Building a Digital Learning Community for Faculty on the Internet

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Abstract

The exponential growth of the Internet and World Wide Web have led to increased competition in the quality of Internet services provided. Increasingly sophisticated users are no longer satisfied with dealing with static sets of information alone and expect a broad array of new services and features on Web sites. In particular, they are expecting more interactivity and want services that help them to connect with other people to exchange and discuss information they find. Engineering faculty are no exception to this trend — the Internet provides them with an opportunity to connect with colleagues and establish professional relationships based on issues around teaching and learning.

NEEDS (the National Engineering Education Delivery System), a digital library for engineering education (www.needs.org) is the distributed architecture developed by Synthesis: A National Engineering Education Coalition (see www.synthesis.org) to enable the sharing of new pedagogical models based on Internet-mediated learning environments. NEEDS has undertaken an effort to learn more about its users and has found that with regards to teaching, faculty prefer to learn from one another. As a result of this research, NEEDS is experimenting with a variety of on-line services that can develop and support emerging communities among the faculty who are interested in interacting with one another in order to better use instructional technology and new pedogogies in their classrooms.

In this paper, we discuss research on the potential impact of Web-based learning communities for faculty who are interested in engineering education. This research has been used in the design of the architecture necessary for NEEDS to provide and support this service.

I. Introduction

One result of the exponential growth of the Internet and World Wide Web is that faculty (like other users) are no longer satisfied with dealing with static sets of information alone. Faculty want to use it to connect with colleagues to discuss and learn about teaching and learning in increasingly sophisticated ways. For example, both faculty and students turn to the Web and digital libraries as a resource to find information that is not available in traditional libraries; they

communicate via Internet Relay Chat, and teach using specially developed courseware that aid students in visualizing complex physical concepts, manipulate large real time data sets, or deal with complex case studies. Faculty use computers and the Internet as communication tools, much as they use them to gain information¹.

The Internet's potential, as a powerful communication tool is becoming more and more apparent, as individuals as well as organizations begin to rely on it as a means to communicate information about themselves and services. Because of this reliance, it becomes increasingly important that we understand the importance of the relationship between community, communication, and learning. People seek information by communicating with members of existing and potential communities; they look not only for materials and specific answers, but also for corroboration, new interpretations, and new methods of finding information². It is through this act of seeking information that they learn from their community. Learning, seen as a social phenomenon,^{3, 4} depends upon interaction with peers and a shared community of practice, reflected through a common language, set of methods, and perspectives.

As learners, faculty interact with multiple learning communities, in multiple ways, and for multiple purposes. They attend conferences and meetings sponsored by professional societies, academic and government institutions, and industry. At these events they participate in formal and informal discussions — all of which are critical to their ability to meet their professional obligations. Faculty as members of disciplinary professional societies focus on innovation in their areas of expertise and research; they participate in organizations such as ASEE (American Society for Engineering Education) and the FIE (Frontiers in Engineering Education) annual conferences that are devoted to promoting learning about innovations in teaching, and they attend meetings regarding both. Faculty report that they highly value opportunities to connect with colleagues within their field and related fields as necessary to learn about and discuss shared concerns, generate new ideas, and create new ways of doing things⁵. In short, they are describing communication within a set of communities from which they learn about their research, teaching, and learning. The communities described by faculty however, need not depend only on meetings or conferences which are defined by time and location, and can be fleeting and/or sporadic. Computer-mediated learning communities offer faculty the opportunity to develop and maintain long-lasting communities, focused on particular issues, with the ability to share thoughts, conversation, and information instantaneously across vast distances⁶.

In this paper, we will discuss and outline a means for faculty to learn from one another about engineering education via a digital learning community. We will review the literature and research associated with developing computer-mediated learning communities for faculty, and describe how NEEDS, a digital library for engineering education, has initiated the development of learning communities for engineering faculty. (Learning communities for other users, most especially students, are also being designed, but are not the focus of this paper.) The purpose of creating faculty learning communities is to provide them with a means to learn from one another unconstrained by barriers of time, distance, technology, and geographic location. The digital learning communities envisioned by NEEDS are being formed around the premise that faculty prefer to learn in situations where they are a member of a community that is built upon shared values and interests regarding teaching, learning, and pedagogy, and the desire to form and sustain relationships and through on-line communication links^{7,8}.

II. Background

An Overview of Communities and On-line Communication

The concept of community can be defined and interpreted in a number of ways. One definition of community is the "dynamic whole that emerges when a group of people share common practices, are interdependent, make decisions jointly, identify themselves with something larger than the sum of their individual relationships, and make long-term commitments to the well-being of the group"⁹. Another definition describes community as a cohesive social grouping that includes a sense of membership and ongoing social interaction¹⁰. Regardless of the specific definition, the notion of community involves a group of individuals who engage in some form of communication through a common bond. These communities may be spatially co-located or they may be separated by large distances. In either case, it has been shown that a community forms out of the common interests of its members ¹¹; like-minded individuals who congregate for a common purpose, and share thoughts and information in the pursuit of common goals.

The evolution of the Internet has enabled users to connect with communities that would otherwise remain separate, and supports their ability to foster innovative ideas among them¹². There are an increasing number of on-line activities that have supplemented their physical counterparts, such as virtual classrooms and telecommuting. These advances illustrate the means by which the transfer from physical to virtual communities can occur. The virtual community can actually serve to reinforce the physical community¹³, and just as they would in the physical world, members of virtual communities have expectations of one another based on their institutional¹⁴ and organizational roles^{15, 16}. Such roles often require different means of communication, and on-line communication can equalize the roles that members play in a physical environment. For example, there are countless anecdotal examples of how people who might be considered as being of lower status, for example a student, contact another of higher status (a Nobel laureate) and establish an on-line relationship. With an E-mail address, they can make contact through the Internet in a way that has fewer gatekeepers and other barriers than in physical forms of access.

Compared to physical communities, on-line communities tend to be more densely knit and have members with more homogeneous attitudes¹⁷. Physical communities are often formed out of proximity, while on-line communities are typically formed when people actively seek out others for a specific purpose. Two neighbors may live in the same physical community and have very little in common, while any two members of the same on-line chat room probably share strong common interests in the chat room theme. As a result, members of on-line communities may hold meaningful discussions on specific topics with others that are located many miles away. Without the presence of such a virtual world, these personal connections might never occur.

One reason that virtual communities are so attractive is that there is a sense of "place" in virtual communities where users have an identity and experience visual cues^{18, 19}, much like the physical environment in which they live and interact everyday. Many on-line chat rooms are laid out like a physical dwelling. Users enter into a *lobby* and proceed from *room* to *room* via a

hallway. These cues, in addition to advances in technology, have aided the transition from physical to virtual communities in that they help users establish a sense of place.

Virtual communities require a means for communication that meets the purpose of the community. Enormous growth of the Internet in recent years has shown that users want communication at least as much as they want information access²⁰. As in the physical world, the means for communication will depend upon the needs and practices of the community. E-mail, real-time chat, threaded and linear discussions, mailing lists and newsgroups are examples of on-line communication that connect groups of individuals. Each of these technologies support communication and each have their strengths and weaknesses depending on the needs of the communicate via informal E-mail, share documents and can build shared bodies of data for their use²¹. On the other hand, for communities that value interpretation, discussion, and re-interpretation of concepts, E-mailed discussions can become confusing and overwhelming. The relationship between people, tasks, and tools is not constant — changing one element will change the other two²².

To add to the complexity of this issue, research shows that computer-mediated collaboration is well suited to the transmission of information such as opinions and suggestions but is a poor means for communicating issues involving conflict and negotiation²³ due to the lack of visual cues to provide context. Since conflict and negotiation are integral to the formation of learning communities²⁴, a form of on-line communication that allows for and encourages negotiation of conflict and understanding must support these communities. One possibility is technology that supports on-line conversations clustered around artifacts such as those found at NEEDS that provide a common point of reference. This type of clustering successfully supports more indepth on-line conversation²⁵.

Faculty Views of Web Based Communication, Communities and Learning

In the Spring of 1999, NEEDS initiated a set of user studies in order to better understand its engineering users' interests and requirements, and to begin to understand the needs of a broader base of potential users, in particular faculty in the sciences and mathematics. Information regarding engineering faculty use of the Web was gathered via an on-line user survey. Faculty participants in two engineering Coalitions, representing approximately 15 different colleges and universities were surveyed regarding their use of the Web. The broader group of faculty views were gathered from a series of seven focus groups held with mathematics, physics, and chemistry faculty from community colleges and four-year colleges and universities.

The on-line survey was designed to elicit faculty perceptions of specific services offered by the World Wide Web and NEEDS, with a focus on search functions. Also included in the survey were questions regarding how these faculty use the Web. The survey was administered as a pilot study and 44 engineering faculty responded to the survey, with over 90% of the respondents reporting that they use the Web to locate information associated with their profession, and 78% reporting that they use the Web as a way to communicate with their professional colleagues. When asked about using the Web to locate learning materials, 68% of these same respondents reported using the Web quite regularly, with 36% of the total group checking the Web as

frequently as once a week. Approximately 45% of the respondents also reported using the Web to learn more about teaching²⁶. These preliminary data indicate that faculty use the Web primarily to communicate with one another and find information, and they do so with regularity.

The focus groups were designed to better understand the needs of science and mathematics faculty with regards to teaching, learning, and the formation of a digital library for the sciences, mathematics, engineering, and technical education. The focus groups were conducted at five respected professional conferences associated with the sciences and mathematics: American Mathematics Society, American Association for the Advancement of Science, American Association for Physics Teachers, Modular Chemistry Consortium, and the Community College Conference on Learning on the Internet. Prior to this study, requirements analyses of the engineering community had been conducted under the auspices of the Synthesis Coalition^{27, 28}. The focus group participants, like the engineering faculty who completed the survey, were quite adept at using computer technology, including the Web, for teaching and for communication purposes. The groups' discussions were wide ranging, covering many topics including the types of services and features a digital library should support, the content that should be included, the quality of that content, and how to encourage the use of such a digital library. Integral to their discussions were issues associated with the kinds of communication that a Web-based digital library should encourage and facilitate, and how a sense of community among the faculty users was necessary for success.

Emerging from the analysis of the focus group transcripts were several themes common to all the groups regarding community and communication. These included the notion that faculty highly value learning from communities of like minded faculty such as those initiated in workshops, meetings, and conferences. Another dominant theme centered on the belief that technology is an effective means for individuals to connect with a community, and that it encourages communication and dialogue about shared concerns. Faculty described community and personal contacts as being a driving force in learning about and supporting innovation. Digital libraries for these faculty, had to be more than just content, or as one member said: "a useful digital library has to not only have the content, but also build a sense of community of users...give you a sense that you're talking to other practitioners who have similar interests and problems and you can learn to trust and rely on the information..."²⁹.

Faculty Learning Communities and Communication in Engineering Education

Just as there has been an explosion in the development of the Internet as a resource for teaching, so too has there been a rapid growth in the development Web-based software supporting courses and course management (e.g., WebCTTM or BlackboardTM). Faculty also report increased reliance and use of E-mail and Web-based communication to stay in touch with colleagues, track information regarding professional societies, and meet with others to learn about how to use these new technologies effectively. In short, both faculty and students have begun to view the computer (and the Internet) as a tool integral to teaching and learning. Faculty however, have identified a number of problems in their ability to integrate and use computer-mediated learning and the Internet in their teaching. Specific concerns include: their lack of time to learn about the materials, inability to easily find usable materials, and lack of opportunity to be trained in using those materials³⁰.

Lack of time, a wide array of options, and differing opinions regarding the value and effective use of computer-mediated learning highlight a need for faculty to look beyond their disciplinebased communities for support. On-line communications technologies have the potential to meet these needs for faculty communication and collaboration. Yet, the potential is far from being reached as there are few coordinated efforts to build on-line faculty learning communities for engineering education. Without communication, it appears that faculty will remain "a collection of individuals coincidentally working on similar tasks"³¹.

What models can we build on in designing an on-line learning community for faculty? In education, discussions of learning communities are frequently associated with distance and Internet-mediated learning. Here the focus of the learning activities is defined by the relationship between the instructor and students, and how technology mediates that relationship. Within this framework, learning is described as an active process in which instructors and students must participate, where a "web of learning" is created and knowledge acquisition is collaboratively created³². Faculty learning communities, however, differ from this view in several ways: faculty are peers, the purpose of learning is self-defined, and the rewards for learning are more nebulous (e.g., their participation is not graded). Faculty do share several characteristics with students engaged in distance learning. Faculty are not necessarily tied to communities of professionals geographically or by their own campus. Their research and publication activities and their associations with professional societies and organizations connect them to a large set of colleagues with shared interests, values, and concerns with which they communicate regularly. By this communication, they act to create community³³, and the very nature of these communities is to learn from one another. In our initial review of engineering education Web sites, we found no communities such as we envision; the current work aims to fill this void.

III. Developing a Learning Community on the Web

NEEDS (www.needs.org) was developed by the Synthesis Coalition to support and enable new pedagogical models based on Internet-mediated learning environments^{34, 35}. Currently, NEEDS catalogs and disseminates courseware and other instructional technology developed nationally and internationally to provide a resource for both instructors and learners to search, access, and download educational materials. NEEDS has author-assisted cataloging features for adding materials into NEEDS that are consistent with library cataloging standards and include a basic review of the courseware as it is cataloged. Each metadata (bibliographic) record describes the pertinent information about the courseware in the same manner that traditional on-line public access catalogs provide information on books (i.e., title, author, publisher, subject heading, keywords, etc.). A user can search for courseware, view the metadata record that describes the courseware, and if available, download the courseware for their use. Materials held in NEEDS are diverse — content ranges from single topics that can be covered in a few minutes to fully integrated, term-long courses.

A New Focus

NEEDS has evolved to a focus on developing and serving a community of users, building on our prior work in cataloging and disseminating courseware. This evolution emphasizes interactivity

and learning with the goal to connect like-minded users in engineering and the sciences, in order to encourage user-to-user communication and community building. In this new approach, users will have a wealth of services available to them in addition to a collection of educational software and learning resources. Ultimately, services will allow all users to search and retrieve a set of resources based on particular pedagogical methods and content-based concepts within engineering and the sciences, e.g., teaching "teamwork" or "freshman design", in contrast to only retrieving specialized pieces of software for a particular application, such as a specific module for teaching "dimensioning and tolerancing in engineering drawings". Users' search results may include discussion topics, user comments, and instructors' guides as well as the educational software itself and related audio and video elements.

In this community-centered approach to a digital library, faculty and student users will be able to discuss various concepts using a form of threaded discussion, as well as to comment on, and review the educational courseware contributed by various developers. They will be able to connect to a network of other faculty and courseware developers and engage in a dialogue on teaching and learning in their fields. Faculty will have a peer-reviewed source of information on the various ways to educate students on the fundamentals of engineering and the physical sciences. Collaboration will allow faculty members that are at a distance to assist one another in restructuring their curricula. The NEEDS site provides an organized, efficient, and convenient way for faculty to gather materials based on a particular topic and to see what colleagues have contributed in the form of critique and discussion. The learning community itself serves to bring this diversity of faculty learners into a dialogue³⁶. People seek information by communicating with others in their respective communities and they look for corroboration and new interpretations of existing information, as well as traditional materials and specific answers³⁷. Such corroboration has the potential to enrich the learning processes both for the faculty themselves as learners as well as the students whom they teach.

Realizing a Learning Community

Creating multiple means of communication among faculty users is a major component of NEEDS' focus on learning. Threaded discussions — sometimes referred to as on-line forums — are being integrated into NEEDS as one way to build community among faculty users of NEEDS. Threaded discussions were chosen as they are better suited for contextualized conversations requiring a structure for questioning, answering, and commenting on complex topics. They allow in-depth interactions along multiple, parallel, or interrelated topics or "threads", and control over the frequency and time of the interactions³⁸. As they allow time for reflection and development, these threaded statements tend to be more focused than general newsgroup discussions³⁹. This type of discussion would not be well suited to real-time chat where responses are typically short, basic in meaning, and are frequent. In addition, threaded discussion model, responses can be associated with any message, thus a discussion can branch out infinitely⁴⁰ and provides a convenient means for users to track the history of a conversation from its inception. E-mail and other forms of linear discussion lack this feature, allowing multiple and simultaneous conversations to become intertwined.

Threaded discussion also provides the user more control over frequency and focus of the interaction. Mailing lists can easily overwhelm a subscriber if the size of the list population expands. Traditional newsgroups have the benefit of providing context to the messages but require the user to constantly check with the group for updates. The mailing list model fails because the user can only subscribe to the list as a whole, and not an individual topic within it. E-mail messages arrive in no particular order and lack the context that makes true communication and conversation meaningful⁴¹. The NEEDS prototype has combined several features of traditional threaded discussion, newsgroups, E-mail, and mailing lists in order to create a form of threaded discussion that can branch, be tracked, and inform users when responses have been posted to their query or comment. These additional features reduce the costs borne to the user in participating in a discussion. The following scenario is one example of how a faculty member might enter into a community and make use of the NEEDS threaded discussion system.

One Scenario

John is an assistant professor in Mechanical Engineering at a small private university. He is interested in revising and updating his course on mechanics of materials. John visits NEEDS and searches for materials associated with this class. In the list of results of this search, he finds a threaded discussion that sounds interesting and seems to address his content area of interest. He enters the discussion and quickly digests its evolution by scanning the various threads. After browsing the messages, John decides to post a message asking for additional sources of information regarding teaching one particular subject in the class that he feels is not adequately covered — inelastic deformation. In the body of the message, John includes the address of his Web site which appears as an active link to other users who read his posting. Then, he selects a feature that will automatically E-mail all replies to his posting to him.

Two days later, John receives an E-mail message from NEEDS alerting him that someone has responded to his posting. The message is from a professor named Carolyn from a large public university over a thousand miles away. This message contains the date and time of Carolyn's reply, along with the reply itself, and an active HTML link that leads back to her reply that is posted on the NEEDS' discussion site. John visits the link and reads Carolyn's response in the context of his original posting. In her response, Carolyn suggests a number of journal articles on inelastic deformation as well as a piece of courseware located on NEEDS that explains the subject, and that she has her students use as a tutorial in her course. John sends a quick reply to thank Carolyn for her suggestions and then downloads the recommended software from NEEDS for evaluation. He looks up and reads the journal articles and prepares a preliminary outline for his new course. John uses the software as Carolyn suggested, and observes that students who used the software as a tutorial scored better than the students who did not. As a result, John decides to more fully integrate it into the class the next time he teaches the course. *He returns to NEEDS and posts a user comment attached to the courseware regarding* how his students reacted to it, and he goes to the discussion to post a note regarding his experience and asks about others' experiences with the software. As he waits for a response, John returns to the search function in NEEDS to check what new courseware has been added. As he browses the site, he begins to think about how he might expand on

Carolyn's ideas, and based on his own experience, adapt the courseware. He goes back to the discussion group to outline some of his ideas and get feedback from the group.

John's experience illustrates how a faculty member might draw upon and add to a community of users. John has made a valuable contact (Carolyn) in the field that he may never have met otherwise. He has found courseware that helps students learn, as well as a group of faculty who share his interests, and through this interaction he has developed a deeper understanding of his students, and has generated new ideas about teaching and curriculum development. By identifying himself and his interests during the registration process on NEEDS, John was able to select several customized services that will keep him up to date on developments in his community, content areas of interest, and other opportunities to learn from his peers ⁴².

This scenario illustrates how, unlike general threaded discussion forums where users converse for recreational purposes, the NEEDS discussion prototype might promote focused, structured discussion on a particular topic, namely a concept or theory rooted in engineering education or education in mathematics and the physical sciences. The NEEDS discussion prototype adds a valuable communication tool to the wealth of resources currently available on NEEDS. It gives the faculty user an alternate way to learn about these resources and to experiment with others who share the same interests.

IV. Implementing Learning Communities of Faculty in NEEDS

While the learning communities designed by NEEDS are not limited to those intended for faculty, this paper focuses on faculty users because of their role in the origination and development of NEEDS. In developing a system for virtual communication and collaboration, strong user participation in the design is important⁴³, both from a usability standpoint and from an evaluation perspective. Faculty currently make up a strong and identifiable set of NEEDS users. NEEDS initiated a prototype for threaded discussion during Spring 2000. This prototype was pilot tested on an existing faculty community associated with the NSF Engineering Education Coalitions program. Two separate on-line discussions were held.

This pilot test of the discussion prototype aims to answer a number of research questions, including: Is threaded discussion an appropriate form of on-line communication for a digital library when discussing concepts or holdings? Is concept-centered or courseware-centered discussion more productive for learning communities in a digital library? What is the critical mass of users needed to successfully support such communication? Finally, do participating faculty recommend the use of such a system to the students in the classes that they teach?

The first discussion was concept-centered, specifically; it focused around the concept of mechanical dissection and associated multimedia cases of engineering design with active links leading to related courseware located on NEEDS. This concept-centered discussion began with a short abstract describing the pedagogical concepts associated with integrated dissections/cases:

A number of schools across the country have incorporated the study of artifacts and processes into the case-based approach to engineering education. These hands-on experiences help students become familiar with the machines/mechanisms that surround

them in order to help them gain confidence in their ability to work with, build up, manipulate, and redesign them. There are many variations to the dissection/case approach. Students may dissect products while playing the roles of user, assembler and design engineer, in series. Another approach is the have students dissect products in conjunction with a multimedia case study that offers perspectives of the engineers who actually designed the product and explanations of design details. Yet another approach is to view dissection as a reverse engineering and redesign process. In this on-line forum, these and other variations of the "product dissection" approach to exposing students to hardware and design issues will be demonstrated and discussed.

The second discussion was courseware-centered in that it centered on particular pieces of mechanical dissection/case courseware. The entry Web site for this discussion began with brief abstracts of the pedagogical benefits of the targeted courseware. Both discussions were seeded regularly by discussion leaders and ran for a period of two weeks. The goal of the experiment was to determine the features and user behavior associated with concept-centered versus courseware-centered discussions in NEEDS. Such results provide insight into how the building of a learning community of users in NEEDS will evolve over time.

The evaluation of the experiment is scheduled to be completed in May 2000. Qualitative analysis of the discussion (i.e., coding and categorization of the text of the discussion) will be used to evaluate the effectiveness of the discussions. The content analysis will include evaluating the depth and focus of the discussions as well as the level of collaboration, reflection, social acknowledgements, unsupported claims and opinions, justified comments, questions, and protocols associated with building contacts. Quantitative levels of activity will be determined by examining the quantity and frequency of discussion, as well as by the number of active participants, and the quantity of related courseware that was downloaded during the discussion session. The quality, quantity and length of the discussion will determine the critical mass of users that is necessary to support such communication. Faculty members who participated in the discussion will be interviewed after the discussions have been completed in order to elicit their perceptions and opinions regarding the session.

The results of this test will be used to further refine the prototype in order that it may be integrated into the next generation of community building services and features in the NEEDS digital library. NEEDS is committed to realizing its vision as a digital library serving communities of learners vested in efforts to strengthen, broaden, and improve engineering education.

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