

PREPARING FOR PROFESSIONAL PRACTICE: COURSE EVALUATION AND IMPLICATIONS

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Abstract: *One goal of engineering schools is to prepare students to become engineering practitioners. At the University of Washington, we have been conducting a variety of research projects devoted to the concurrent goals of (a) articulating what it means to be preparing students to become an engineering practitioner, (b) assessing students preparedness for being an engineering practitioner, and (c) designing and evaluating activities that promote student preparation in areas potentially overlooked in traditional curricula. In this paper, we focus on the evaluation of a two-credit course designed during the summer of 1999 and taught during the fall of 1999. In particular, we describe the motivations behind the course design, the primary components of the course design, and the outcome of an empirical and extensive student-based evaluation of the course. In addition, we discuss the possible implications of the evaluation results.*

Index Terms – Professional Practice, Classroom Activities, Reflective Writing, Guest Lecturers, Ethics

PREPARING FOR PROFESSIONAL PRACTICE

A growing concern that engineering graduates are not currently as prepared as they should be, documented in recent reports on the state of engineering education, has led to a variety of curricular reform efforts in the engineering education community (NRC, 1995; NSF, 1995). For example, researchers are exploring strategies for understanding student approaches to engineering design and for teaching design better (e.g., Radcliffe and Lee, 1989; Atman, Chimka et al., 1998). In this paper, our focus is on learning how we can enhance current programs in order to explicitly help students become better prepared as professional engineering practitioners.

Images of the professional engineering practitioner can come from a variety of sources. For example, the contents of the professional engineer licensing exam, the "PE" exam, provide insight into the types of technical problems that society expects a particular type of engineer to be able to solve (Young, 1994; Young, 1996). Another image stems from the collection of skills and knowledge that are part of the new ABET accreditation criteria (ABET, 1997).

We are investigating another perspective – thinking about a professional engineering practitioner as an expert problem solver. As a result, we have been looking into the literature to determine what contributes to problem solving

expertise (Chi, Feltovich et al., 1981; Chi, Glaser et al., 1988; Ortega, 1989). There, we find at least three contributing factors. First, expert problem solvers organize their knowledge differently than novices do. Second, experts often rely on extensive knowledge of context. Finally, experts often draw upon cases when solving problems.

These ideas are currently guiding us as we explore research targeted toward student preparedness for professional practice. In this paper, we focus on one area of research - the design and evaluation of instructional activities that can enhance student preparedness. Specifically we report on the design and evaluation of a civil engineering professional preparation course that we taught in the fall of 1999. The paper begins with a description of the course and the evaluation approach. We then present the results of the evaluation, covering the eleven topics and the three primary instructional strategies of the course. Based on these results, we suggest some general implications for course redesign.

OUR COURSE

The course we taught was in civil engineering. Table 1 provides an overview of the course. The course had two emphases – providing students with an opportunity to learn about the elements of professional civil engineering practice and providing opportunities to help students restructuring their disciplinary, professional knowledge base. We developed the course by identifying (1) topics that would be associated with each class emphasis, (2) instructional strategies that would be used, and finally (3) class design constraints (e.g., such as the requirement that the class meet on Monday for 2 hours). Examples of the topics and instructional strategies are shown in Table I. The final course design represents a merging of these three considerations.

Concerning the elements of civil engineering practice, it is clear in civil engineering that professional practice requires more than knowledge about structural theory, environmental theory, and other such technical and scientific areas. For a practicing civil engineer, knowledge about contracts, about the processes of getting civil engineering work, about ethics, about quality assurance and about legal issues are all very important. These were the types of

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TABLE I
ELEMENTS OF OUR PROFESSIONAL PRACTICE COURSE

<p>Elements of civil engineering professional practice</p> <p><u>Topics</u></p> <ul style="list-style-type: none"> - Getting civil engineering work (5) - Setting up a Project, Project management (6) - Contracts (7) - Ensuring project success (8) - Preventing & handling problems (9) - Ethics (10) - Cases (3) <p><u>Instructional Strategies</u></p> <ul style="list-style-type: none"> - Guest lectures (L)
<p>Restructuring disciplinary, professional knowledge base</p> <p><u>Topics</u></p> <ul style="list-style-type: none"> - What is civil Engineering? (1) - What is a profession, (2) - Identifying project scope and info needs (4) - ABET Learning Outcomes (11) <p><u>Instructional Strategies</u></p> <ul style="list-style-type: none"> - Class activities (A1-A4) - Weekly reflective writing (W1-W3)

professional practice issues that were identified as important for the course.

With the exception of the ethics class, these topics were covered by guest lecturers. The guest lecturers were invited to speak on the specific topics. It was expected that the guest lecturers would be knowledgeable about their topic, could supplement the topic with specific stories from their experience, and might provide students with professional contacts.

The other emphasis of the class was helping students restructure their disciplinary, professional knowledge base. The underlying goal of these activities was to get students to start thinking about civil engineering holistically and to revisit and structure their knowledge in anticipation of professional practice. Our strategy was to identify topics that would be integrative as well as activities that would promote integration. The integration focused topics included the following: describing civil engineering, exploring the meaning of profession, and discussing the ABET learning outcomes. The instructional strategies that supported the integration/ restructuring goal included a series of class activities and a weekly writing assignment.

A variety of class activities were used. During the first few weeks, students spent class time developing a group concept map of civil engineering. Concept maps are a cognitively motivated learning and assessment tool (Turns, Atman et al., in-press). In the group concept-mapping task (A1), the students were to collaboratively construct, extend, and refine a concept map of the discipline of civil engineering. Other class activities included a problem solving activity in which students identified information needs for the design of a playground (A1), an individual concept mapping task (A3), and a peer review activity in

which students gave each other feedback on their writing assignments (A4).

The weekly writing assignment was the other primary instructional strategy chosen to support the second goal of the course. Each writing assignment consisted of two parts – a synopsis of the material covered by the guest lecturer (W1) and a response to a reflective thought question (W2). We included the synopsis because of the lack of control we expected to have over the content presented by the speakers and because of the open ended nature of the class activities. The synopsis was meant to be a way to reinforce the learning objectives of the course by getting students to reflect on the events and articulate the events and their value to themselves. The reflective questions, which changed each week, provided some context for students to apply the material discussed in class. Because of the nature of the assignments, feedback (W3) was emphasized over scores in the grading of the assignments.

EVALUATION APPROACH

Given the newness of the course, we wanted to conduct an evaluation that would give us some immediate insight into which elements of the course worked and which did not. We also wanted both quantitative and qualitative data. We chose to use a two-part survey.

In the first part of the survey, students individually and quantitatively evaluated the success of each topic and instructional activity used in the class. They did this by rating each topic and instructional activity on five dimensions: enjoyment, thought-provoking, learning, job preparation, and time-worthiness. Appendix I contains a portion of the survey showing how students rated the class topics on the dimension of job preparation.

In the second part of the survey, the students worked individually or in self-formed groups to provide open-ended feedback. Specifically, they provided feedback on (1) their most favorite and least favorite topics, and (2) the strengths and weaknesses associated with the three main instructional strategies (i.e., the guest lecturers, class activities, and weekly writing assignments).

METHOD

The survey was distributed on the last day of class. Students were given an unlimited amount of time to complete the survey. Most completed the first part within 10 minutes and the second part within 15 minutes. Of the 68 students enrolled in the course, 53 students completed the survey. On the second part of the survey, the students formed 19 groups ranging from one to six members.

In this paper, we report on a subset of the overall data collected. Specifically, we focus on (1) the students' perceptions of which the class elements prepared them for their job and (2) the students' open-ended qualitative

comments from part II. A detailed analysis of all part I data is in progress (Turns, Atman et al., in-progress).

The data on student perceptions of job preparation is in the form of agreement ratings ranging from -3 to 3, where the negative values represent disagreement. Because the data is in the form of ratings, we report the median and both quartiles. Mock box-plots, such as shown in Figure 1, were created to display the results. The boxplots show the median value embedded between the first and third quartiles (producing the “box” of the traditional boxplot). The height of this “box”, the difference between the third quartile and the first quartile, represents the interquartile range and is a measure of the variability of the data.

Our analysis of the qualitative data from part II of the survey was done via informal content analysis. The first author organized each set of responses and developed codes to capture clusters of responses. This type of informal content analysis is sufficient for developing a general understanding of the issues represented in the data.

EVALUATION RESULTS

Overall, the evaluation of the class resulted in mixed results – students indicated that some aspects of the course were quite successful and that others were much less successful. Further, students’ opinions on almost all features of the class were quite varied. Often for the same course element, there were students who found the element very successful and students who found the element very unsuccessful.

Topics

As discussed earlier and shown in Table 1, the class touched upon 11 distinct topics. Figure 1 shows students’ agreement with the statement “It prepared me for work.” The figure

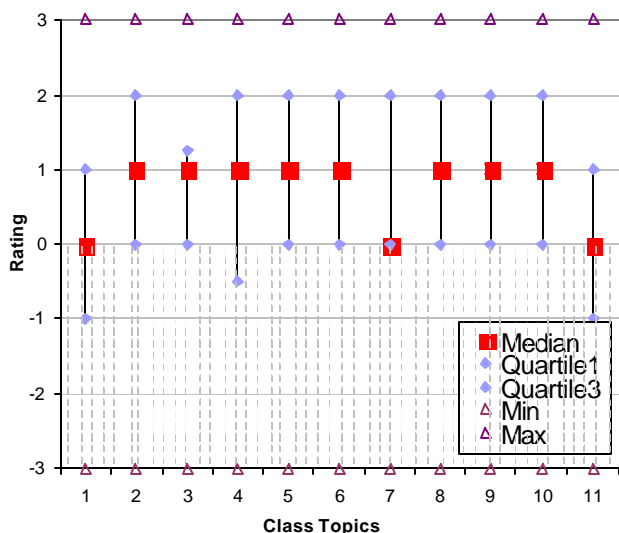


FIGURE 2

STUDENTS’ LEVEL OF AGREEMENT WITH THE “PREPAREDMEFORMYJOB” PROBE, IN RELATION TO CLASS TOPICS

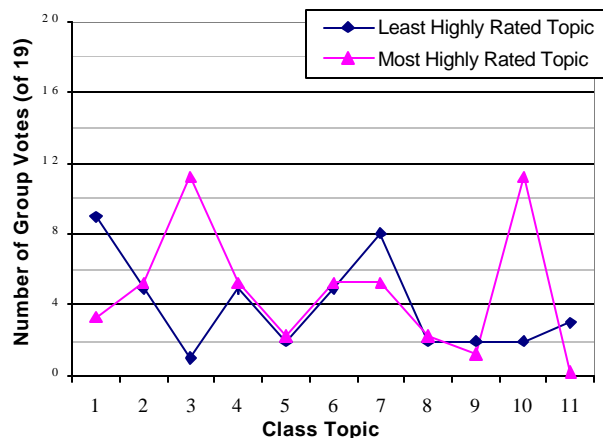


FIGURE 1

NUMBER OF VOTES EACH TOPIC RECEIVED AS MOST HIGHLY RATED AND LEAST HIGHLY RATED

shows that for all but three topics, the median agreement rating was one or higher, indicating moderate agreement. Further, for all but three topics, the third quartile agreement rating was 2, indicating strong agreement that the topic prepared them for work.

The topic of contracts (#7) was one of three topics not perceived as valuable for work preparation. Specifically, the median rating was 0 indicating ambivalence even though the third quartile rating was 2 indicating strong agreement. The students’ qualitative comments shed light on this reaction. Many students had taken an entire class on contracts and felt that the topic was redundant. In contrast, other students who had not taken the contracts class appreciated learning about the topic. Thus, there was a division in reactions.

Another perspective on the topics comes from looking at what topics student groups chose as the most highly rated and the least highly rated. In the qualitative portion of the assessment, students working in groups identified the three most highly rated topics and the three least highly rated topics (where the phrases “most highly rated” and “least highly rated” referred back to the individual ratings students had made in part I of the survey). Figure 2 shows the number of “most” and “least” votes that each topic received. The results in figure 2 should be interpreted with caution for three reasons: the groups did not uniformly choose three topics but sometimes show more or fewer topics, the number of students in the groups varied, and not all of the items listed in response to this question were topics (sometimes the students indicated instructional strategies such as concept mapping).

Nevertheless, the figure shows interesting pattern – all topics received at least one vote as the least highly rated topic and all topics except ABET received votes as the most highly rated topic. For two topics, the case study and ethics, the number of positive votes was much greater than the number of negative votes. In one case, “What is CE,” the number of negative votes exceeded the number of positive

votes by six votes. In the remaining 8 cases, the number of positive and negative votes was similar. For example, it is interesting that the topic *contracts* received five positive votes and seven negative votes. This suggests a difficulty in teaching a class such as this – that students have quite different perceptions of what is valuable.

Instructional Strategies

While the topics were clearly one important element of the course, the instructional strategies represented another important perspective. Specifically, this course relied significantly on guest lecturers to present content material to the students. These guest lecturers were supplemented with class activities, mostly collaborative. Finally, students were also required to write a weekly individual report where they synthesized the week’s activities into a synopsis and then drafted answers to reflective questions.

Again, we can look at students’ level of agreement with the “prepared me for work” prompt in order to understand the success of each of these instructional strategies. Figure 3 presents a box-plot summarizing students’ agreement ratings for the “prepared me for work” prompt in relation to each of the instructional activities.

From the plot, it is apparent that the students were more ambivalent about the instructional strategies than they were about the class topics. Further, it is apparent that there were elements of both the class activities and the writing assignments that students did not perceive as preparing them for work.

Specifically, three elements of the instructional strategies – the guest lecturers (L), the problem scoping activity (A2), and the reflective questions in the weekly reports (W2) – received moderate agreement ratings from most class members. One strategy – the synopsis section of

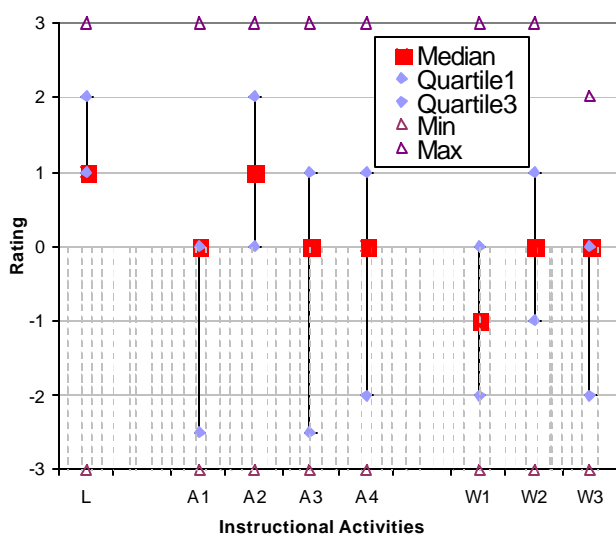


FIGURE 3

STUDENTS' LEVEL OF AGREEMENT WITH "PREPARED ME FOR MY JOB" PROBE, IN RELATION TO INSTRUCTIONAL STRATEGIES

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the weekly reports (W1) – received overwhelming disagreement. The remaining elements of the instructional strategy resulted in neutral or ambivalent ratings -- the median agreement rating was 0. In the subsequent sections, we explore these results further as well as discuss students’ qualitative comments concerning the strengths and weaknesses for each of the three main instructional strategies.

Guest Lecturers

As Figure 3 shows, the students were very much in agreement that the guest lecturers had helped to prepare them for their jobs. In their open-ended comments, the students identified a variety of strengths associated with the *guest lecturer* instructional strategy. Specifically, two groups mentioned that having different presenters was good, two groups mentioned that they gained professional contacts (the speakers), two groups indicated that they found the materials used by the speakers to be high quality, and three groups mentioned simply enjoying the presentations made by the speakers. Overwhelmingly, students alluded to the experience of the speakers (e.g., “practicing engineers,” “information came from first hand experience”) and the “real world” nature of the information (e.g., “real world perspective,” “glimpse of the real world”). It seems, more broadly, that the speakers were viewed as authentic and that the students felt that the authenticity was helping them in some specific way. Perhaps the key is in one group’s response concerning the speakers – “they know what they were talking about and we respect work experience.”

In terms of improving the use of guest lecturers, the students overwhelmingly suggested that the lecturers come from more than one company (12 of 19 groups suggested this). In our class, all but two guest lecturers represented a single large consulting civil engineering firm. In designing the class, we (the authors of the paper) had thought that a use of speakers primarily from one firm would promote continuity. However, it seemed that students were more concerned about gaining insight into a variety of possible job environments. Students’ comments in this vein included:

- “Too many speakers from firm x. What about environmental, public agencies, construction, grad school.” and
- “Get someone besides firm x (I wouldn’t want to work for firm x)”.

Most of the remaining comments dealt with ensuring that the presentations were as effective as they could be. While one student suggested that we accept what we get, “seems like they are helping us. Therefore we should not be picky,” others made insightful suggestions about changes. For example, three groups noted that the speakers may not have talked in a level appropriate for the student audience (e.g., “We think the speakers assumed too much background knowledge.”) Four groups suggested that the speakers could have made better decisions about the scope of material they tried to present (e.g., “don’t try to cover so much” and

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“some speakers tried to present TOO MUCH information in a short period of time (NOT FOCUSED.)” Three other groups made suggestions about materials including a request for more illustrations of actual civil engineering sites and more handouts for the students. Two groups expressed concern about overlap between topics by different speakers. This is ironic since one reason we decided to use guest speakers from one firm was to promote continuity and minimize overlap. Finally, three groups made specific suggestions about how to better integrate the speakers into the class, including (1) introducing lecture topics one week in advance so students could prepare questions and (2) having guests lecture for only 30 minutes (rather than the 45 we used) and thus leaving more time for questions.

Class Activities

The students cited three general areas of strength for the class activities. First, 9 of 19 groups indicated that the interaction among students was a strength of the activities. Second, 7 of 19 groups indicated that the class activities were thought-provoking, through comments such as “activity spawned thought,” “students challenged to think differently,” and “concept maps stretched our thinking.” In addition, three groups indicated that the class activities made class lively (“broke up class so wasn’t as boring) while two groups commented on the quality of the materials used to organize the class activities (e.g., “clarity of expectations, good handouts”).

The suggestions for improvements came in three broad categories – specific activities, the appropriateness of the activities, and general improvements. Concerning specific activities, seven groups of 19 suggested discontinuing use of the concept maps, two suggested discontinuing the peer review, and one complained about the ethics activity. A minority of groups expressed deeper concerns. One group suggested that the activities were busywork (e.g., “didn’t require us to expand on topic”). Two groups suggested that the activities underestimated their abilities as seniors (e.g., “I think that people felt like we were being led by the hand” and “Concept mapping makes you feel like you are back in grade school”). More general suggestions for improvement included a request for more variety (4 groups), maybe including field trips (1 group), and assigning the activities as homework so groups could do them outside of class (2 groups). A final suggestion, made by a single group, was to have class earlier in the day – the class was held once a week on Monday from 3:00-5:00.

Weekly Writing

Recall that the weekly reports had three elements: the synopsis, the reflective question, and the feedback. Like the class activities, these different elements of the weekly reports received different reactions from the students. In the case of the reflective questions and the feedback, the median rating of 0 indicated ambivalence that the activity prepared

them for work. Concerning the synopsis, over 50% of the students indicated moderate disagreement that the synopsis prepared them for their job. In these results, we were curious about the ambivalent results concerning the feedback and the reflective questions, and intrigued with the negative result concerning the synopsis. The qualitative comments shed light on these results.

The three most commonly cited strengths of the reports were that they (1) reinforced the materials covered in class (7 of 19 groups), (2) stretched thinking (7 of 19 groups), and (3) resulted in a reference for use later after the class. We were reassured to see students articulating these strengths since we had intended for the reports to be used in these ways.

The prominent suggested improvement was to stop requiring the synopsis. Student comments on this element of the reports helped us to better understand the negative rating. For example, students’ comments included:

- “Regurgitating material is a waste of time”, and
- “Documenting what we did in class was tedious. You might as well just make attendance mandatory and take role.”

It seems that students believed that the goal of the first part of the report was to demonstrate that they had been in class. That they may not have understood the learning power of writing a synopsis is suggested by the verb “regurgitating” in describing what they were writing in the reports. We had hoped the students would synthesize. Overall, nine of 19 groups suggested that the synopsis be removed.

The remaining suggested improvements addressed the reflective questions, the feedback, and the submission of the reports. Concerning the reflective questions, students suggested that the questions were sometimes excessively long. Concerning the other issues, students wanted more thorough feedback on their reports and wanted to be able to email their assignments.

IMPLICATIONS

Since we will be teaching a new course in the spring of 2000, we are quite interested in the results of this evaluation. The evaluation results have implications in the following areas:

- 1 Learning to use guest lecturers effectively. Our results suggest that even though our use of guest lecturers was successful overall, we still have room for improvement. Specifically, the students’ suggested, in their open-ended comments in part II of the survey, that we can help the guest lecturers be more effective by (1) helping them understand the knowledge level of the students, (2) helping them identify an appropriate scope for their talk, and (3) providing greater guidance in order to prevent overlap between lecturers. Further, we heard the students loud on clear on one issue – next time we will use speakers from a variety of work environments.

- 2 Ensuring effectiveness of designed activities. While the finding that students disliked the synopsis was not so surprising, the finding that they may have misunderstood its purpose was surprising. This suggests to us the importance of explaining, and continually emphasizing, the motivation behind activities such as the synopsis. While this point may be true in all instruction, it seems that it could be particularly important in a course about preparing for professional practice since the topics and activities may be out of the norm for many students.
- 3 Managing individual differences in preferences and needs of the learners. In almost all of the results presented in Figures 1 and 3, we see students both agreeing and disagreeing about the effectiveness of each topic and instructional strategy. This suggests an underlying challenge in teaching a course such as the ones we are exploring. Specifically, students have different learning styles, different perceptions about what they find interesting, different perceptions about learning, and different ideas about what is valuable to learn. Thus, it may not be possible to satisfy all students at once. The challenge may be to balance the various elements and also to find ways to help everyone to find each element valuable.
- 4 Understanding what students think prepares them for professional practice. For the final issue, we return squarely to the goal of the course. We are interested in designing courses that help prepare students for professional practice. Our results that a number of students gave low ratings to each topic suggest that we may need to explore what student think prepares them for professional practice and their jobs. For example, the ABET topic, which could have been seen as directly related to assessing preparedness for jobs, was not seen as valuable for job preparation by many students.

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APPENDIX I. SURVEY EXCERPT

Evaluation of Topics: Please use the following tables to complete the rating task for the various topics covered in CIVE 440. Each table provides you with the opportunity to rate the topics relative to one specific statement. Please remember:

- 3 = I strongly agree with the statement
- 0 = I neither agree nor disagree with the statement
- 3 = I strongly disagree with the statement

4. **Prepared me for Work.** Please circle the number to the right that indicates the extent to which you agree with the statement, "It prepared me for working in an engineering context." when applied to each topic.

TOPIC	I Enjoyed It						
Week 1: What is civil engineering	-3	-2	-1	0	1	2	3
Week 2: Being a Professional	-3	-2	-1	0	1	2	3
Week 3: Overviewing a Project – I90 Interchange	-3	-2	-1	0	1	2	3