Data Collection

We archived the online discussion forums and surveyed students each week. An initial survey collected background information, and a final survey asked about their overall experience with in-class and online discussion. One author (not the instructor or TA) interviewed eight students at the end of the quarter.

Method	Number of Papers	Number of Messages	Messages Per Paper	Average Messages Per Author Per Paper	Average Replies Per Author Per Paper	Average Character Contribution Per Author Per Paper
EPost	13	299	23	2.23	1.15	2485
WebAnn	12	470	39.2	4.71	1.58	4401

Table 1: Student participation using EPost and WebAnn.

RESULTS

Online discussions easily exceeded the required participation level. WebAnn activity differed substantially from EPost discussion. One significant observation is that all students printed out and read paper versions of papers. This removes important potential advantages of WebAnn and affects its use and reception. Despite this, WebAnn was used more than EPost and the pattern of use provides guidance to the design and use of anchored annotation systems.

More participation using WebAnn

As we expected, the ability to anchor comments precisely led to more comments in WebAnn weeks, given that students would be likely to concatenate comments in EPost threads. Table 1 shows key per-author participation statistics using the systems. Using WebAnn, there was an average of 39 comments per paper, with EPost 23. Several students also remarked on the increase in survey responses. For example, "*I made more comments with WebAnn. With EPost I was disinclined to make minor or very contextual points—the kind it is easy to do with WebAnn. I also think I wrote more replies in WebAnn because it was easy to do so (and easy to see the context).*"

Students also replied more when using WebAnn. With EPost, the average number of reply messages per author in each discussion board was 1.15 (most students made only the one required response per discussion forum). Using WebAnn, authors averaged 1.58 replies per paper. A paired-samples t-test showed the averages were significantly different with $p < 0.03$. In fact, 8 out of the 11 students made more replies using WebAnn than using EPost. One student averaged a remarkable 3.33 replies per paper using WebAnn, and only 1.5 with EPost.

While we thought WebAnn annotations might be short, since students would not need to reconstruct the context for each comment, we were not sure how the total participation per student would vary since students would probably make more posts using WebAnn. We found that students wrote almost twice as much with WebAnn. Each student wrote an average of 4,401 characters per paper using WebAnn, compared to 2,485 characters per paper using EPost. These are significantly different based on a paired t-test ($p < 0.001$). Although increased participation in discussion does not necessarily imply enhanced learning, grades in this class included participation and there were no exams, so increased participation was considered a positive outcome.

General vs. Specific Discussion

The two systems support very different types of discussions. EPost discussion boards are completely separated from the paper being discussed, while WebAnn discussions are anchored directly to specific parts of the paper. As we expected, these differences affected the type of online discussion that occurred in the two systems, and this was reflected in student survey responses. For instance, one student observed that with WebAnn it was "*More difficult to make high level comments about [the] paper, [and] discussions usually focused on sentences or paragraphs ...*" and another noted that with EPost "*It's definitely harder to make pointed comments about these papers."* In response to the final survey, one student said "*I think the comments were at a higher level in the E-Post system and more general opinions were presented*" and another said "*...the comments were more specific and numerous [with WebAnn]. I think this is because I could transfer notes I'd made on paper and section of text I'd highlighted directly to the annotation software*."

Although the preference for more general or more specific discussions varied, many students observed that WebAnn led to more thoughtful, involved discussions. For instance, one student observed "*More scattered, but more insightful comments in WebAnn,*" while another saw "*More involved discussion—more back and forth,*" and a third said "*I think the quality of annotations and online discussion [with WebAnn] was better than with E-Post*."

Week	1	2	3	4	5	6	7	8	9
System	EPost	EPost	EPost	WebAnn	WebAnn	EPost	EPost	WebAnn	WebAnn
1. Discussions in class were valuable	5 (11)	5 (11)	5 (11)	5 (10)	5 (10)	5 (10)	5 (11)	4 (9)	5 (6)
2. Online Discussions outside of class were valuable	4.5 (10)	5 (11)	4 (11)	4 (10)	5 (9)	4 (11)	4 (11)	4 (10)	3 (5)$^{+}$
3. The review method [software] was beneficial to my learning	4 (9)	5 (11)	4 (11)	3 (10)	4 (9)	4 (11)	3 (11)	4 (10)	3 (5)$^{+}$
4. I prefer this reading review method	*N/A**	*N/A**	*N/A**	2 (8)	3 (8)	4 (11)	4 (11)	3 (10)	5 (6)

Table 2: Median student ratings on a selection of questions from the weekly surveys. (1 is Strongly Disagree, 6 is Strongly Agree). Numbers of students who responded to a question are in (). *N/A**: There was not yet a basis for comparison. $^{+}$Only 4 students participated in the online discussion this week, which may have impacted the ratings.

Student Preferences

Table 2 shows median student ratings on several key questions from the weekly survey. The ratings are on a 6 point Likert scale where 1 is "Strongly Disagree" and 6 is "Strongly Agree." Table 3 shows the median student ratings for key questions from the final survey, also on a 6 point scale where 1 is "Low" and 6 "High," except for question 6 where 1 is "Disagree" and 6 "Agree." Only the ratings for amount of time spent on software in Table 3 (concerning software trouble) were significantly different between the two systems based on paired sign test ($p < 0.02$).

Value of Discussion

In general, students gave high ratings to the value of discussions both in class and online throughout the course, and there is little quantitative distinction in the value of discussion supported by the two systems. In surveys and interviews students commented more specifically on the value of online discussion. Some examples: *"[online discussion] made the discussion [in class] a lot more interesting," "since they [online comments] are written, they are definitely more composed," "[through online discussion I] got to know people's opinions, the people who aren't as vocal in class,…having the online discussion encouraged everyone to participate in-class as well,"* and *"there were a couple of people who often dominated the class conversation, but they wouldn't dominate the online discussion because everyone got a change to talk."*

Finally, two interesting ratings from Table 2 are the 3's given to WebAnn in week 9 for questions 2 and 3. In this week, most students used their paper skips and only 4 students participated in the online discussion. This affected satisfaction with online discussion. One student commented: *"It's really boring when no one says anything."*

System Preference

Based on their subjective ratings, students preferred EPost slightly overall. However, with only 11 students the data are inconclusive, and individual student preferences varied. Table 2, question 4, illustrates that WebAnn preference ratings started low and rose over time. This may reflect the improved versions of WebAnn that were introduced. Table 3, question 6 shows that on the final survey both EPost and WebAnn received the same median rating, despite having encountered more technical and access problems with the WebAnn software. However, comparing a particular student's ratings of the two systems, for example, if they rated EPost a 4 and WebAnn a 3, we obtain more information: 5 students preferred EPost, 3 preferred WebAnn, and 3 had no preference. In this regard it is useful to keep in mind that by reading printed copies of papers, students lost the advantages of annotating and seeing comments of others as they first read a paper and were thus reacting primarily to the discussion features.

> Comments on the final survey indicated that preferences for a particular method were based on a range of factors, including access and perceived quality and granularity of the discussions. Favoring the EPost system, one student said "*I didn't have [a]* preference. *[The] only issue was that I could use EPost at home*." Another expressed a

System	1. "The quality of the online discussion was"	2. " My satisfaction with this method of online discussion"	3. "The quality of the in-class discussion was"	4. "My satisfaction with the in-class discussion"	5. "The amount of time I spent on problems with the software"*	6. "Overall I prefer this method"
EPost	4	5	4	4	1	4
WebAnn	4	4	5	4	4	4

Table 3: Median student ratings on questions from the final survey. For the first 5 questions 1 is Low, 6 is High. For question 6, 1 is Disagree, 6 is Agree. *The only significant difference is for question 5.

"*slight preference for EPost because it allowed for more articulation of complete ideas/thoughts.*" A third observed that "*It was easier to understand other student's opinions by reading all their comments in a single message. Also, I think the comments were at a higher level in the EPost system and more general opinions were presented*."

In favor of WebAnn, one student said "*I prefer WebAnn (later versions) over EPost. I think the quality of annotations and online discussion was better than with EPost. WebAnn allowed us to comment on specific portions of text, which was nice…*" and another observed that WebAnn was useful because students "*can comment on particular parts of the paper easily…*"

ISSUES AND OPTIONS

Based on the survey ratings and comments, most students felt that online discussion helped the live discussion start quickly and gave it focus. The online discussion space also provided an outlet for students who said less in class, and overall increased class participation. In addition to these successes, though, we learned a number of important lessons about incorporating online discussion into a class. We start by describing some of the major issues we encountered, then we discuss potential changes in technology and process that would help address them.

Student and Instructor Workload: In general, incorporating online discussion into the class created more work for the students and instructor by requiring everyone to keep track and participate in the online discussion at some level.

Although some students felt WebAnn led to more thoughtful online discussions, and clearly it resulted in more extensive online discussions, WebAnn required students to do more work to post their reviews. As noted above, although all papers for WebAnn discussion were made available in html format, all students printed them out to read. To enter WebAnn comments they had to go back and annotate the papers online. One student commented: *"I found WebAnn much more time-consuming to use, perhaps because I prefer to read on paper, and then had to go back through to do the annotations."*

Should professors or teaching assistants participate online beyond reading or leave it as a space for students? We observed both, and each has advantages and disadvantages. In our study the instructor and TA generally participated very little (3 posts in EPost, 5 in WebAnn) beyond reading all messages. This was less work for the instructors and allowed students to take the lead, but meant questions could go unanswered or issues left undeveloped. One guest lecturer in a WebAnn week addressed most questions and issues students raised online, an approach used successfully for design reviews of student assignments using CoWeb (Guzdial et. al, 2000). Students seemed to appreciate the responses. One advantage of having the instructor, the TA, or even an expert in the field respond to students is that it may encourage students to go back and read through the comments. On the other hand, students may avoid controversial points if an author or known expert will reading them. In this case, one student deleted or edited one or more comments when he realized the paper author (the guest lecturer) might read them.

Online and in-class discussion: Before the study, we saw the online discussion as a complement to the in-class discussion, leading to a more engaging classroom discussion focused on issues raised online. Each week after student reviews and comments were due, the instructor and TA read all the comments and replies. The TA also created a list of interesting issues and comments to start in-class discussion if necessary. Some students found this helpful, but others commented:*"…[it would] be more effective if there were some way to better integrate online discussion with in-class discussion,"* and *"[class time] was redundant."* Smoothly integrating the two was more challenging than we expected. In a sense, in-class and online discussion competed with one another.

Integrating online and in-class discussions was complicated by the timing of the online discussion and the differing amounts of participation in the online discussion (both posting and reading comments). Because weekly reviews were due Tuesday and replies were due Wednesday just prior to class, the time for students to read through responses was limited, a problem exacerbated by the fact that some could access the system only from home or from work. If a reply was added shortly before class it was unlikely that many students would read it. This negatively impacted the in-class discussion. A student who made a long or complicated reply on-line might not want to repeat it in class, even when asked to by the professor. As a result, interesting replies were not always picked up in class.

Differences in time commitments and interest levels led to varying student participation online, which could take a fair amount of time. Students who participated online often seemed uninterested in continuing that discussion for those who had not participated online. In one instance, following a spirited WebAnn discussion among six students, the professor tried to bring up the issue in class for further discussion. One student said there had already been a *"pretty good discussion on [the] board."* This comment, along with others like it, ended the classroom discussion on the topic. The students who had participated online saw no need to discuss the topic further.

Global and specific comments: With WebAnn it was easy to make or understand focused comments but awkward to make general notes about large sections or even long paragraphs. Conversely, EPost required considerable context to comment on a particular point. Each tool readily supported one type of comment. The ideal tool would facilitate comments at multiple levels.

Focus of Attention: Online discussion systems face a tradeoff between focusing attention on threaded comments or on the document being discussed. CoNote (Davis & Huttenlocher, 1995) places links to content in threaded discussions; CaMILE (Guzdial & Turns, 2000) places links to discussion in content. WebAnn splits the focus between comments and document. (With EPost, only comments are viewed.) In the interviews, some students noted this tradeoff and suggested that more space be devoted to comment threads. When reading the document and making comments the document might be the focus, but these students did most reading on paper. When reviewing others' comments and replying, the comments might better be the focus. In fact students could adjust the size of the frames in WebAnn, but did not discover this.

Discussion overload: When examining student participation in the online discussion we found they contributed much more during the WebAnn weeks. While this suggests that anchored discussions in WebAnn encourage students to participate more, some students remarked that the number of comments and replies was overwhelming. Clearly, this could become an even larger problem with bigger classes. EPost discussions could also be problematic with large numbers of participants. This tradeoff between encouraging student participation in online discussions and keeping online discussions a "manageable size" has also been noted by Guzdial and Turns (2000).

Convenient universal access: As other studies have found, convenient access is critically important (Hmelo et. al, 1997). We were initially concerned with making sure all students had some access to WebAnn, which runs only on Windows 2000. However, it turned out that *where* students had access was also important. With EPost, 9 of the 11 students had access both at school and home. Using WebAnn, although all students had access either at home or school, only two students had access in both places. With access in only one location, students were limited in when and where they could do their reviews and participate in the online discussion.

Improvements to WebAnn

The subjective ratings and comments suggest the majority of students had a small preference for EPost, even though they contributed more using WebAnn. Factors including access, workload, software use, and different types of discussion seem to influence students. In this section we focus on technical improvements to WebAnn, or any other online discussion system, that might address issues raised by the field study.

Access: Making access as universal as possible by supporting more operating systems and browsers would enable students to review the discussion more often from more locations, and might improve participation in making and reading comments. Adding an offline mode would also help students with slower internet connections.

A more sophisticated solution might allow comments and replies to be sent through e-mail in addition to being added as web page annotations. When students did not have access to the annotation system, they would still receive annotations in e-mail. Replying to the e-mail would add their response to the online discussion. The MRAS video annotation system found this approach successful in a number of studies (Bargeron et al., 2001).

Filtering and Notification: Several students suggested adding filtering that exists in EPost to WebAnn: author-based filtering and identifying notes and replies that are new. Mechanisms that assist in quickly finding replies to a person's comments and highlight potentially interesting discussions based on collaborative filtering, perhaps by allowing students to rate each others' posts, could further reduce discussion overhead and student workload, making it easier to keep up with the online discussion.

Although EPost can notify students of the presence of new posts, only 3 students subscribed to this for one week of the study, suggesting a need for improvement. Notifications could summarize the comments made that day, rather than just alerting a student to the fact that comments were made. This could provide a sense of the ongoing discussion and encourage checking online for the full comments. Notification messages could include clickable links to take a student directly to the online discussion (Bargeron et al., 2001). Finally, an optional feature that notifies a note's author when someone replies could encourage more back and forth discussions.

Advanced notifications features have the potential to allow students to follow the online discussion more easily. This could support easier integration of online and in-class discussions, reduce student and instructor workload, and help students deal more effectively with discussions containing a large number of comments.

Supporting General Comments: Students wanted to add comments at many different levels, from general comments about an entire paper to specific comments on a particular issue. To better support online discussions, WebAnn needs a mechanism for easily commenting on larger document units, including paragraphs, sections, and the entire paper. Softening the display of anchors in the web page, perhaps with vertical lines in the margin instead of outlining the text, might make users more willing to overlap comments. More ambitiously, mechanisms for clearly supporting comments at every level of the document could be provided, perhaps through menu items that specify "comment on this document," "comment on this section," and so forth.

Allocating Screen Space: As noted above, the interface should clearly indicate that the annotation and document frames can be resized to accommodate a focus on threaded comments or a focus on the content.

Process Changes

Along with technological improvements, careful consideration of the process of use might smooth the experience of combining online and in-class discussions.

More time for reviews: It would have benefited students to have all online discussion before the first class of the week, and to have the review and replies due earlier to provide more time before class discussion for reading and responding. Scheduling class meetings for the end of the week could also address weekend access issues.

Summarize online discussion in-class: A short summary of the online discussion at the beginning of class might help cope with the different levels of on-line participation and frame an in-class discussion that builds on the online experience. Explicitly acknowledging students who took part in the online discussion could encourage other students to participate.

Consider instructor role: The pros and cons of active instructor participation online were noted above. On the whole, if instructors join the discussion late, it can provide an incentive for students to contribute to and review discussions. If online participation were not required—and some students felt mandatory replying to others' comments was artificial—this might be essential to motivate discussion.

Adjust the number of papers discussed online or in class: Using the online discussion for addressing fewer papers in more depth rather than for all the papers would reduce the amount of work. Dividing the papers into those that are discussed only on-line and those that are dealt with only in class would also reduce workload. Alternatively, classroom time could be focused more on other activities, such as demos and discussing student projects.

Reduce the number of students participating at any one time: To combat discussion overload, reduce workload, and help integrate online and in-class discussion, the number of messages students produce or read could be reduced. Students could be asked to comment on fewer papers, or participation could be made optional for large classes. Alternatively, students could be divided up into discussion groups, and each discussion group could briefly summarize in class what was discussed online, greatly reducing the number of messages a student must read.

Reduce assignments: Another approach for reducing student and instructor workload is to limit the number of assignments the students have, or to more dramatically reduce the time that is spent in-class. The broader issue is to consider what classes are best served by the technology. Possibly classes with less reading, (that students may be more likely to do online) would better exploit the value of anchored discussions. Or perhaps discussions could revolve around assignments and projects, which might have shorter blocks of text, as in Guzdial & Turns (2000).

CONCLUSION

Online anchored discussions hold great potential for extending in-class discussion beyond the classroom door. In our study, online discussions allowed the less vocal students to contribute equally and made in-class discussions more interesting, but integrating the online and in-class discussions was challenging. Rather than serving as a starting point for in-class discussions, the online discussions often competed with the classroom discussion. Students who participated frequently online seemed uninterested in addressing the same issues in-class with the rest of the students.

Because students in this class uniformly printed and read assignments on paper, many potential advantages in annotating in context were lost. Nevertheless, WebAnn led to more discussion, while requiring the greater effort of a second pass to add comments. With improvements in technology and appropriate process modifications, anchored discussions are an exciting avenue for distributed education and a viable tool to supplement classroom instruction.

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