

2009

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Recommended Citation

Meservy, Thomas O.; Helquist, Joel; Deokar, Amit; and Kruse, John, "Enhancing E-learning using Artifact-Based Collaboration" (2009). *AMCIS 2009 Proceedings*. 774.

<http://aisel.aisnet.org/amcis2009/774>

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Enhancing E-learning using Artifact-Based Collaboration

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ABSTRACT

Given the increased focus on e-learning, educators are interested in finding new ways to incorporate techniques that foster active learning. To leverage the asynchronous nature of e-learning settings and provide collaborative learning opportunities for participants that go beyond mere information exchange, this paper proposes an integrated model of collaboration and e-learning. This approach ties together two research streams, namely the distributed e-learning environment research and the information systems collaboration research. Further, descriptive categories of collaboration approaches are presented: solution-based collaboration and artifact-based collaboration. An artifact-based collaborative e-learning tool is developed and discussed with the aim to improve the collaborative, e-learning process.

Keywords

Collaboration, e-learning, community of inquiry, cognitive presence, and social presence

INTRODUCTION

Technology-supported collaboration has been studied in the information systems field for decades with numerous articles hitting well-respected journals in the field. In fact, a recent analysis of top research publications suggested that collaboration-oriented research emerges as one top research topics in the information systems discipline (Sidorova, Evangelopoulos, Valacich and Ramakrishnan, 2008). Much of the information systems collaboration literature has focused on facilitated, synchronous, face-to-face (FTF) environments (Fjermestad and Hiltz, 1998), with success often based on satisfaction with the collaborative process or the outcome of the collaborative effort (Reinig, 2003). In spite of the significant amount of research in the area, this form of collaboration has never achieved widespread implementation in the day-to-day activities of many organizations (Briggs, de Vreede and Nunamaker Jr., 2003).

The emergence of recent web 2.0 technologies has promoted a grass roots collaboration effort that has filtered into many organizations. This form of collaboration looks very different from the collaboration efforts of the past. Many of these collaborative efforts are asynchronous, distributed, and the facilitator (if there is one) plays a more subdued role. Over the last couple decades, multiple technologies (such as discussion groups, forums, instant messaging, and wikis) have emerged and have been adopted at organizations in order to share a wide variety of information between individuals and groups. While many consider these "collaboration" technologies, often these tools are simply used to share information.

The term collaboration is thrown around loosely in most casual conversations. However, it can be more precisely decomposed into four levels that build on each other: 1) information sharing, 2) coordination, 3) cooperation, and 4) collaboration (Denning and Yaholkovsky, 2008). Most of the "collaborative" technologies that have recently emerged primarily support the lower levels of collaboration (i.e., information sharing and coordination). A truly collaborative solution allows for synergistic or concerted efforts by participants. Technologies that support this highest level of collaboration create

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and support “a process through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible” (Gray, 1989). Thus, in our view, information systems collaboration refers to the appropriation of technology to create and support the flow of information between group members (e.g., defining objectives, sharing perspectives, contributing ideas, evaluating ideas) to enable groups to achieve shared goals (e.g., finding solutions to problems).

Most of the collaborative technologies that are being widely adopted by the masses are not structured in a way to support this highest level of collaboration. Moreover, the lessons from the information systems collaboration literature do not necessarily directly translate to these new technologies. However, insights may be drawn from the e-learning literature in which participants use technologies to support distributed, asynchronous learning with minimal input from a facilitator/moderator (i.e., the instructor).

The asynchronous nature of e-learning provides students with additional time to reflect, compose, and present discourse to fellow students compared to face-to-face learning environments. The e-learning environment provides the participants with more time to analyze a given situation, enabling broader discussion of the issues being discussed (Benbunan-Fich, Hiltz and Turoff, 2003; Gupta and Bostrom, 2004). Thus, online learning fosters both improved reflection and discourse which are two key components of meaningful education (Garrison, 2006).

Researchers often describe these e-learning activities as collaborative learning. However, these activities are primarily information exchange activities, where students simply share information. As suggested earlier, collaboration implies a higher level of interactivity and independence between the participants. We propose that by providing enhanced technological support for collaboration in e-learning, participants will be more engaged, leading to an improved learning experience.

This paper discusses collaboration from the perspective of the distributed, collaborative learning literature and the information systems collaboration literature. The paper also introduces descriptive categories that are useful in characterizing existing collaborative approaches: artifact-based collaboration and solution-based collaboration. An integrated model of collaboration and e-learning is presented and propositions are discussed. In order to further understand artifact-based collaboration, a collaborative system for e-learning has been developed in order to assess the system's impact on collaboration and e-learning success.

DISTRIBUTED, COLLABORATIVE LEARNING

A central premise of e-learning is that learners who are actively involved in the learning process gain greater knowledge than if they would have received this information passively. Those who passively receive the information. Active learning activities include activities such as small group discussions or debates; these activities provide the students with an opportunity to actively participate and cognitively process the material (Bonwell and Eison, 1991).

Active learning aligns itself with the constructivism learning epistemology. Constructivism is a learner-centric model whereby the students create knowledge from their own experiences. In this approach, learners build new knowledge through interactions and negotiations, building on prior knowledge and making learning relevant (Bonk and Wisner, 2000). Collaborative learning tools aid the participants in creating this knowledge by enabling interaction and discourse with peers and instructors (Weasenforth, Biesenbach-Lucas and Meloni, 2002). In this manner, “[l]earning will be seen as more socially shared, active, and interactive than in the past” (Bonk and Wisner, 2000).

One such mechanism for enabling active learning in a distributed, e-learning context is the traditional discussion forum. In this scenario, the instructor provides an article or subject matter for the students to discuss. The forum is then used for the students and the instructor to debate and discuss the topic. This type of asynchronous, distributed learning has been shown to enable higher order thinking (Meyer, 2003). These online discussions often form the basis of a learning community that fosters critical thought and promotes active learning.

The community of inquiry model has been presented as one way to characterize and investigate the online educational experience (Garrison, Anderson and Archer, 1999). This model posits that there are three requisite components of an educational experience that are shared by the students and the instructor: social, cognitive, and teaching presence. It is the interaction of these three elements that creates an effective learning environment (Garrison et al., 1999; Gilroy, 2001).

Cognitive presence is arguably the most important of the three as it is the most fundamental to educational success. Garrison defines this term as the students being able “to construct meaning through sustained communication” (Garrison et al., 1999). Cognitive presence refers to the inquiry and dialogue that accompany the learning process. In a learning community, students are able to ask questions, provide insights, and resolve unknown or unclear concepts as part of the learning process.

Social presence allows the students to project their own personal characteristics in the community. This dimension provides support for the cognitive presences by enabling group cohesion. Social presence impacts the motivation of the students to actively participate in the e-learning community.

The last element in the community of inquiry model is teaching presence. This presence encompasses two main objectives. First, the subject matter and content to be discussed must be selected. Second, the discussion must be facilitated. Like social presence, teaching presence is a supportive mechanism that facilitates the cognitive processes involved with learning (Garrison et al., 1999).

These three elements are present during the community of inquiry activities. Garrison (2001) identified the generic phases that the community and students use in the learning process. First, the triggering event provides the impetus for the collaborative learning exercise. In education, the triggering event may be the instructor providing a task, project, or assignment. Second, the community explores the topic, thinking through the assignment and the subject matter. In this phase, the community diverges and generates different insights or ideas. Third, the community begins to synthesize and integrate the discourse that has been created. In this phase, the community identifies trends and relationships, converging on common threads or ideas. The final phase, resolution, entails arriving at some level of consensus or finished product. This phase may not be applicable in all e-learning scenarios.

As noted by Garrison (2001), these phases involve varying levels of private, personal reflection and public interaction. The students are able to cognitively process the information privately then share insights or new information. The process is repeated as the students process ideas or discourse from their peers. Participation in a community of inquiry e-learning activity requires the students to become more involved and actively participate in the process. The students must adapt and assume more responsibility over the learning process and increase their effort accordingly; this adaptation phenomenon has been called role adjustment (Garrison, Cleveland-Innes and Fung, 2004).

Moving to an online, asynchronous learning environment requires the student to adjust to the roles of an online learner. Specifically, the student must adapt to new environments and personal requirements. These adjustments include such things as acquiring the knowledge and skills about using the technology. Similarly, the student must increase the levels of self-direction and motivation (Garrison et al., 2004).

TECHNOLOGY-SUPPORTED COLLABORATION

Knowledge of how participants engage in collaborative tasks enables development of tools to support these sociocognitive processes. Briggs, de Vreede, and Nunamaker, Jr. (2003) characterize five basic patterns of collaboration: Diverge, Converge, Organize, Evaluate, and Build Consensus. Kolfshoten and de Vreede (2007) additionally propose Clarify as another pattern, resulting in six foundational patterns of collaboration. These patterns of collaboration constitute broad categories that encompass detailed collaborative activities (Briggs, de Vreede, Nunamaker Jr. and Tobey, 2001; de Vreede and Briggs, 2001). These patterns operate at the overall collaboration process level in which the facilitator engages all the participants simultaneously in activities that elicit one collaborative pattern after another (Briggs et al., 2003).

When considered within the collaborative e-learning context, these patterns can be generally mapped to the four phases of Garrison et al.'s (2001) community of inquiry model, as illustrated in Table 1. The mapping reflects that, in an e-learning environment, the patterns do not occur at the overall process level as originally proposed. Instead, participants themselves play the role of the facilitator; participants have the flexibility to move back and forth between different patterns. For example, participants may post messages offering new ideas in an exploratory manner (diverge), or refer a previous message to discuss the contextual meaning (clarify), or synthesize previous messages in a succinct manner (reduce).

Table 1. Mapping Between Phases of Critical Thinking and Patterns of Collaboration

Phases of Critical Thinking (Garrison, 2001)	Indicators of Phases of Critical Thinking (Garrison, 2001)	Patterns of Collaboration (Briggs et al., 2003; Kolfshoten et al., 2007)
Triggering	Recognizing the problem	NA
	Sense of puzzlement	
Exploration	Divergence within online community	Diverge: Move from having fewer to having more concepts in the pool of concepts shared by the group
	Divergence within single message	
	Information exchange	Clarify: Move from having less to having

Integration	Suggestions for consideration	more shared understanding of concepts and of the words and phrases used to express them.
	Brainstorming	
	Leaps to conclusions	
	Convergence among group members	
	Convergence within a single message	
Resolution	Connecting ideas, synthesis	Reduce: Move from having many concepts to a focus on fewer concepts that the group deems worthy of further attention
	Creating solutions	Organize: Move from less to more understanding of the relationships among concepts the group is considering
	Vicarious application to real world	Evaluate: Move from less to more understanding of the relative value of the concepts under consideration
	Testing solutions	Build Consensus: Move from having fewer to having more group members who are willing to commit to a proposal
	Defending solutions	

Typical e-learning environments provide discussion forums that allow the students to discuss the assigned topic and exchange relevant ideas and insights. The forums provide an easy mechanism for the students to engage in critical analysis of the subject matter. However, these forums do not provide a high level of interactivity or promote an increased level of collaboration. These deficiencies may hinder the students from realizing the full potential of the collaborative e-learning exercise. Additional collaborative tools and functionality are needed to further engage the students, improving the level of collaborative involvement and learning. Thus, integrated tool support for different phases of critical thinking (Garrison et al., 2001) and different patterns of collaboration is required.

CATEGORIZING COLLABORATIVE APPROACHES AND TECHNOLOGIES

Collaborative approaches and technologies can be divided into categories based on the overall objective of the collaborative effort. We coin terms for two broad categories that can be used to describe most collaborative approaches/systems: artifact-based collaboration and solution-based collaboration. Previous research has also suggested that collaboration approaches can be categorized by task type (e.g., problem, decision) (Zigurs and Buckland, 1998). Each task type may require a different level of technological support for communication, process structuring, and information processing. The categories that we present here, while there are similarities, are broader than previously suggested categories. Additionally, we believe that these categories better describe many of the "grass roots" collaborative efforts that have recently emerged.

Solution-based collaborative systems describe the class of collaborative approaches and systems that engage in a collaborative effort with the objective of finding a solution (or gathering of information that will support in discovering a solution) to a suggested problem or issue. This paradigm might also be described as problem- or issue-based collaboration. Typically, technology to support this paradigm emerges in the form of a complete, separate system where users meet proximally to participate in the collaborative exercise. Most traditional group-support systems fall under this category. Some of these systems, perhaps because they have origins in the FTF environment, still employ a synchronous, moderated environment. Recently, however, several large-group, distributed systems have emerged which utilize semi-structured activities and individual contributions to moderate the interactions of the group. One well-known example of such a system is Google Moderator. In this example, users can contribute ideas/suggestions/answers to a particular problem or idea and then they can further evaluate previously submitted ideas in an effort to find a solution to a given problem.

Artifact-based collaborative systems refer to those approaches and systems where the collaborative effort is based around a central artifact. Technology supporting this paradigm often emerges in the form of support for individual collaborative activities (e.g., submitting ideas, evaluating ideas, categorizing ideas using tags) that are situated relatively close to the artifact. A common example of this type of collaborative system is comment sections underneath news articles or blogs. In this paradigm, the collaborative effort is centered around the artifact which is presented proximally to it. This concept of artifact-based collaboration, though not called that, is common in e-learning environments where students read articles and then discuss what they have just read. It is important to note that these categories are not necessarily mutually exclusive. However, most approaches or systems primarily fit in one paradigm or the other.

INTEGRATED COLLABORATION E-LEARNING MODEL

To examine the relationship between collaboration features and collaborative success, we propose a model that bridges the e-learning literature and the information systems collaboration literature. A premise of past research is that collaborative features (often incorporated into a collaborative tool), if used appropriately, will lead to collaborative success.

As introduced earlier in this paper, the community of inquiry model identifies three core constructs relating to e-learning: social, cognitive, and teaching presence. As previously outlined, these constructs encapsulate the critical components of an online, distributed environment. We posit that these constructs mediate the relationship between collaborative features and success factors (see Figure 1). This section discusses key propositions based on the presented model.

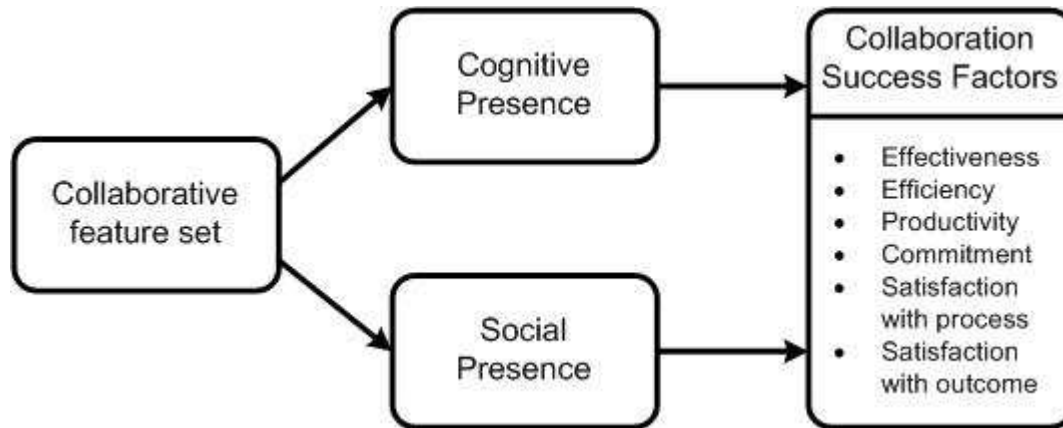


Figure 1. Integrated Collaboration E-learning Model

We posit that the inclusion of the additional collaborative tools enhances the e-learning environment by further supporting discourse and integration of ideas. For instance, the students might be able to more easily evaluate, tag, filter, and identify the discourse that is relevant during the learning exercise. This enhancement in supporting discourse is posited to lead to an increased sense of community and ultimately improved ratings of social presence.

Proposition 1: An enhanced collaborative feature set positively impacts social presence.

An enhanced collaborative feature set, such as the ability to rate, tag, and filter discourse, also impacts perceptions of cognitive presence. Overlapping the teaching and cognitive presences is the requirement that the collaborative environment enables the participants to identify and select content. With the collaborative tools, students are able to focus attention on comments or discourse that is worthy of further consideration. The collaborative tools provide important metadata that improves the synthesis and integration of the discourse. By improving the filtering and selection of important content, the collaborative tools enhance the cognitive presence by focusing attention on specific discourse that is highly rated.

Additionally, use of the collaborative tools encourages the students to remain active in the learning process. The collaborative activities promote critical analysis of existing discourse, improving comprehension and synthesis.

Proposition 2: An enhanced collaborative feature set positively impacts cognitive presence.

The final area of investigation examines the relationship between social and cognitive presence with collaborative success factors. Social presence was found to be positively correlated with students' perceptions of perceived learning and satisfaction with the instructor (Richardson and Swan, 2003). Similar research found a positive correlation between students' ratings of perceived social presence and satisfaction with the discussions (Swan and Shih, 2005). The Swan study also showed a strong correlation between social presence and students' perceptions of perceived learning.

Collaboration success factors have been extensively studied in information systems collaboration literature. We propose that success factors are much richer than just satisfaction with the instructor or the learning. Success of a collaborative effort such as collaborative e-learning may be assessed from multiple dimensions. Duivenvoorde et al.(2009) recently reported on synthesizing outcomes described in several collaboration research studies to propose following key dimensions for measuring successful collaboration from a participant perspective: effectiveness, efficiency, productivity, commitment, satisfaction with process and outcome.

Group effectiveness is the extent to which the resultant collaborative outcome meets the intended goal or outcome. Participants' expectations and the value attributed to collaborative effort are likely to drive their perceptions of effectiveness. It is useful to thus measure intended results as well as expected results (Duivenvoorde et al., 2009).

Group efficiency, from a participant's perspective, is the extent to which the resultant net usage of resources meets the expected expense of resources. Resources could be in any form such as time, effort, attention, knowledge, and even physical resources such as money or infrastructure facilities (Duivenvoorde et al., 2009).

Group productivity measures participants' perceptions of the extent to which the expense of resources are commensurate with the quality of results derived from the effort. This balance between time and effort expended and the quality of results is an important success factor, distinct from group efficiency and effectiveness (Duivenvoorde et al., 2009).

Commitment of resources to the group goal is the willingness of the participants to expend resources such as time and effort to achieve group goal (Meyer and Herscovitch, 2001). It also considers the motivation to participate as well as the extent to which participants have a stake in the collaborative goal and their perceived importance of the collaborative effort (Duivenvoorde et al., 2009).

Participant satisfaction can be measured with respect to the collaborative process as well as the outcome of the process (Duivenvoorde et al., 2009). Emotional satisfaction is implied here, which is a manifestation of a response resulting from a perceived shift in yield with regards to personal goals (Briggs, Reinig and de Vreede, 2008). A related notion is that of judgmental satisfaction which results from an individual cost-benefit analysis of expending resources with respect to the results and is measured through perceptions of group productivity, effectiveness, and efficiency (Duivenvoorde et al., 2009). An interesting finding reported is that participants reporting higher values of satisfaction with the collaborative outcome have a tendency to report higher values of satisfaction with the process (Reinig, 2003).

Indicators of social presence include such things as asking questions and sustaining discussion. Indicators of cognitive presence includes other items such things as identifying key issues, synthesizing ideas, resolving problems, and so forth also lead to collaboration success. In combination, these indicators lead to collaboration success that results in factors such as effectiveness, and efficiency.

Proposition 3: Social presence positively impacts collaboration success.

Proposition 4: Cognitive presence positively impacts collaboration success.

COLLABORATIVE TOOL TO SUPPORT E-LEARNING

The balance of this article investigates an artifact-based collaborative system that was created for an e-learning environment. This collaborative tool can be used to improve distributed, asynchronous collaborative learning by improving the sharing of ideas and comments related to a specific article or topic. The improvements in the tool are predicted to improve the community of inquiry by improving the ratings of social and cognitive presence. These improvements will be manifest in the ability of the community to explore and integrate ideas.

Collaborative learning tools should include the requisite functionality to adequately support the sharing of information and interaction among students. Overlapping the social and cognitive presence constructs in the community of inquiry model is the requirement that the learning environment should support discourse (Garrison et al., 2004). The tool should foster an environment that encourages and promotes more and higher quality discourse. Further, the tool must be designed in such a way that participants are able to easily access the information. Similarly, measures must be in place to guard against information overload. These measures may include searching and filtering mechanisms that enable the participants to more easily search and manage the information that is presented (Good, Schafer, Konstan, Borchers, Sarwar, Herlocker and Riedl, 1999; McLaughlin and Herlocker, 2004).

The design of the tool and the ability to navigate through the information plays an important role in the motivation of the participants to stay involved in the learning exercise (Taran, 2005). Some research has been conducted to start examining the impact of collaborative tool features on participant involvement. In one paper by Tiwana and Bush (2000), the development of a collaborative tool is discussed. A collaborative tool is proposed that provides each of the participants with feedback regarding his or her own level of participation versus that of the rest of the group. By providing this feedback on ranking and performance, the authors are attempting to improve the motivation and involvement of the participants.

As part of this research, a web-based system was designed to examine artifact-based collaboration. Major portions of the system were divided into separate web pages which were arranged as "tabs" at the top of the page. In this way, users could

easily switch between understanding what they were asked to do (instructions), viewing the article, carrying on an interactive discussion, and viewing how others perceived their contributions (rankings), see Figure 2.

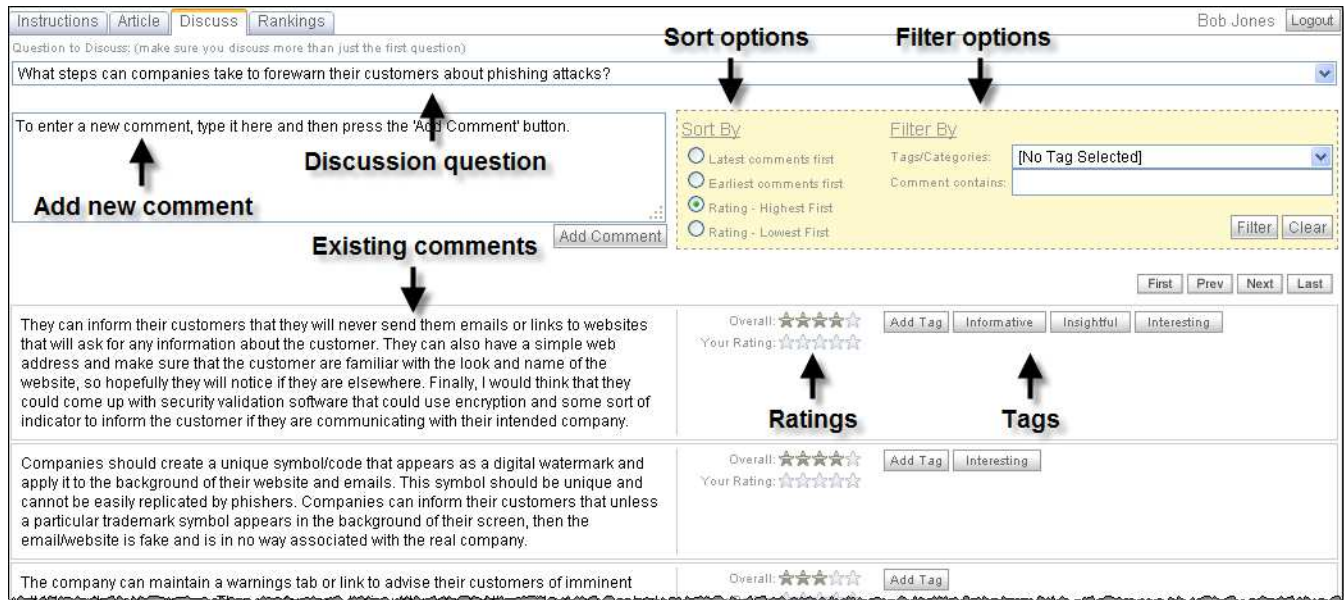


Figure 2. An annotated snapshot of the main discussion page

E-learning tools provide varying levels of technological support for the different phases of critical thinking. For example, most provide support for the exploration phase by allowing participants to enter comments. However, many tools lack adequate features to help users during the integration and resolution phases. This collaborative system introduces several features to enhance the integration phase. Table 2 captures the mapping of tool features to the phases of critical thinking.

Table 2. Tool feature mapping to phases of critical thinking

Phases of Critical Thinking (Garrison, 2001)	Tool Feature
Triggering Event	Discussion questions at the top of the page
Exploration	Ability to add comments
Integration	Ability to add personal ratings
	Ability to view overall ratings
	Categorization of comments using tags
	Ability to sort comments by ratings
	Filtering using tags/keywords
Resolution	Minimal (ability to add additional comments)

The "article tab" presents an artifact to the user. Any web-based content (e.g., html pages, pdf files, audio/video) can be presented as an artifact to discuss. The "discuss tab" is the portion of the system where collaboration occurs (see Figure 2). Multiple, pre-specified discussion questions are located at the top of the discussion page. These questions are used to focus the discussion and act as the triggering event. Exploration of new ideas, including brainstorming, suggestions for consideration, and other general information exchange is accomplished by allowing users to enter new comments. Additionally, users can view all previously submitted comments. The "rankings tab" displays the relative contribution of each individual in the collaborative effort based on not only the perceived quality of contribution, but also the quantity of comments submitted.

One of the greatest challenges in collaborative engagements, and in e-learning in general, is appropriately handling the glut of information that is produced from the exploration phase. Not all comments/ideas are equally informative or useful. Mechanisms must be provided that allow for the promotion and integration of good ideas and the reduction of irrelevant or low-quality content. Integration is supported by allowing users to personally rate each comment and also view the overall average rating (all users) for each comment. These ratings provide a mechanism to gauge the overall contribution/quality of the comment. Users can also individually categorize the comments using pre-specified or custom tags. This extra collaborative functionality provides the participants the ability to perform additional analysis that results in useful metadata for each of the comments, encouraging the participants to more critically evaluate each of the comments stay engaged in the learning activity. Additionally, sorting and filtering mechanisms were implemented in the tool to allow users to focus on just the content that best matched criteria of interest. The end result of tagging is an enhanced ability to filter comments to more easily locate specific comments or ideas. All of these features promote an enhanced integration of ideas.

During the resolution phase of critical thinking, learners test and defend solutions. Minimal support exists in e-learning tools for the resolution phase and unfortunately this tool is no exception. While not the focus of our current efforts, the tool only provides minimal support by allowing students to defend solutions by contributing additional comments and clarifications.

One other notable feature of the artifact-based collaborative tool is a ranked list of contributors. The ranking list was implemented with the assumption that it would provide enhanced motivation to contribute and evaluate ideas, and subsequently return to collaborate. Figure 3 displays a snapshot of user rankings. The number of ideas that each user has contributed is listed along with the average rating (by others) of those ideas. Individuals are ranked using a metric called quality points which is calculated using both the quantity and quality of contributed ideas.

Ranking	Name	Quality Points	Average Idea Rating	Number of Ideas
1	djjohnson9758	8	3	4
2	wdtucker	6.92	3.31	3
3	vkstacks	6.74	2.68	4
4	gjjg	6.18	4.09	2
5	chakaran	6	2.5	4
6	System Librarian	4.31	2.08	4

Figure 3. Sample individual ranking overview

In order to begin testing the ideas put forth in this paper, a pilot study involving this tool is currently underway utilizing students at two U.S. universities. The task requires participants to read a short article on an Internet security issue and then engage in online discussions with other subjects. The discussion is seeded with specific questions intended to encourage collaborative discourse and active learning.

Initial feedback from participants suggests that students believe the tool has potential:

- “I think with more research and development, this online learning and collaboration system can be a good tool for online learning.”
- “I like the opportunity to express our opinion and what we think...”
- “I thought it was a very interesting discussion and most people participated effectively.”

CONCLUSION

This paper discusses collaboration from the perspective of the distributed, collaborative learning literature and the information systems collaboration literature. The paper also introduces descriptive categories that are useful in characterizing existing collaborative approaches: artifact-based collaboration and solution-based collaboration. In order to further understand artifact-based collaboration, a collaborative system for e-learning was developed in order to assess the system's impact on collaboration and e-learning success.

The contributions of this paper include: 1) mapping of the collaboration and e-learning literature (in general) and more specifically, a mapping of the community of inquiry model with patterns of collaboration; 2) an integrated collaborative e-

learning model that utilizes the community of inquiry constructs from the e-learning literature, as well as collaboration success factors from the information systems collaboration literature; 3) characterization of collaborative approaches/systems—namely, artifact-based and solution-based collaborative systems; 4) the introduction of an artifact-based collaboration system for use in e-learning.

These contributions are expected to benefit both the e-learning and collaboration communities. Specific recommendations for tool features were suggested that should enhance cognitive and social presence, resulting in an improved e-learning environment. The collaboration community will benefit from consideration of cognitive and social presence as mediating factors between collaborative feature sets and overall collaboration success metrics.

This paper lays the foundation for future research work which needs to test the integrated research model, develop additional collaborative feature sets that further promote cognitive and social presence, examine and evaluate research instruments, examine cognitive and social presences in other collaborative contexts, and investigate additional characteristics of solution- and artifact-based collaboration in order to further understand the collaboration problem-space.

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