Exploring the Teaching Challenges of Engineering Faculty: What do they really want to know?

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Abstract: The engineering education community currently focuses a great deal of attention on helping engineering educators adopt effective teaching practices. While strategies in current use have had an impact on engineering teaching and learning, the persistence of engineering courses in which lecture is the primary teaching method indicates that there is room for improvement. We suggest that the success of current strategies is limited by the knowledge we have about the concerns of engineering educators. To address this, we are conducting research on engineering educator teaching challenges. To collect data, we are tapping a unique source — a program that has been highly successful in supporting engineering faculty as they implement effective instructional methods in their courses. This paper reports on this work to date.

Introduction

Ensuring excellence in engineering education is an important goal (National Science Foundation & U.S. Department of Education, 1980; National Research Council, 1995, 1996; National Science Foundation, 1996). In response, the engineering education community has become increasingly committed and responsive to requests for changes in the way that we educate and prepare engineers for the future. For example, a number of organizations and stakeholders have sponsored initiatives focused on defining new goals, developing materials, and providing resources. Such efforts include NEEDS – the National Engineering Education Database (a digital library of educational technologies), the NSF Course Curriculum and Laboratory Improvement program (that supports resource development projects), the new ABET outcome-based accreditation policy, and the NSF Coalitions program (that brought together institutions around coalition-specific missions and large-scale curricular reform).

Work directly with faculty has been a key element of efforts to enhance engineering education. Such efforts to support faculty with their teaching activities can be collectively termed instructional development. Strategies for supporting faculty include workshops, one-on-one consultations, support at campus-wide centers, support at engineering specific centers for teaching and learning, and creation of large scale communities (e.g., the coalitions).

There are clearly a number of tradeoffs among these various strategies. Workshops are a common practice in instructional development; however their success has been limited (Mann, 2001). Although individual consultations may be more effective for fostering lasting change than workshops (Gillespie et al., 2002; Lewis and Povlacs Lunde, 2001), workshops can reach much larger numbers of faculty. Although many universities have a campus-wide instructional development centers offering a variety of services, relatively few engineering faculty participate in campus-wide instructional development programs, in part because they are perceived as irrelevant or useless (Brent et Felder, 1999). Thus, campus teaching centers have had relatively little impact on how engineering faculty teach (Brent et al., 1999) and the practice of spending time and effort on instructional improvement has not become established in engineering academic communities (Brent et al., 2000). The funding of large-scale multi-institutional efforts has promoted teaching innovations more broadly. For example, the NSF Coalitions programs have brought about some changes in teaching (Brawner et al., 1999; Brawner et al., 2001). However, these types of large scale efforts are difficult to sustain.

While such efforts are contributing to the goal of improving teaching, there is still room to enhance the teaching practices in engineering classrooms. For example, full-time lecturing is still the primary teaching method in over 87% of engineering courses (U.S. Department of Education, 2001) even though it is widely recognized as one of the least effective methods for learning.

One response to this situation is to find ways to improve each of the individual instructional development strategies mentioned above. Another approach would be to pursue a mechanism that can contribute to the improvement of all of these strategies. What type of research activities could enhance each of these instructional development strategies? We suggest that one way to make significant progress is to better understand the teaching challenges and concerns of the faculty because strategies that address specific needs of engineering faculty are more likely to be adopted, adapted, and sustained.

In this paper, we report on some of our ongoing work to identify engineering faculty teaching challenges and needs. The work is informed by the tenets of user-centered design, specifically an early and critical focus on the user. The work also takes advantage of some unique opportunities available at the University of Washington.

Thinking of Instructional Development through the Lens of User-Centered Design

In our work, we are approaching instructional development through the lens of user-centered design (Gould and Lewis, 1995; Maquire, 2001). Faculty are users of current as well as prospective instructional development activities. They are the intended audience for instructional development resources, and it is faculty who choose to engage in activities that impact their teaching and their students' learning. Instructional development goals can include helping faculty better engage with curricular materials or better implement pedagogical strategies. Instructional development can be evaluated by the impact that it has on the teaching practices of individual faculty or on the collective teaching practices of the larger community of practice.

How then do the principles of user-centered design apply to the process of improving instructional development? A central principle of user-centered design is early focus on users (Gould and Lewis, 1985, Dumas and Redish, 1999). Early focus on users entails developing a detailed characterization of users that can inform design. There are many types of information to be gained about users, such as information about their goals, their knowledge, and their culture (Turns and Wagner, accepted). Information about user concerns is particularly important because failure to address user concerns can lead to reductions in satisfaction, compliance, participation/use, and effectiveness.

As an example, in a study of users of an arthritis information website, the users were characterized along more than twenty dimensions including their knowledge about arthritis, their specific questions, and their age. In the context of instructional development, users might be characterized by their years of teaching experience and their teaching domains. Additionally, users of instructional development could be characterized by their level of pedagogical content knowledge - knowledge about the challenges of helping someone learn specific content and strategies to overcome these challenges (Bullough, 2001; Shulman, 1987), and pedagogical design capacity - ability and willingness to adapt instructional materials to specific teaching contexts (Brown, 2002).

Information about users, tasks, and contexts is critical to setting design goals, selecting among potential alternative designs, and refining design solutions. In the context of the arthritis information website, decisions affected by user, task, and context information included the content of the site, the tone of the written information, the size of the text, and the depth to which misconceptions needed to be addressed. In the context of instructional development, information about users, tasks, and context could guide decisions of which instructional development strategy to use, where to start, and what level of detail to provide.

Practitioners of user-centered design draw upon a variety of strategies for collecting information, including surveys, interviews, focus groups, ethnographic data collection, informal observation, and verbal protocols (e.g., Maquire, 2001, Robertson, 2001, Ford and Wood, 1996). For example, in the arthritis information website context, a combination of a web survey, phone interviews, and lab-based usability studies were used to collect the data. Data collection methods used to inform instructional development could include surveys and interviews of faculty members and observations of the design and execution of teaching activities.

One of the challenges of user-centered design, particularly in light of constrained resources, is the challenge of defining the data collection plan. Given the wide range of information that can be collected about users, how can the information needs be prioritized? How does a designer decide what is the most important information? Additionally, given the wide range of methods available to collect data, what methods should be used in a particular context? Factors that affect the design of a data collection plan include not only the availability of time and financial resources, but also assumptions made about the users (e.g., to what extent they can describe their own knowledge and goals) and the accessibility of the users (e.g., where are the users, is it possible to meet face to face).

Our current work in instructional development reflects these issues by representing one means to collect information in order to characterize the users of instructional development. Our choice of data collection method reflects the following assumptions about faculty and their teaching activities: (a) teaching, and particularly preparation for teaching, tends to be an invisible activity and one that is rarely discussed openly and (b) faculty have few opportunities to talk about their teaching. Thus, our specific challenge was to find a window into the teaching challenges and concerns of faculty.

The Grant

In June of 2002, we received a grant from the National Science Foundation for a project entitled, "The Teaching Challenges of Engineering Faculty: Insights from a Model Instructional

Development Program (EEC-0211774)." In this project, we are seeking to understand how to more effectively support engineering faculty efforts to increase their teaching effectiveness. To meet this end, we are studying the existing instructional development program at the University of Washington (UW) offered through the Center for Engineering Learning and Teaching (CELT). The mission of this program is to provide professional development for UW College of Engineering faculty in the area of pedagogical innovation. We are conducting research on the CELT program in order to answer the following questions:

1. What are concerns of engineering faculty regarding their teaching activities?
2. What types of information do engineering faculty value when learning about effective teaching practices?
3. How do engineering faculty describe their concerns (e.g., language, key phrasing)?
4. What processes are effective for supporting engineering faculty (e.g., helping articulate their concerns, interpreting research across education and engineering communities)?

The premise of our research methodology is that CELT's instructional development program provides windows into the engineering instructional development process. Our goal is to capture and document the insights that arise from those activities through a rigorous combination of interviews and direct observations. Our work will unfold in three phases. In Phase One, the research team will meet informally with CELT's instructional consultant (also a co-PI on the grant) to discuss her perceptions of recurring themes in her work with engineering faculty. The preliminary results from this Phase One investigation are presented in the methods and results section of this paper.

In Phase Two, the research plan for this study becomes more rigorous, as outlined in Table 1 below. The research will make use of debriefing interviews and case studies (combinations of interviews and observations). Interview and observation data will be audio taped and videotaped respectively.

Table 1. The Research Plan (Phase Two)

Instructional Development Activities			**Estimated Numbers**	
Level	Audience	Strategy	Debriefing	Case Study
Individuals	Faculty	Consultation	60	5
Groups	Department	Workshops	8	1
	College	Workshops	10	1
	Campus	Workshops	5	1
	National	Workshops	2	1
			Total: 85	Total: 9

Over the next two years, the research team will meet regularly with CELT's instructional developer to debrief consultations she has with individual faculty members. The focus of these *debriefings* (see Table 1) will be: (a) the questions, queries, concerns, and topics of engineering faculty regarding teaching strategies, (b) the language they use to talk about their interests, (c) the ways in which faculty progress through these concerns (e.g., which concerns typically precede which other concerns, how quickly faculty move from one type of concern to another), and (d) observations about the culture of engineering education that may affect how engineering faculty engage in instructional development activities. In addition to the debriefings, the research team will conduct *case studies* (see Table 1), in which individual faculty members are interviewed about the issues they bring to the instructional development process and their perceived benefits from participating. This research format, focusing on debriefings and case studies, will also be extended to instructional development workshops conducted by CELT.

In Phase Three, the results of this investigation will provide a set of design heuristics and actual content for a website devoted to providing resources exclusively for the engineering educator. The topics addressed in this website will arise from our debriefings, our observations of instructional development events, and a review of engineering education resources that are currently available. It is our hope that this website, and the fruits of our research, will provide support and direction to engineering faculty nation-wide.

Methods: Phase One

Our first steps have been intended to create a conceptual framework for the further exploration of engineering education concerns. Engineering educators share many of the same concerns as faculty across campus. Engineering is unique in the academic milieu, however, being a complex blend of mathematics, physical sciences, social sciences, computer science, and product development techniques. Instructional development in the engineering context is continually charting new territory as it seeks to optimize student learning in these changing times. Our preliminary attempts have been focused on grounding our research in the explicit concerns of engineering educators and instructional developers.

Currently we are holding informal, semi-structured discussions with CELT's instructional developer. These discussions have concentrated on the themes that reappear in her work with engineering faculty. These themes are quickly becoming a lens by which we will be able to narrow our field of inquiry. We are also beginning to differentiate levels of engineering faculty concerns, including concerns about the institutional context (how engineering educators can best interact with their administration and staff), the classroom context (the challenges encountered when working with students and technology), and the career context (the specific needs of engineering faculty regarding career development). In addition, we have completed a preliminary review of several online resources for engineering educators. This review was conducted to more fully understand the current state of internet-based resources for our targeted audience.

Results: Phase One

The phase one research has given us preliminary insights related to each of our four research questions (i.e., teaching concerns, preferred information types, preferred language, and effective instructional development processes). These preliminary results are discussed below.

<u>What are unique concerns of engineering faculty regarding teaching activities?</u>

Based on discussions with CELT's instructional developer, we have identified the following areas of interest to engineering faculty:

- *Teaching students how to learn.*
  Engineering faculty want classroom strategies for teaching students how to learn. In addition,

some faculty members have directly requested assistance in approaching the administration for systemic solutions.

- *Increasing student confidence in the student/instructor relationship.*
  Engineering faculty share a concern that students are not using office hours as a resource, not coming with their course-related questions or problems.
- *Understanding cultural differences in approaches to education.*
  Engineering faculty, many of which having an international background, may be unaware of some trends in American student culture, especially regarding the outside responsibilities of American students, and the types of educational opportunities in secondary schools.
- *Creating tests that are true measures of student learning.*
  Engineering faculty may be unprepared to evaluate and assess their students effectively.
- *Supporting student collaboration, especially online.*
  Engineering faculty often want to optimize student collaboration in class projects, but may be unsure how to incorporate technological solutions such as Internet tools.

Another perspective on faculty concerns can be gained by looking at the types of questions being asked repeatedly by engineering faculty. Table 2 contains a sample of the types of questions engineering faculty ask, as identified by CELT's instructional developer. It is important to note that these questions represent a sampling of the instructional developer's cumulative impression of faculty questions, based on her experience. Through our research, we will be able to document questions in a way that more precisely captures the questions asked by engineering faculty.

<u>What information do engineers value when learning about teaching practices?</u>

The information needs of engineering faculty, naturally enough, seem to reflect their occupation. These faculty members respect hard data in the form of experimental results, wanting validation for the claimed merits of various classroom techniques. In addition, engineering faculty seem to want concise procedures and action items. They appreciate materials that present a digest of the pertinent and applicable information and provide guidance for classroom activities.

<u>How do engineering faculty describe their concerns (e.g., language)?</u>

This question has yet to be answered to any great extent. However, discussions with the instructional developer reveal that many engineering faculty have strong negative reactions to standard instructional development terminology, or little familiarity with it.

<u>What processes are effective for supporting engineering faculty?</u>

The instructional developer in this study has reported that reframing individual concerns into more global issues is foundational in her practice with engineering faculty. Her clients appreciate the connection made to a larger population of individuals facing the same issue. As mentioned above, these faculty want concrete and specific information. Providing specific guidelines for classroom strategies, such as active learning or student collaboration, gives these instructors and researchers needed information without extraneous detail. For many engineering faculty, information about student lifestyles and student expectations of the educational process can be revelatory. Educating these faculty members about the challenges students face in the present social and economic climate can help them leverage classroom time and resources more effectively. Two additional processes that are effective for supporting engineering faculty are (a) recognizing the varying levels of pedagogical expertise and (b) recognizing that engineering faculty have varied reactions to common instructional development vocabulary.

Table 2. Types of questions asked by engineering faculty

Interfacing with the administration
- How can I get college or campus support for my ideas?
Supporting students as learners
- How can I teach students how to learn? - How do I get students to take responsibility for their own learning?
Increasing student interactions with faculty
- Why don't students come to office hours? - Why don't students follow my suggestions?
Understanding and deflecting math anxiety
- Why are my students anxious about their math abilities? - How can I increase students' confidence in their math abilities?
Writing exams
- How can I write tests that reflect my students' abilities? - How can I write tests that measure student learning?
Supporting student collaboration
- How can I help students work better on teams? - How do I help students deal with a dominating team member? - How can I help a student team actually collaborate rather than divide and conquer?
Using class time
- How do I use class time most effectively? - How can I use examples effectively in the classroom? - How can I make sure students are comfortable asking questions?

While a significant amount of material has been gleaned thus far, much more is waiting to be discovered in the Phase Two research process. As the debriefings and case studies are performed, the resulting data will be added to this matrix of information.

Looking to the future

We are just beginning to learn about instructional development in engineering, specifically to probe into the concerns, processes, and cultural issues associated with engineering teaching and engineering instructional development. In this section, we identify and address some issues associated with this work, building on themes introduced earlier in the paper in light of what we have learned thus far.

<u>Issue 1: What we realize that we do not know</u>

An important part of user-centered design activity, and possibly of research in general, is to find out what we do not know. While our research is clearly premised on the idea that we need to learn about the concerns of engineering educators, we are also identifying other questions to explore. For example, we have come to recognize that the information-seeking behavior of engineering educators remains largely unknown. While our interviews will provide insights into terminology and areas of interest, we know relatively little about how engineering educators find and use the information about teaching that is already available online. How do they formulate searches or browse for the information? Tools to gather this information include an online survey distributed to a wider audience of engineering educators about typical usage patterns of online teaching resources.

Issue 2: Using what we have learned so far…

Although the findings to date are preliminary and raise additional questions, we have already identified a number of ways in which the findings that can be used to immediately impact instructional development activities. The preliminary list of concerns suggests topics for instructional development and provides a basis for surveys exploring the concerns of specific groups of faculty. Documented variability in the level of individuals' pedagogical expertise indicates that instructional developer effectiveness can be enhanced by beginning instructional development interactions with efforts to ascertain participants' pedagogical knowledge. Such assessment, which can be either formal or informal, can help instructional developers to customize activities to suit their user(s). The importance of vocabulary and terminology to engineering faculty suggests that instructional development materials and activities be reviewed for potentially dissonant vocabulary. Instructional development professionals can be introduced to terms that may cause difficulties with engineering faculty. Glossaries or style guides that match traditional faculty development terms with other options could help instructional consultants avoid problematic terms.

Issue 3: Putting the results into practice - The design of the Teaching Challenges website

As mentioned earlier, we will be using the results of our research to develop a website organized around the teaching challenges and concerns that we identify. Our initial results indicate that design of the website should be guided by the following principles:

- Website articles and search functions should contain information that is accessible to varying *levels of expertise* (because faculty have differing levels of pedagogical expertise).
- Website articles and search functions should employ language that is common to engineering educators, since engineering faculty may have strong reactions to terminology commonly used by faculty developers in their work with other faculty.
- Website search functions should have both keyword- and question-based capabilities, and allow for iterative refining of search results, since users may search in an exploratory manner.
- Website articles should contain both *pedagogical research* and *classroom applications*, since engineering faculty want practical solutions in addition to background information and educational research results.

Issue 4: Thinking ahead to the overall results of the study

The value of our findings will become clearer as we complete Phase 2 of the research (in one to two years). We anticipate that the results of this combination of interview and case study research will differ from the preliminary results in at least three ways: (a) we will have more generalized themes with specific examples, (b) we will have more complete information about the prevalence of the issues, and (c) we will know something about different instantiations of the issues.

Conclusions

Helping engineering educators adopt effective teaching practices is an important goal of instructional development. Because the success of current instructional development strategies may be limited by available knowledge about the true concerns of engineering educators, we are conducting research to characterize engineering educator teaching challenges. In this paper, we have described our work to date, including the results of informal discussions and implications of these early findings. We look forward to sharing the richer, more detailed research results as they become available.

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