Collaborative Support for Learning in Complex Domains

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Abstract

Engineering is a complex domain to learn. CaMILE (Collaborative and Multimedia Interactive Learning Environment) aims to facilitate engineering students' learning. CaMILE builds on Cognitive Flexibility theory [14, 15] in a CSILE-like structure [10, 11] through which students share multiple media and collaborate to develop understanding across diverse perspectives. CaMILE includes a collaborative NoteBase, a hypermedia database with guides, and an electronic book format. We believe that CaMILE supports students' engineering activities, but a cultural shift is required for CaMILE to effectively support students' learning.

Keywords — Collaboration software, multimedia, engineering education.

1. Introduction

Engineering is a classic example of (a) a design domain [13] which implies a set of problems for learning and (b) a complex domain in which it is difficult to learn and perform [15]. Learning engineering means developing understanding in a wide variety of conceptual domains (e.g., physics, behavior of materials, mathematics) while also developing expertise in problem understanding, problem-solving, and integrating diverse conceptual domains [12]. Adding to this already large load, engineering educators are now calling for more relevance of educational programs to actual practice – for example, emphasizing collaboration skills because of the increased use of engineering teams in the workplace [1, 2, 7].

We have been working with two different engineering curricula at Georgia Tech (Sustainable Development and Mechanical Engineering) to develop technology to support learning and doing of engineering students. We draw a set of criteria for technology that can facilitate learning in complex domains from the work by Rand Spiro et al. on Cognitive Flexibility theory [14, 15]. Our goal was to meet those criteria but with specific support for learning collaboration skills. Our model for collaboration support was Scardamalia and Bereiter's CSILE [10, 11].

We have designed and implemented a learning environment called *CaMILE (Collaborative and Multimedia Interactive Learning Environment)* [4]. In CaMILE, students create multimedia compositions and share them in a discussion that can draw upon diverse perspectives. CaMILE consists of:

- A collaborative NoteBase where students discuss topics and integrate diverse media;
- A MediaBase where multimedia documents (text linked to multiple media) are provided along paths featuring anthropomorphic *guides* [8, 9]; and
- An Electronic Book format for making text resources easily available, annotated, and integrated into the NoteBase.

CaMILE was first used in the 1994-1995 academic year in a Mechanical Engineering course on design [5, 16] and in a course sequence on Sustainable Development [17]. In this paper, we describe CaMILE and its first year of use. While students made frequent use of CaMILE in support of their engineering activities, we see a need to change culture for enhanced learning.

2. Description of CaMILE

We identify three critical kinds of supports for student learning and how CaMILE addresses each based on the theoretical work we identified:

- *Support for reflection:* The collaborative NoteBase enables students to take an active role in discussions and in integrating diverse media. In addition, the NoteBase provides support for reflecting on the collaboration.

- *Support exploration of multiple perspectives:* The MediaBase provides *guides* which support different perspectives in a domain. For example, in a MediaBase on sustainable development, guides may represent the perspectives of economists, ecologists, and bankers or of developing versus developed nations.

- *Support integrated use of multiple resources:* All of the three subcomponents of CaMILE (NoteBase, MediaBase, and Electronic Book format) support links to a variety of media. For example, the NoteBase allows students to link to their discussions the following resources: any document on their computer (e.g., word-processing document, spreadsheet, drawing), sounds, graphics, digitized video, World-Wide Web pages, links to a particular node in the MediaBase or page in an Electronic Book, or a particular case in a case base (using the case-based design aid, ARCHIE [3]).

NoteBase: The core of CaMILE is a collaborative NoteBase where students can post multimedia notes in group discussions. The NoteBase uses a simple structure for multimedia composition called a Media Margin [6]. Student notes in the NoteBase contain text on the left two-thirds of the document and multimedia annotations appear as icons in the margin in the rightmost third. Students can directly manipulate the icons so that a media reference appears next to corresponding text.

Students are guided in their collaboration and are encouraged to reflect on their collaboration through a prompting mechanism based on CSILE's procedural facilitation [10, 11]. When students create a new note (Figure 1 left side), the NoteBase asks them to identify the *kind* of note that they are creating in terms of the contribution's role in the overall discussion (e.g., raising a *New Idea*, or making a *Rebuttal*, or asking a *Question*). Based on the kind of note selected, CaMILE then makes *suggestions* on productive things to say in this kind of note (Figure 1 right side). In this way, students are encouraged to reflect on their collaboration (i.e., what kind of statement are they trying to make?) and are given some structure and hints on how to conduct the collaboration.

MediaBase: The MediaBase encourages students to explore a topic in multiple media and guides them through alternative and often conflicting perspectives on a subject. In the MediaBase, a content expert has previously placed information into *nodes*, which are collections of text with multimedia annotations (similar to the notes in the NoteBase). These nodes are organized into collections called *paths*. Each path contains nodes that are related to a common topic or theme.

Students are guided in the MediaBase by the use of anthropomorphic agents called *guides*. A MediaBase guide presents a specific point of view on the presented data. Guides have been shown to help a student make sense of complex domains which can be approached from several different angles [8]. A guide presents an opinion on a given node, and points to a path, called an *agenda*, with more information about the guide's subject.

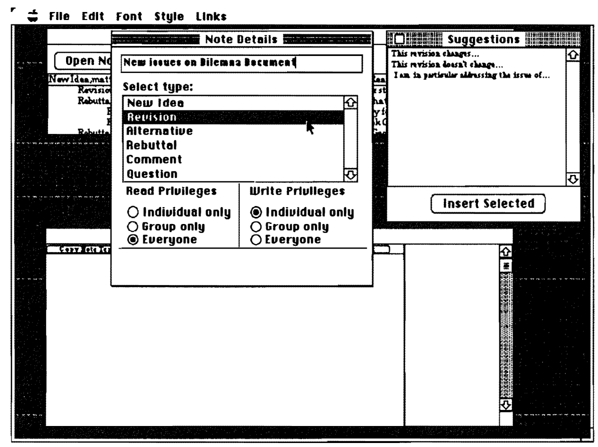

Figure 1. Prompts in CaMILE for kind of note and suggestions. A blank note appears at the bottom, and a discussion window listing related notes is visible at top left.

Electronic Books: A third component of CaMILE is an Electronic Book (*Ebook*) format. Much of the information available to undergraduates is in the form of text. While text provides information in a useful form, it cannot be easily linked with other related resources, commented upon, and shared. The CaMILE Ebook format supports linking of text to external multimedia resources, allows students to annotate the book in useful ways (e.g., writing notes in the margin, underlining key phrases, adding bookmarks, creating links from relevant phrases in the book to their own relevant material), and supports sharing of students' notes with one another. Students can link from a NoteBase discussion to an individual page in an EBook.

3. First Year of CaMILE Use

CaMILE has been used in three quarters in a Mechanical Engineering course and for one quarter in a Sustainable Development course.

- In the Mechanical Engineering class[1], students used CaMILE to discuss designs that they were developing in small groups (4-5 students) and to share material on those designs (e.g., drawings, design reports, timelines). Electronic book versions of the course texts were provided.

[1]During the first two quarters of use, students in the ME course volunteered to participate in a lab class in which CaMILE was used. During the Spring '95 quarter, a whole section of the course used CaMILE.

- In the Sustainable Development class, students used CaMILE to discuss cases being analyzed in lecture. A MediaBase of sustainable development cases is being created for this class, but was not available for this use.

Students used CaMILE to a much greater degree than we expected, particularly in the Mechanical Engineering course. For example,

- During Fall 1994, 14 students (plus a TA and teacher) generated over 400 notes in the ten week period, with over 100 links to external media. The majority of the links were to word-processing files (e.g., students sharing parts of a design report for comment), spreadsheet files, and design drawings. There were no links to EBooks at all.
- During Winter 1995, 7 students (plus a TA) generated over 200 notes with some 50 links to external media.

We can characterize the use of CaMILE as having two types:

- *Discussions on Assigned Topics:* Students were assigned topics to discuss using CaMILE to mediate the discussions, as a means of teaching students how to use CaMILE and where it could be useful. The discussions on assigned topics made use of the collaboration supports in CaMILE, but the quality of the discussion was relatively low – which was not surprising given the inauthentic nature of the use. What was the surprising in this kind of discussion was the students' relatively frequent use of the Media Margin to exchange files (e.g., word-processing documents typed at home without network access and posted on campus).

- *Discussions to Meet Goals:* These discussions were created by the students (most often protected as private to a group) for the purpose of meeting design goals: Agreeing on a design issue, exchanging materials for a design report, etc. Students in these discussions exchanged numerous files with one another, such as pieces of design reports or sketches. While this use was authentic and meaningful to the students, there was relatively little use of collaboration support (e.g., most notes were labeled *Comment*) and there was little discussion more than "Here's my report for review" and "Here's my revision."

4. Discussion

In general, our experience with CaMILE was different from the CSILE experience described by Scardamalia and Bereiter. While the software was designed to offer similar functionality, we did not see the enthusiastic use, carefully crafted arguments, and evidence for learning-through-collaboartion seen in the CSILE transcripts. Instead, we saw students using CaMILE as a virtual mailbox or group memory for sharing media of all sorts (documents, drawings, plans), but not as the collaborative knowledge-building activity that the CSILE people discuss. While such use suggests that CaMILE was valuable (based on frequency of use) to students in support of their engineering *doing*, CaMILE was not being seen as supportive of their *learning*. Thus, we argue that CaMILE is facilitating students in coping with the performance part of the complexity of the engineering domain, but we also believe that CaMILE can play a more significant role.

We believe that the difference between the CSILE experience and our own is a difference in terms of classroom culture and curriculum. CaMILE was used in relatively traditional settings with relatively traditional curricula, where the goal is to conduct engineering activity primarily and to learn from the activity secondarily. The value of *knowledge-building* that is so central to CSILE was not part of the dialectic in the classrooms where CaMILE was used.

Building knowledge for the sake of knowledge is not a value that can easily be instilled in an engineering curriculum. However, building knowledge so as to inform problem-solving or to create a group memory that includes arguments and differing perspectives are activities which can be valued. We might call such a perspective as *knowledge-building for action*[2]. Our future directions are to explore tighter integration of CaMILE and a value for knowledge-building for action with the culture and curricula of the engineering educators with whom we are working. Such a change in culture might encourage student use of CaMILE for reflection, exploration of multiple perspectives, and integration of diverse resources in the ways that we believe will lead to student learning.

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