Instructing with Advanced Collaboration Technology:

Lessons Learned and Unexpected Transformations

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Abstract. This paper provides lessons learned and some unexpected transformations in the learning process when advanced collaboration technology was used to overcome limitations of a popular, existing collaboration technology. The activities pursued in these advanced undergraduate and graduate computer and information sciences courses replicate many of the activities in collaborative knowledge work in organizations. Therefore, the lessons learned should be applicable to transforming other kinds of joint knowledge work in general.

1 Introduction

New technology that is not adopted fails! Prospective users of new technology are experiencing "new tool fatigue" [1]. Teachers, like corporate uses of new technology, are wary of unfulfilled promises of new technology and increased burdens to learn and use the technology. Teachers need enhancements to their instructional processes that integrate "naturally" into what they do. The best technologically-based solutions entice by leveraging existing skills and knowledge in such a way that instruction improves, learners excel, and the technology presence fades, i.e., successful adoption of technology-enabled transformational instruction demands stealth! Increased capability to instruct should emerge as needed during the instructional process while the fact that the capability is technology-enabled fades, i.e., enhancements should be integrated incrementally and available on an as-needed, just-in-time basis. Awareness of transformation should only occur upon reflection of where one was and how far one has come in the employment of advanced technology to develop more successful learners.

While many feel collaborative learning to be an innovation whose time has come, problems persist [2]. This paper describes the use of advanced collaboration

technology that transformed the learning process in unexpected ways. The activities pursued in these advanced undergraduate and graduate computer and information sciences courses replicate many of the activities in collaborative knowledge work in organizations. This paper discusses the limitations of a popular, existing collaboration technology which propelled us to try something new; reviews the notion of Collaboration Envelopes™ that wrap around group processes as a way to build more cohesive architectures to fully support collaborative processes; discusses the co-development of joint artifacts; describes the new technology used; and explores lessons learned and some unexpected transformations in the learning process which should be applicable to transforming other kinds of joint knowledge-work in general.

2 Problems with Current Collaboration Technology

While there is overlap in functionality in collaboration technology, and these technologies can be used in a complementary fashion, it is useful to divide collaboration technology into three functional categories:

⇒ **Technology that overcomes the limitation of people not being in the same time at the same place** where they can meet face-to-face and can share common artifacts, such as documents. This includes real time technology such as Instant Messaging; web-, video- and tele-conferencing; and application sharing, such as Microsoft's Net Meeting. This also includes asynchronous technology such as email, email and attachments; shared folders on LANs and the WEB; and chat and threaded discussions.

⇒ **Technology that assists in the co-development of artifacts**. Specifically, technology that helps to overcome the social, cognitive, and procedural complexities in planning, creating, evaluating, negotiating, and consolidating joint artifacts.

⇒ **Technology that assists in the coordination of tasks** that can be completed independently but are interrelated to others. This includes workflow and project management technology.

Overall, current e-learning technology focuses on content delivery, as opposed to supporting students to solve more complex and open-ended tasks [3]. Most collaboration technology seems to be stuck in trying to overcome the limitation of people not being in the same place at the same time [1, 4]. Blackboard™, an electronic version of a blackboard, is a popular collaboration tool used in education that fits within this category. Blackboard™ is the typical portal-based architecture that is mostly used to store various artifacts, such as syllabi, class documents, and presentations; and has little-used add-on tools, such as chats and threaded discussions. In Blackboard™, if one wants access to a document for displaying to and updating by a class, one must typically do the following: 1) navigate to the document through a series of Web pages; 2) download it; 3) navigate to the downloaded location; 4) open it up in the application; 5) modify it; 6) save it to the file system; 7) delete it in Blackboard™; and 8) re-add it to Blackboard™. While the document is available for viewing, the document cannot be jointly edited. This

makes it all but useless in real-time and asynchronous interactions. In addition, Blackboard's functionality reinforces a prevailing notion that course documents are static. Is there something limiting in Blackboard's conceptual view of collaborative support as essentially providing a common depository for static artifacts that affects its design and usefulness [4]?

3 Collaboration Envelopes™

> Incorporating collaboration functionality in a piece-meal approach in different ways as add-ons within a portal-based architecture can place heavy demands on users to learn, organizations to train, and ultimately limit the potential of collaboration technology to achieve organizational goals [4].

There must be an intellectual break away from the notion of individual tools that incorporate collaboration functionality in a non-integrative fashion [4]. The notion of a Collaboration Envelope™ is introduced as a way to envision technology that seamlessly wraps around socio-cognitive work. For the most part, existing technologies focus on sharing data and not on supporting the sensemaking activities of participants engaged in a collaboration. Human and non-human agents may participate in multiple collaborations with different participating agents in parallel, switching among various collaborations. In some sense, an agent may even engage in a collaboration with himself. For example, during reflection on an issue, one's perspective and understanding may have changed since the last time the issue was visited. Collaboration Envelopes™ help build and maintain understanding by each member of the group. They must support the process of working within a collaboration and then shifting attention and working effectively within another collaboration.

3.1 Co-development of Work Products within a Collaboration

Joint work products that evolve as part of the sensemaking process include such things as plans, reports, budgets, specifications, architectures, contracts, designs, and software code. Collaboration Envelopes™ must support all phases [5, 6]:

- Planning. Collaborators establish the objectives, structure, and divide up parts of the shared work product to be created.
- Creation. Collaborators compose their portion of the joint work product. Although they may work alone, it is important that they are aware of what the other collaborators are doing.
- Evaluation. Collaborators review, propose changes, and add comments to each other's work.
- Negotiation. Collaborators discuss proposed changes with one another and decide on what changes should be made.
- Consolidation. The collaborators resolve conflicts and merge changes into the shared work product.

It should be stressed that these phases are normally not sequential. There is continuing cycling through these phases for different sections of the shared work product. For example, while negotiation is occurring for one part, creation could be occurring for another part. Dealing with these social, intellectual, and procedural complexities, collaborators work asynchronously and synchronously as they navigate through these phases [7]. They must establish and maintain a common understanding of the situation and solve problems such as work product structure, while adopting procedures that will enable them to get their work launched, circulate drafts, circulate comments, and incorporate changes in order to finalize the joint work product [7]. Collaborators usual work synchronously when planning, negotiating, and consolidating and asynchronously when creating and evaluating, but this could be because of inadequate asynchronous technologies to support all phases. Maintaining situational awareness of what others are doing is especially difficult yet critical to effective joint development of shared work products [8].

4 Augmenting Collaboration with SenseMaker™

SenseMaker™ integrates the following collaborative functionality into existing work processes and products. The current enhancement is to Word, but could be extended to all of Office and many other Windows-based products:

1) **Word processor:** The most common word processor is Microsoft Word and exists on over 90% of client computers. MS Word users possess extensive semantic and syntactic knowledge of Word.
2) **Subdivision of work-products.** Word documents can be dynamically subdivided into hierarchical subsets as small as one character while the system automatically maintains a perfectly formatted, complete higher subset or full work product. This avoids consolidation errors, time, and tedium.
3) **Work on Subsets.** Subsets can be opened separately or as part of a document and the full features of Word is available to work on the subsets. Benefits:
   a) True parallel development. All the augmentation facilitation described in this section works equally well on a subset as the whole work product.
   b) Bandwidth - can download a fraction of the document. Especially important to mobile users
   c) Display limits - some displays would be overwhelmed with a full large document, but could handle a few words or a sentence.
   d) Input limits - there may be limited input devices that make it difficult to deal with large documents.
4) **Control.** Each subset can be controlled by a single user.
5) **Security.** There can be different levels of security on each subset - controls viewing, writing, downloading sections etc.
6) **Asynchronous/Synchronous.** Work can be conducted by any number of users synchronously or asynchronously.
7) **Online/Offline.** When possible, it is beneficial for work to proceed when not connected to any active server. Work can be performed online or offline and then synchronized automatically with others who work online or offline.

8) **Undo.** For use during current editing, there is use of extensive, existing Word features.
9) **Versioning.** Versioning can occur for any document or subset and is separate from any document or subset. Extends undo to states between sessions.
10) **Compare operations.** Can be done between any previous and current version.
11) **Suggesting Alternatives.** Use mostly when artifacts or subdivisions of artifacts are not under one's control, one can suggest an alternative of any subset of the artifact.
12) **Argumentation Facilitation/Rationale Building using DrillDowns.** Dynamic labeling of conversations, arguments, or supporting material that can be associated with any subset and exists separately from any subset.
13) **Notification - Situation Awareness.** Notification of changes to any aspect of the joint work-product development process, including subsets, alternatives, drilldowns, etc.
14) **Cognitive Support to Quickly Achieve Work-Product State for Each Collaborator.** For each collaborator, knowing what has changed since the last time a collaborator evaluated the joint work-product.
15) **Recording Awareness.** Recording when users become aware of changes.
16) **Management Reports.** Providing reports as needed to understand what work has been accomplished, by whom, and when others become aware of such work.
17) **Generalized Ability to Construct and Maintain Relationships among Files.** Currently files of work products are stored and relationships implied by users in the way they may be stored. Providing a general means to store files and relationships can provide powerful augmentation of file management.

5 Transformations to Instruction and Learning

One class is a senior-level, two-semester undergraduate course where groups of students create real information systems for real-world clients; the other class is a graduate course in human usability design. Much of the instruction focuses on experiential learning and deals with the co-development of information system artifacts for a given problem scenario over the course of the semester. Students are then tested in skill-based practical exams and teams apply these skills to design and develop real-world systems. This section describes the evolution of a better understanding of the process of co-development of joint artifacts and the unexpected transformations in the learning process that occurred as a result of using SenseMaker™.

5.1 Assessing Progress and Individual Contributions

SenseMaker™ enhances co-development of project submissions and facilitates assessing progress and individual contributions. When first advocated in the literature, collaborative learning focused on group participation to enhance learning. Assessment of learning was always done at the individual level. The group exercises were relatively simple, many times accomplished within a single class, and the outcome of the group was not assessed. However, the value of groups manifests in

difficult, novel, complex projects. Students must learn to work in groups on such projects and are graded on the joint outcome of the effort. Universally, instructors who employ demanding group projects find assessment of group progress and individual contributions within the projects difficult. SenseMaker™ can help mitigate these assessment issues. For example, one student questioned her grade for her contribution to the group effort, which was partially determined by peer evaluations. In SenseMaker™ we reviewed her contributions by dynamically comparing her versions with changes performed by other members. It was clear that group effort was under-reported. While reviewing this student's contribution, the technology was applied to another student's contributions who also received poor peer evaluations. It became clear this other student's contribution within the project team was greater than initially evaluated based on peer evaluations and the instructor's perceived effort. It may be that this student's peer evaluation was not very good because he is exceptionally quiet. Based on this analysis within SenseMaker™, this other student, who did not question his grade, also had his grade changed.

5.2 Transition between Asynchronous and Synchronous Interactions within Class

For the most part, the common notion of class is that an instructor interacts synchronously with his or her students. It has become common practice to have the class breakout into project teams and work on samples of the problem in class. At this time they are now working synchronously within the team but asynchronously with respect to other project teams and the instructor. In one class, where students did not have direct access to computers, they added their solution to SenseMaker™ sequentially with the help of the instructor. In the graduate class, students were able to use SenseMaker™ directly during class to post their answers to the problem. Once posted, project teams presented solutions to the entire class synchronously. This reinforces the notion that classroom experience is a continual transition between synchronous interaction among all class participants, and asynchronous interactions among groups that work together until there is a need to share again synchronously with other groups in the class.

5.3 Peer Learning and Transition between Asynchronous and Synchronous Interactions between Class

This is similar to within a class, but more pronounced. A major problem in following a problem in-class throughout the semester is the problem of providing some way for the groups to continue to work on the problem between classes and then pick-up with some progression in the next class – one can't easily save what each group has done on the board or project what one's solution is to the problem.

> "Having the capability to use SenseMaker™ during class was very useful. Basically it saved some work for the students from writing down the notes and everybody had the capability to view the notes at any time and print them

out. It was a useful tool in the class, because everybody can participate in the class and (it) created an environment where everybody was helping out each other with understanding the concepts of the material being discussed in class [Anonymous]."

Several features of SenseMaker™ were invaluable to this process:

⇒ Subdividing. Artifacts could be subdivided and then assigned to teams to work on in parallel with other subdivisions by other team members. This permitted teams to work on their section and also see how other teams were progressing in their solutions. This also permitted progress on the solution as a whole.

⇒ Suggesting Alternatives. When class convened for the next section, some group's solution would be displayed to the class. As a class we could review the solution. However, instead of making changes directly to the solution, using SenseMaker™ an alternative can be suggested. This means a copy is made and linked to the original solution. Then, as a class, we could work on the alternative together and save it. Students have available the original result of their thought processes and the corrected version. In this manner, the differences of their understanding and the solution are always available for review.

This process meant almost the complete elimination of the use of the whiteboard in class and Blackboard™ in general. All work was created and available for use by the class. Since exams were practical exams to demonstrate learned skills; some students either downloaded the joint artifacts to their own notebooks for use during the exam, while others made hard copies. In the future, we intend to provide wireless access to SenseMaker™ artifacts during classes, including exams.

5.4 Co-development of Joint Artifacts

The enhanced features of SenseMaker™ provided "controlled" co-development of project submissions required of each team. Project teams could subdivide submission documents and work in parallel.

> "Now, I believe SenseMaker™ is useful especially when working in groups. Because everybody can save their own work on SenseMaker™ and everybody can view each member's work without making any changes to it, unless the creator of the section wants to give permission for other users to change the context of the section. Also, it allows you to keep track of who is contributing to the project and who is not [Anonymous]."

Without resorting to technology that has problems with firewalls when sharing applications, such as Microsoft's Netmeeting, SenseMaker™ provided the functionality of secure application sharing without firewall problems while still co-developing in parallel:

> "It was useful especially when we were completing the last submission. Since it was due at 6:00 in the morning, SenseMaker™ was helpful, because we all talked on the phone while doing the submission and one person was responsible for typing up what other members were saying and the best part was all the members could view the changes and tell the person typing for any changes, so it was like capability to have shared views and live changes when the changes were saved. It made the process organized

and went smooth and without this feature we would have not completed the submission on time or be organized [Anonymous]."

5.5 Joint Evaluation

There were a larger number of project teams than usual and evaluation was more time consuming. Because SenseMaker™ permits parallel evaluation also, the teaching assistant was assigned to review submissions for certain aspects, such as correct format of the technique and grammar, while the instructor focused on more critical, time-consuming feedback. In one situation, the TA highlighted a portion of a submission and made a comment for the group. Although not expected because the evaluation and grading was not completed, a student in the group provided feedback to the TA. The instructor was then able to confirm the answer of the student. At first, what occurred was unexpected, then encouraged. In situations where the artifacts are created based on some interpretation, the feedback of the creator may be critical in understanding the thought processes. This began to be repeated and it was clear that in these situations evaluation should be done jointly. The added benefit of this process is that students can "see" the evaluation in progress. It may provide some psychological comfort similar to the "status bar" when downloading some large file. In this case, instead of a black hole until the graded submission is returned, the student can see the evaluation in progress and even provide feedback to assist in the evaluation.

5.6 Virtual Nods™ (Vnods™)

An assumption behind most collaboration technologies is that face-to-face is the best medium and one must use technology to overcome the limitation of not being able to collaborate in person [9]. However, there is growing evidence that face-to-face interaction may not always be best [10, 11, 12]. Asynchronous work may be superior to face-to-face in complex problems, while face-to-face may provide superior motivational cues for participants to pay attention [10, 12]. In a face-to-face interaction, non-verbal cues such as nodding provides this feedback on a continual basis as ideas are expressed. In an effort to incorporate motivational characteristics of face-to-face interactions within asynchronous interactions, SenseMaker™ records the date and time a participant visited some content. Since content can be subdivided into units as small as necessary to express unique ideas, SenseMaker™ can record the date and time a participant visited some sub-division of content related to an atomic, unique idea. This is important, because there can be many separate ideas expressed in a document, such as a syllabus, which is described in more detail in the following section. Initially, there was some resistance to this feature because it could be perceived as "big brother" watching; however, when it was reframed as a "virtual nod" and a way to improve interaction asynchronously it has gained acceptance.

In addition to the motivational benefit of Virtual Nods™(Vnods™) within SenseMaker™ helps to controls interaction feedback in a number of ways: First, it eliminates countless numbers of emails that would be needed to incorporate virtual

nods on ideas or comments; Second, the instructor "pulls" the information when needed by easily reviewing who in the project/class has visited some content; Third, there is functionality within SenseMaker™ for the instructor to easily "push (send email)" to request a Vnod™ from the whole group or from the subset who has not yet vnodded on something. Vnods™ have been invaluable in providing motivation and focused feedback usually available within face-to-face interactions, but less available within asynchronous interactions.

5.7 Rethinking what is Static and Dynamic

With current web technology that provides the ability to post, there is an implicit assumption that the posted documents are static. For example, prior to using SenseMaker™, a syllabus seemed like a static document that was distributed or posted. However, the syllabus is far from static. The schedule can change. Students can have questions as to what is meant by some aspect of the syllabus. There could be errors in the original syllabus. Using SenseMaker™, the syllabus was subdivided into major subsections and these further subdivided as necessary. When a change was made to a section, only that section was updated. In the usual process, the complete syllabus would be deleted from the website, modified, and then reposted. In lengthy syllabi, it is unlikely that the student will take the effort to see the change; and without Vnods™, there would be no way to ensure whether the student is aware of the change. In another example, a student posted a question by attaching the question to a particular section. The response was made by the instructor and the section modified. Other students could see the question, the response, and the modification. Through the use of Vnods™, the instructor can see who saw the question, the response, and the modification. Finally, one can make questions that students have about the syllabus a positive experience. For example, students, who question the clarity of some wording in the syllabus, are encouraged to use SenseMaker™ to suggest alternative wording. This provides an opportunity to provide feedback to improve the syllabus and students gain practice in writing in a more clear style. Those students who provide such feedback can be awarded with extra credit.

6 Summary

Incorporating collaboration functionality in a piece-meal approach as add-ons within a portal-based architecture can limit the potential of collaboration technology to transform joint work processes. This paper discussed the limitations of a popular, existing collaboration technology which propelled the trial of more advanced collaboration technology. It reviewed the notion of Collaboration Envelopes™ that wrap around group processes to build more cohesive architectures to fully support collaborative processes. The co-development of joint artifacts was discussed and SenseMaker™ functionality was presented. A number of unexpected instructional transformations were discussed, such as the rethinking of static, joint evaluation, increased peer learning, and support for the transition of work between classes.

7 Acknowledgements

SenseMaker™, Collaboration Envelope™, Virtual Nods™, and Vnod™ are trademarks of SenseMaking Technologies Corp. Blackboard™ is a trademark of Blackboard Corp. Dr. Nosek is president of SenseMaking Technologies Corp.

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