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# Designer Support for Online Collaboration and Knowledge Construction

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**Abstract**

Designer support is critical for facilitating collaboration and knowledge construction in an online learning environment. Designer support in this paper refers to the mechanisms that a designer builds in a technology-mediated environment to facilitate online learning. This paper focuses on two aspects of designer support: 1) creating a shared context, and 2) facilitating online communication and knowledge construction. Examples of these two aspects of support are presented along a continuum ranging from technology that simply allows collaboration to collaborative technology that makes collaboration more accessible to users. Examples of strategies for creating a shared context include the use of metaphorical designs to graphically represent the virtual environment for intuitive navigation and role transplantation, the use of informational support for decision-making, and the use of multiple information channels and tools to support coordinated collaboration in task-based projects. In order to facilitate online communication and knowledge construction, on the other hand, designers can employ communication scaffolds to structure online communication and artifacts as shared representations that provide contexts for online discussions. Finally, the potential application of similar mechanisms to online course management systems is discussed.

**Keywords**

Designer support, Online collaboration and knowledge construction, Facilitation of online communication

## Introduction

With the development of computer and network technology, computer-mediated learning has become a common practice. The effectiveness of such learning environments relies to a large extent on how computers are used. Research scientists proposed the idea that computers function as cognitive tools (Jonassen & Carr, 2000; Jonassen & Yueh, 1998; Lajoie, Lavigne, Guerrera, & Munsie, 2001; Teasley & Roschelle, 1993) that extend students' capacity to learn and create knowledge. However, the functions of computers in online learning environments created by currently adopted course management systems in most schools and universities (e.g., Blackboard, WebCT) are far from what is desirable. The manner in which technology is used is partly determined by the design of the learning environment as it embodies the designers' ideas and impacts human-machine and human-human interaction. Designer support, thus, is critical for facilitating collaboration and knowledge construction in an online learning environment.

This paper focuses on two sources of designer support in online learning environments: one is support from designers to create a shared social context and the other is support that facilitates online communication. Support in creating a shared social context is associated with the problem of making transparent the social structure that is tacit in real life. Facilitation of online communication, on the other hand, is related to the mechanisms that can be built into the learning environment to ensure the quality of online interaction, given the research finding that the quality of learning and knowledge construction is closely related to the types of communication that occur between learners (King, 1999).

Apart from the different areas that designer support addresses, it should also be noted that such support exists in a continuum ranging from features or systems such as instant messaging systems that simply allow collaboration to those that support collaboration. This is a distinction that was made in a recent paper by Dimitracopoulou & Petrou (2003) to differentiate technology supported systems based on the extent of support. They consider those systems that allow collaboration to be collaborative use of technology where users of the system have to make efforts for collaboration to occur, while the systems that support collaboration are classified as collaborative technology where designers create opportunities for collaboration and/or make online collaboration more accessible to users.

In the following discussions, examples from existing design practices will be used to illustrate what mechanisms have been used to address the social structure issues and facilitate online communication and knowledge construction in online environments. In addition, the examples will be presented along the continuum of designer support, ranging from features that allow collaboration to those that support collaboration.

## Creating a Shared Social Context

A shared social context is important for online learners to socialize, learn, and create knowledge, particularly when learners are strangers with little or no previous collaboration experience. Shared context can be established with various amount of support in design features ranging from having virtual environment representations to foster social relationships, to providing informational support for decision-making, and to having multiple information channels and tools to support coordinated collaboration in task-oriented projects.

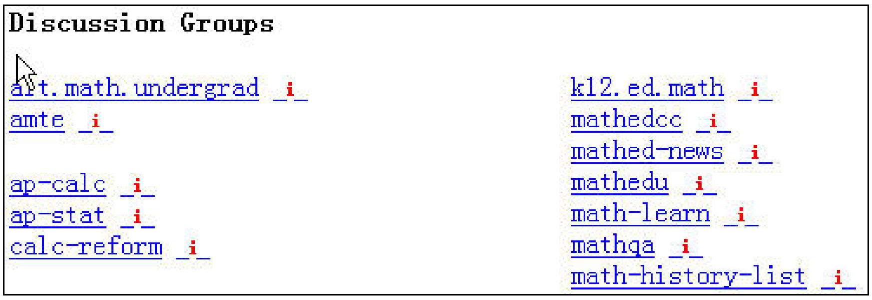
## Metaphorical Design: Graphical Representations of the Virtual Environment

When no social contact is made prior to collaboration, it is essential that a shared context be created to foster the establishment of social relationships. To that end, the socialization structures that have been so integrated into the traditional learning process have to be made explicit in some fashion (Dirckinck-Holmfeld & Sorensen, 1999). An example would be using a metaphorical design to graphically represent the virtual environment to create a sense of time and space. Where elements and the spatial layout of the virtual environment bear resemblance with the physical world that learners encounter in their daily practices, designers make it intuitive for learners to navigate and transplant the roles to which they are accustomed to the new environment.

It is worth noting that research has indicated that the design of the virtual environment has to have the impact of being real and concrete. Barab and his colleagues (Barab, MaKinster, & Scheckler, 2004) discussed their change of metaphors for the Inquiry Learning Forum from “floating doors” that create a pseudo-physical feel to “a more virtual school appearance” (p. 79) that gives users a sense of a concrete place. In doing so, the more realistic look and feel would produce a feeling of “place,” resulting in users of the system being more likely to relate to it and have sustained involvement in the online activities.

## Informational support for decision-making

Designers can also build mechanisms that provide information support to assist with decision-making. It is usually difficult for persons who are new to an online environment to decide what features are of interest to them and they will need support systems that contain information critical to make their decisions. For instance, designers of MathForum (www.mathforum.com) provide an “ i ” at the end of each discussion group so that participants can easily access information when they make decisions on which groups they wish to join.


Discussion Groups

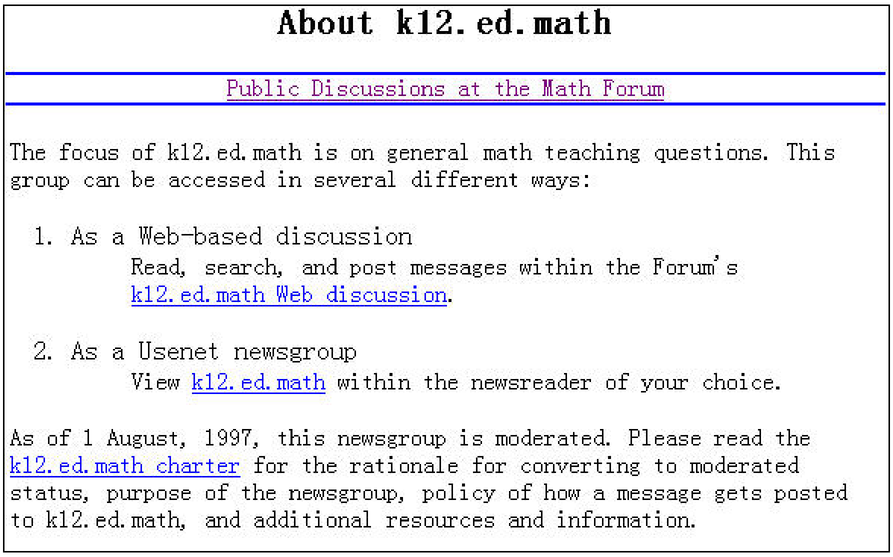
alt.math.undergrad i
amte i

ap-calc i
ap-stat i
calc-reform i

k12.ed.math i
mathedcc i
mathed-news i
mathedu i
math-learn i
mathqa i
math-history-list i

*Figure 1.* List of Mathforum discussion groups
(From http://www.mathforum.com/discussions/)

With a click on the " " button, participations can obtain information on the purpose of the discussion group, how it can be accessed, whether it is moderated, as well as where to obtain detailed information on the discussion group, as indicated in Figure 2. Such assistance that designers provide to support "legitimate peripheral participation" (Lave & Wenger, 1991, p. 29) affects how well the user gets acquainted with the virtual environment and in turn his or her ensuing involvement.


About k12.ed.math

Public Discussions at the Math Forum

The focus of k12.ed.math is on general math teaching questions. This group can be accessed in several different ways:

1. As a Web-based discussion
   Read, search, and post messages within the Forum's k12.ed.math Web discussion.

2. As a Usenet newsgroup
   View k12.ed.math within the newsreader of your choice.

As of 1 August, 1997, this newsgroup is moderated. Please read the k12.ed.math charter for the rationale for converting to moderated status, purpose of the newsgroup, policy of how a message gets posted to k12.ed.math, and additional resources and information.

*Figure 2.* Information on the discussion group of k12.ed.math
(From http://www.mathforum.com/discussions/about/k12.ed.math.html)

Metaphorical design and embedded informational support are useful to get users/learners oriented with the virtual environment, but such support only sets the stage for collaboration. This kind of support does not actively mediate the actual collaboration process and is not adequate when learners are engaged in task-oriented projects. To achieve coordinated collaboration, more informational support is needed to support workspace awareness, as elaborated below.

## Multiple Tools to Support Coordinated Collaboration

In task-oriented projects, learners should not only have knowledge of the environment, but more importantly, they must be aware of what is going on with the project and then act appropriately. At least three kinds of awareness are of concern: social awareness, action awareness, and activity awareness, each of which requires different types of information, as indicated in the following table (Table 1).

Systems can usually provide some support for social awareness and action awareness. One simple example is the chat room in the Blackboard course management system that provides instant information regarding who enters the discussion and who departs at what time. Such information appears in the middle of a conversation and the participants in the online conversation are informed instantly and can act accordingly. Similarly, in some online communities, the following information is provided to support social and action awareness: who logged on, where he or she is in the virtual environment, whether he or she is active, how long he or she has been idling, and in what activity he or she is engaged.

*Table 1.* Three awareness concerns and information that might address them (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003) (p. 611)

| **Awareness concern** | **Information needed to address this awareness concern** |
|---|---|
| Social: “Who is around?” | Presence of collaborators; features of an online collaborator that convey motivational state or attitude; timing, frequency, or intensity of individual or group activity or communication |
| Action: “What is happening?” | Timing, type, or frequency of collaborators’ interactions with a shared resource; location and focus of collaborators’ current activity |
| Activity: “How are things going?” | Creation or changes to shared plans, evaluations, or rationale; assignment or modifications of project roles; task dependencies based on roles, timing, resources, etc.; exception handling |

However, the support for activity awareness that is necessary for the successful implementation of complex and long-term tasks is rare in online learning environments. Activity awareness involves distributed goals, plans, and resources, participants’ understanding of others’ actions, as well as assessment of the current situation. To successfully complete task-oriented projects online, a joint workspace with multiple tools that support the above types of awareness should be enacted. The following example is part of the notification system in the Learning in Networked Communities (LiNC) project for middle and high school students who collaborated in science classrooms. Various mechanisms were built in to provide informational support for social awareness, action awareness, and activity awareness.

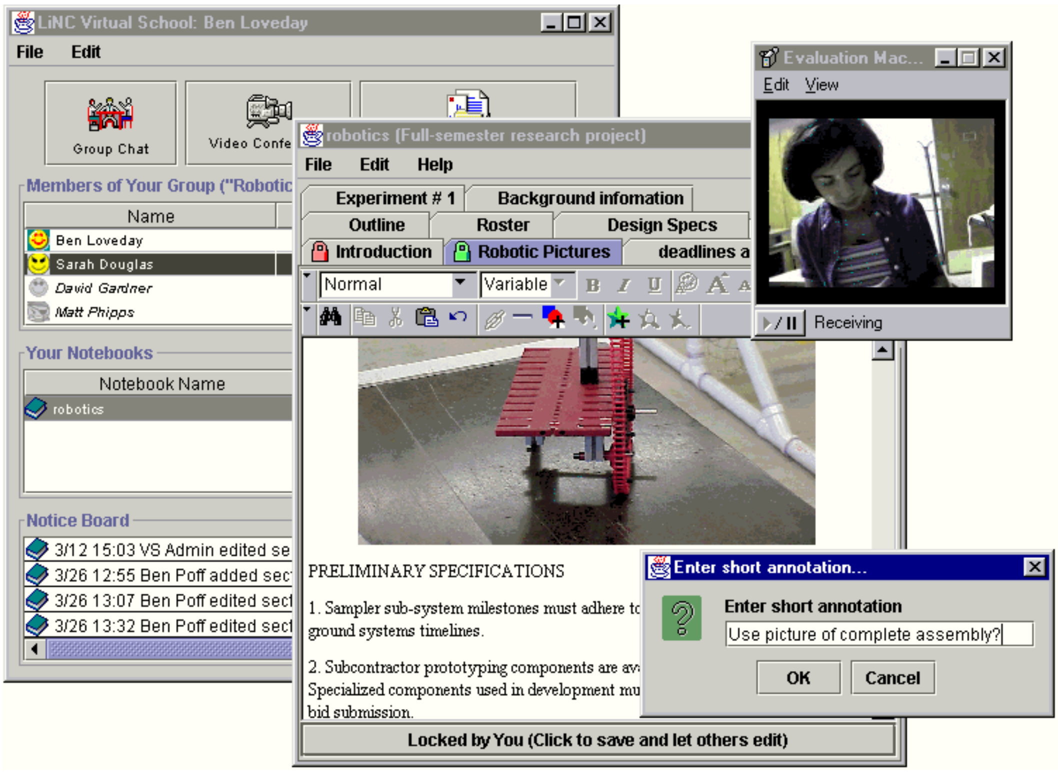



*Figure 3.* Collaboration and awareness tools in the Virtual School (Carroll et al., 2003)

The central tool that is displayed in the middle of the screenshot (Figure 3) is the collaborative editor, “science notebook”, a metaphorical design used to create a shared social context. Learners are notified via auditory cues when their peers join or leave the session. Further, the session manager window on the left of the screenshot has three components: 1) the roster pane that provides information on members of the group, group affiliations, and current presence, location, and activity in the system; 2) the notebooks section that notifies the user the notebook in use; and 3) the notice board that documents significant actions to the notebooks and lists the last time when shared notebooks were edited. Moreover, the Gantt chart views in the planning pages in the notebook can be triggered to obtain information on project state, task descriptions, deadlines, and completed tasks. A shared whiteboard can also be activated for annotation of graphics, and those annotations can be used to inform collaborators of a certain aspect of the project. Different colors were used to indicate what pages are currently under a user's editing control or are being edited by a collaborator. As illustrated in the screenshot, a lock in green is used to indicate the notebook page currently under review by the user is the robot picture. The textual information at the bottom of the window notifies the user that the page has been locked and is unavailable for others' editing.

Similarly, earlier learning environments for collaboration in science projects have also had a wide range of tools to support online collaboration. For instance, CoVis (learning through collaborative visualization) provided collaborators with desktop video teleconferencing; visualization software; shared software environments for remote, real-time collaboration; a special multimedia scientist's notebook; and access to the resources on the Internet (Pea, Edeelson, & Gomez, 1994).

What is evident in the above examples is that to support collaboration in task-based projects, designers may need to have multiple tools to support different types of awareness, particularly activity awareness, and help learners effectively organize and share their experiments or projects to achieve coordinated collaboration. However, when the goal is for users to get acquainted with the online environment, support for activity awareness may not be essential. Thus, obtaining information on the types of activities in which learners will be engaged will give the designer some indication of what kinds of support are indispensable.

## Facilitation of Communication and Knowledge Construction

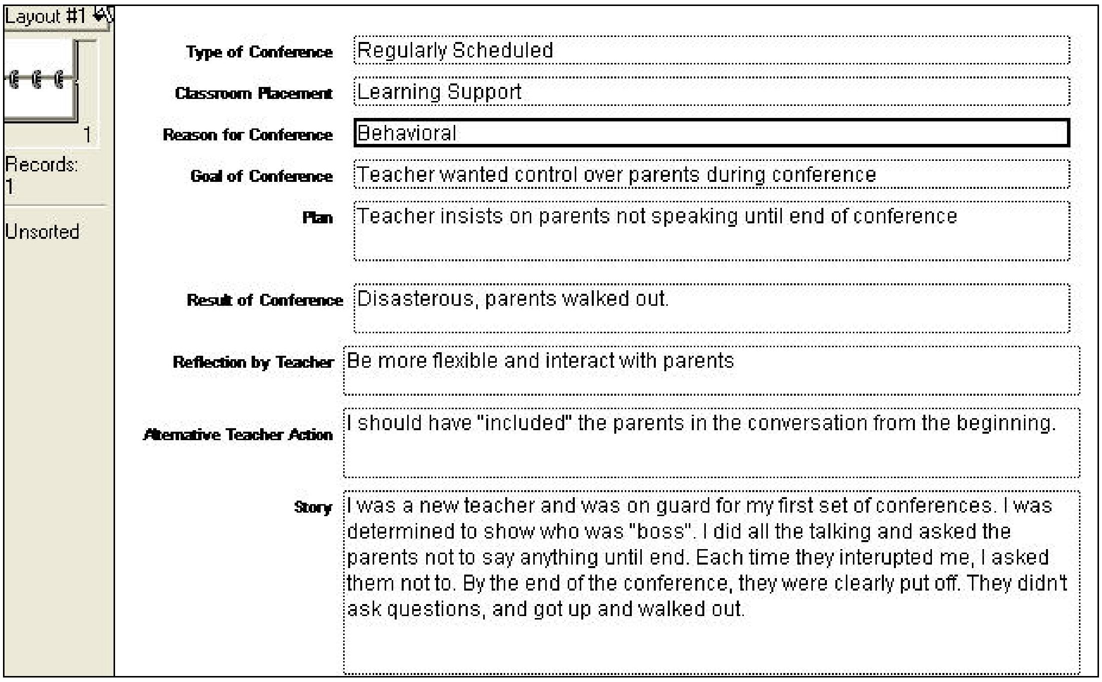
The establishment of a shared context and awareness support provides the potential for sustained conversation and knowledge construction. However, the quality of online learning is, to a large extent, determined by and reflected in the types of interactions that occur while the learners are engaged in the activities. As mentioned before, some technological tools for online communication allow collaboration rather than support collaboration. Emails, discussion boards, and instant messaging systems are not designed to support collaboration. Rather, users of such systems have to make efforts to collaborate with each other in that there are no structures or other forms of representations available that would support their communication.

On the other hand, studies on knowledge construction in collaborative learning have revealed that despite the efforts made in various learning environments (Ge & Land, 2002; McLean, 1999), the students' ability to conduct effective interactions with others was limited. For instance, Bianchini (1997) found "discussions of scientific concepts, applications, and connections appear to be rare," (p. 1053) and the students mainly focused on observational or procedural matters in their activities. In addition, Kittleson & Southerland (2004) observed that there were few instances of knowledge construction where each member of the team contributed and the consensus on a possible solution to the problem was reached. The above research findings point to the need for direct intervention on the part of system designers and online facilitators to support online communication and facilitate knowledge construction.

In the following sections, two examples in which designers provide support for communication are discussed: one uses communication scaffolds and the other uses artifacts as shared representations to provide a context for online discussions.

## Communication Scaffolds

Many methods have been proposed to structure and facilitate online communication (Fischer, Bruhn, Grasel, & Mandl, 2002) and one of the strategies is the use of communication scaffolds. This strategy has been successfully implemented with young learners at KnowledgeForumTM (Scardamalia & Bereiter, 1994) by having students select message descriptions (e.g., "my theory," "I need to understand," "new information") for preparation of their messages. These descriptions serve as metacognitive tools for learners to reflect upon their thinking process as well as to communicate their thinking to each other (McLean, 1999). For instance, the idea has been implemented in creating a case-based database for teachers' professional development (Jonassen, 1999). Scaffolds that center on certain aspects of interest are presented to elicit relevant information from teachers including the type of conference, classroom placement, reason for the conference, goal of the conference, plan, results of the conference, reflection by the teacher, alternative teacher action, and the story (Figure 4).


Layout #1

Records:
1

Unsorted

**Type of Conference**: Regularly Scheduled

**Classroom Placement**: Learning Support

**Reason for Conference**: Behavioral

**Goal of Conference**: Teacher wanted control over parents during conference

**Plan**: Teacher insists on parents not speaking until end of conference

**Result of Conference**: Disasterous, parents walked out.

**Reflection by Teacher**: Be more flexible and interact with parents

**Alternative Teacher Action**: I should have "included" the parents in the conversation from the beginning.

**Story**: I was a new teacher and was on guard for my first set of conferences. I was determined to show who was "boss". I did all the talking and asked the parents not to say anything until end. Each time they interupted me, I asked them not to. By the end of the conference, they were clearly put off. They didn't ask questions, and got up and walked out.

*Figure 4.* Database of teacher stories, from Jonassen & colleagues (1999, p. 161)

The scaffolds in this case serve several functions. On one hand, it fosters reflection on the part of the teacher who actually had the experience (Lin, 2001). More importantly, the communication scaffolds structured the discussions and enabled learners to find different perspectives on similar cases. The differences in perspectives enhance the likelihood that teachers will engage in more reflections and discussions of their practices.

Similar strategies have been proposed, researched, and extended to other online activities. Such strategies include the use of sentence openers in many learning environments including DIALAB (Moore, 1993) and BetterBlether (Robertson, Good, & Pain, 1998), the use of constraint-based argumentation scaffolds to assist learners in problem-solving (Cho & Jonassen, 2001), and the use of argumentation scaffolds and message labels in online debates (Jeong & Joung, 2003). The communication scaffolds not only assist the learners in enhancing the quality of online interaction, but more importantly, they provide online facilitators/instructors an effective means to monitor online interaction, and furthermore, the archived conversations help instructors identify what skills they need to focus on in class.

Caution should be taken when using communication scaffolds. One consideration is for the amount of structure imposed on students. Some systems not only confine the communication moves within the selection of scaffolds but also have the students use the scaffolds in the pre-determined sequence to promote the quality of interaction. Although the sequences of the conversational acts may be significant, scripting the learners' conversations may not be necessary when effective group strategies are used. Studies have also found the potential risk that students may change their intended meaning to fit the given sentence openers and thereby change of the nature of the interaction (Soller, 1999). One possible solution is for designers to provide templates so that instructors can adapt the scaffold to suit the needs of specific tasks. Another concern researchers pointed out was that the communicational scaffolds may not be used by the learners as intended, and thus, the thinking and conversational skills represented in the sentence openers may not be not practiced (Dillenbourg, 2002). Clarifications, training, and practice prior to the use of the communicational scaffolds may help alleviate the problem of improper uses.

## Artifacts as shared representations to provide contexts for online discussions

Artifacts as shared representations can be another method to facilitate collaboration and knowledge construction. Graphical representations have been found to be better than texts in assisting communication, (Patterson, Dansereau, & Newbern, 1992) and they are used to guide interaction in collaborative activities (Suthers & Hundhausen, 2001). In addition, shared representations can also be used to facilitate the building of common ground, which is a critical process of knowledge construction (Ostwald, 1996). In the communication process, there will be breakdowns resulting from the limited shared contexts of participants with different cultures, personal experiences, or professional engagements. With the presence of the shared representations, participants can draw the attention of others to an object by pointing to it or naming it to ensure all are referring to the same thing, and in some cases, the explicit representations themselves become the medium of communication (Suthers, Girardeau, & Hundhausen, 2002). As the shared context between participants increases, their interpretations of the shared representation become similar to one another's, as illustrated in Figure 5.

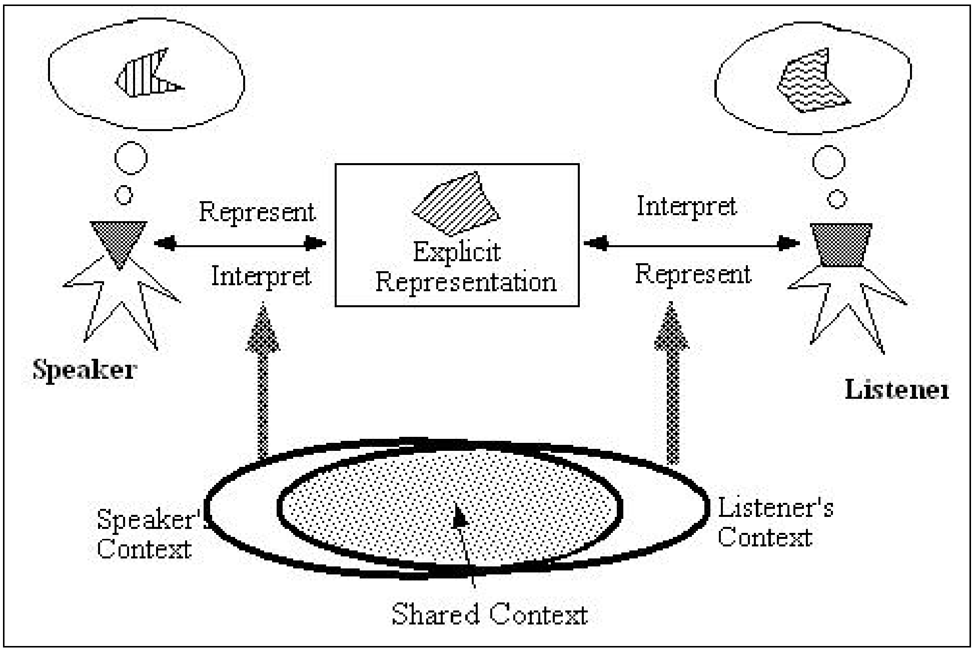



*Figure 5.* Explicit representation assists in creating a shared context (Ostwald, 1996, p.59)

Findings from empirical studies also support the use of collaboratively constructed artifacts. A series of studies by Roth & Roychoudhury (1992; 1993; 1994) found that the students "talked science" in creating the concept maps and engaged in processes similar to those in the science community: collaborative construction of concepts, the use of adversarial exchanges, and the formation of temporary alliances. Likewise, it was found (Fischer et al., 2002) that when the learners are provided with tools to construct content-specific visualization, the process and outcomes of collaborative learning improved.

However, most online environments contain "parallel communication tools" (Suthers, 1999). That is, the artifacts and the associated discussions in such systems appear in separate windows, and the systems do not assure the coordination between the discussions and the related artifacts. For instance, in the Blackboard system, although graphical representations can be collectively or individually created in the whiteboard, the discussions on the associated graphical representations can only be accessed from the group discussion page. Without readily accessible representations, discussions and interpretations may lack a context, which will negatively influence the sustainability of online interaction.

Efforts have been made to improve the situation, and systems that contain "embedded communication tools" have been proposed and created. In such systems, embedded communication tools enable users to conduct discussions in the context of the artifact, and users can capitalize on the advantage by referring to part of the artifact or recovering discussions on certain parts of the artifact. Guzdail & Turns (2000) used documents as anchors to motivate students and stimulate sustained on-topic discussions. Similarly, Suthers and his colleagues have created different tools to facilitate communication. Kukakuka (Suthers & Xu, 2002), which will be discussed below, is one of the systems that use artifacts (web pages) to support online discussions.

Figure 6 displays a web page of a group discussion. One thing in particular about the discussion is that each message is centered on an artifact. Kukakuka, the learning environment, has the capacity to simultaneously display the artifact associated with the message on display, the subject lines of the group messages, and the selected message. In the above web page, the artifact associated with the message "storyboard" appears on the left frame of the screen, while the subject lines of the group messages appear on the upper right frame, and the selected message is shown on the bottom right frame. The display of the associated artifact provides a context for the reader of the message to comprehend the textual information. In addition, since the artifact maintains its presence in both the replies to the selected message and other messages along the same line, it is less likely that readers will misinterpret the suggested revisions in previous messages, and thus, the artifact facilitates the building of common ground and knowledge construction.

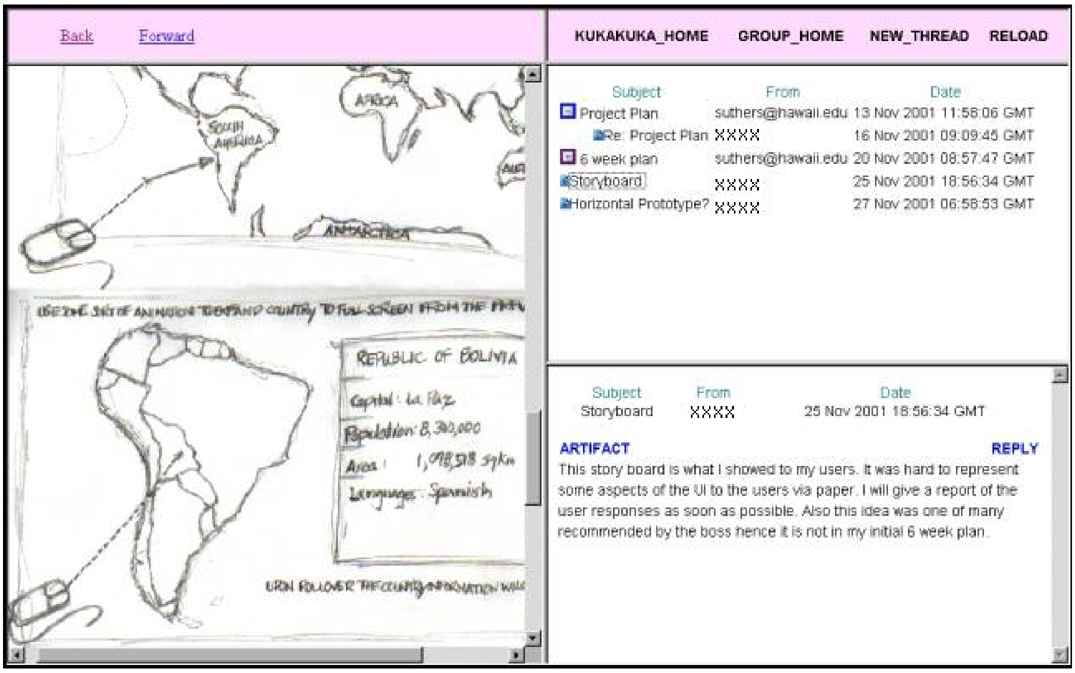



*Figure 6.* Kukakuka: an online environment for artifact-centered discourse (Suthers & Xu, 2002)

This system is undergoing revisions based on users' feedback. Problems are being addressed such as the system's lack of ability to differentiate between previously read and newly displayed messages and the absence of a notification system that would periodically inform users of newly posted messages (Suthers & Xu, 2002). A problem with the systems that contain embedded communication tools is that discussions are usually fragmented by artifacts, which causes learners to lose a holistic view of the discussion and the relationships between different aspects of the artifact (Dimitracopoulou & Petrou, 2003). These are the concerns that have to be addressed if embedded communication tools are to be useful in supporting online communication and knowledge construction.

## Conclusion

Although most of the above support is not available at present in the online learning environments of the course management systems widely in use, they are potentially useful. For instance, metaphorical designs like the following could be used to guide learners in the virtual space: a "student lounge" for social activities, postings of social events, or personal information students would like to share with the class; a "virtual office" where students can have meetings with instructors; a "lecture hall" where students can listen and/or view content related information; and a "discussion forum" where students can annotate each other's work and conduct intensive discussions on course contents. Such design efforts would make the navigation intuitive and transplantation of roles easy in the virtual environment.

Also mechanisms that support coordinated collaboration should be made available for complex projects, such as Gantt charts for students to plan their projects and keep track of actual implementations, notice board to notify students of important actions on documents, as well as instant identification of the presence of collaborators. All of these notification systems would enable students to coordinate their efforts in completing large projects.

To facilitate communication and knowledge construction, designers could build scaffold templates which instructors could later adopt to suit their needs in specific courses. Additionally, the capability of the system to simultaneously display artifacts and discussions would be beneficial to learners when the discussions are context-dependent. For instance, in the planning phase of a project, the display of the Gantt charts along with discussion threads would give a holistic view, inform participants of the current status of the project, and clarify the division of labor while, at the same time, reducing the likelihood of miscommunication.

With improved designer support, more tools that address different aspects of online learning could be made available for instructors and learners to use in ways desirable for online collaboration and knowledge construction. Concerted efforts from designers, instructors, and learners could make computers function as “cognitive tools” in online learning environments.

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