A Look at Integrating Technology into Active, Community-Based Learning

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Abstract - Using learning theory as a guide, the Department of Mechanical Engineering at the University of Texas at Austin initiated PROject Centered Education (PROCEED) to actively integrate projects across the curriculum. During the implementation of PROCEED, it became apparent that there is a growing potential to facilitate project-based instruction with the aid of instructional technology. A PROCEED implemented machine elements class utilized an electronic portfolio to encourage the use of experiential and inquiry-based communal activities, enhance meta-cognitive processes, provide alternative forms of assessment of student learning, and create a repository of student ideas. This paper explores the dynamics of this PROCEED developed machine elements course by analyzing the professor’s motivations influencing his pedagogical decisions, a description of the electronic portfolio used to promote learning processes, and the impact of the electronic portfolio innovation on instructional practice.

Index Terms - e-portfolios, peer-to-peer learning, project-based instruction, teaching practice.

INTRODUCTION
At the University of Texas at Austin (UT), typically mechanical engineering students take a machine elements course in their third year of study. This course offers real-world examples that build upon previously learned strength of materials courses, and provides a precursor to more senior design efforts. In this way, such a course offers a bridge between analysis and design courses. Machine Elements (ME 338) at UT, however, tends to contain numerous terminology and various failure criteria that, while informing students about the various aspects of mechanical components, often fail to tie together engineering analysis and design. In order to address this concern as well as other needs, the Department of Mechanical Engineering initiated PROject CEntered Education, PROCEED [1] to actively integrate projects across the undergraduate curriculum. PROCEED is intended to encourage both teachers and students to focus more on course projects, and is a multi-faceted, department-wide program involving curricular innovations at all levels. In ME 338 student projects were introduced into the curriculum to improve students’ abilities in making connections across various engineering topics and in mastering less tangible skills such as “mechanical intuition.”

Project-centered learning (PCL) “is a social activity that provides an externally valid context in which students can actively formulate and solve problems using a balanced pallet of theory, first principles and pragmatics.” [2] In PCL classes, students are active doing things and thinking about what they are doing. That is not to say that lectures are no longer part of the curriculum, but rather that lectures and student-centered activities are included as instructional strategies. Since 2002, ME 338 has included PCL and efforts have been made to assess its impact on student learning [3, 4]. In this paper, however, the topic of inquiry is not PCL, but instead a look at how pedagogy (that uses PCL) and technology can be integrated into an active, community-based learning environment.

BACKGROUND
In the summer of 2001, the Department Mechanical Engineering formed a committee to explore the use of an electronic portfolio tool to document and assess student progress in PROCEED curricular innovations. After a review of existing portfolios, the decision was made to embark on the development of a customized portfolio system. The College of Engineering has a Faculty Innovation Center (FIC) which provides media, instructional and faculty development services and therefore, the FIC teamed with the committee chair, Dr. Matt Campbell, to build an original portfolio tool. This in-house system called Polaris provides students an environment to record their work, present projects, and reflect on their own educational progress [5].

Rapid developments in computers and digital technologies are influencing instructional practice as is evidenced in Web-based environments like online portfolio systems. Lankes defines electronic portfolios as a “purposeful collection of student work that exhibits the students’ efforts, progress, and achievements” [6]. Creating an electronic portfolio has been a long-term investment with the launching of Polaris in 2003. Since Polaris was internally developed, it is designed specifically for engineering students and is often undergoing iterative changes to enhance its functionality. Polaris benefits students by giving them a personalized yet professional looking Website for displaying projects, journals of internships/co-ops, and other scholastic efforts. It also serves as a forum where students
can reflect on the “whys” of their course work and their development as engineers. Through this reflection, students are better able to present their interests and skills, not just through the materials they post in Polaris, but also in conversations with others.

While many engineering students use Polaris to document their progress, its potential to facilitate instructional interactions, such as those in a project development cycle, had not been explored. Recent publications and educational research indicate the value of integrating technology into active, problem-based classes [7] and, with that in mind, a decision was made to introduce Polaris into ME 338. Dr. Campbell, the professor of this course, was aware that the class tends to be taught in a very content-intensive manner – full of definitions and simple relations for calculating component behaviors and component failure.

The course objectives are as follows:
• To demonstrate improved mechanical intuition,
• To effectively work in teams and apply interpersonal skills in an engineering content,
• To practice selecting and/or designing components,
• To better communicate mechanical concepts, and
• To describe how engineers design to avoid failure.

In order to accomplish these objectives, students in the class complete a series of class projects which complement the traditional lecture-homework-test format.

It is precisely because of Dr. Campbell’s interest in actively incorporating technology in his class, and his support and belief in the importance of a project-centered engineering education, that he is an interesting case to investigate. The course is organized with three projects during the semester, all of which incorporate critical ideas. In the past, groups of two and three students turned in written project reports and prototypes that were assessed solely by the professor. He wanted to, however, modify Polaris so that it could allow for student work to be electronically posted in order to undergo multiple phases of project planning, analysis, feedback, research, revision, and consultation with their peers.

With funding from VaNTH [8], a graduate student researcher from the College of Education was hired to help modify Polaris to incorporate current approaches advocated in the How People Learn framework [9] and to document the professor’s experience as he undertook this process. A study like this provides an examination of the multidimensional context within which learning occurs.

**Methodology**

The initial objective of this project was to improve an existing instructional technology and to explore pedagogy by examining the actions, characteristics and observations in a classroom and of its instructor. With this case study, a particular instructor is “under the microscope” in order to get an in-depth perspective on the multifaceted aspects of pedagogical thinking and change. The basic qualitative methodology used in this study is grounded theory [10], a systematic and inductive approach to qualitative research that “grounds” its results and theories in the data. By allowing the emergence of concepts (versus the deriving of theory) you avoid “putting together a series of concepts based on experience or solely through speculation (how one thinks things ought to work.” [10]. In this project, however, the researcher went beyond that of strictly an observer to participant observer with active involvement in the process of revising course projects for compatibility with Polaris. This active role promoted an iterative process of analysis, feedback, reflection and revision with the professor and the Polaris development team.

In order to get an in-depth insight of an educational change process, multiple points of data are needed. The data in which this study are grounded consist of detailed field notes of classroom observations (four total), two tape-recorded and transcribed semi-structured interviews with Dr. Campbell, articles describing his PCL approaches in his machine elements course, and papers describing the pedagogical aspects of Polaris, original and revised projects assigned to students and a tape recording of the planning/revision session of the second project.

Specifically the field notes and observations describe the classroom environment and include documentation of student engagement, type of teacher/student interactions, questioning techniques, class activities, resources, the degree of teacher- and student-centered instruction, and instructional methods. Interviews, planning sessions, and related articles enabled a deeper look into the beliefs and motivations that influenced pedagogical decisions, his views on the role and purpose of an instructor, his perspective on community, and his attitude toward and valuation of technology in the learning process. These multiple sources of data, collected over a four month period, provide a holistic view of the learning experiences of the course and help to ensure a more accurate representation through the process of triangulation.

Field notes and transcribed interviews were analyzed through an open coding process that is context-sensitive in order to determine common themes and categories. During the process of initial coding, additional areas and dimensions are realized that influence further data collection as well as sensitize the researcher to aspects of the data. Thus initial categorizations and coding are challenged and reformulated. Finally selective coding and coding for process were done in order to identify relationships between categories, it integrate and develop patterns of connectivity, and to generate a theory to explain how instructional methodology in this case study impacts technological innovation and classroom community. This initial study is intended to help create a framework for future research and to help the faculty member reflect on pedagogical approaches and their implications.
INSTRUCTIONAL PERSPECTIVE

The professor involved in this study began his academic career at UT and approached teaching by “teaching how he was taught.” Although in his department and in the College there are numerous resources like the FIC to support faculty development, Dr. Campbell for the most part relies on practical experience when it comes to pedagogy. The process of critically examining his approaches and beliefs about teaching and learning gave him insights into the “whys” of instructional practice and also resulted in case of contradictions as illustrated in Figure 1.

Personal beliefs about the purpose of education and the teacher’s role have a significant role in informing instructional decisions [11]. While Dr. Campbell’s own schooling did not involve a lot of hands-on learning, he could see students benefiting from it. He uses lectures for the “heavy intellectual lifting” and noted, “I’m standing there, and not to be self-centered, but they’re there to hear some amount of wisdom spew from me for the next 75 minutes. And like I said I’m really trying to connect things in the book.” His view of a classroom is one that is teacher-centered where peer interactive learning is for outside class. With this perspective in mind, he promotes a shared learning community outside of lecture through the use of projects and home work assignments.

![A Case of Contradictions](image)

**FIGURE 1 A CASE OF CONTRADICTIONS**

**EMERGENT THEMES**

From this study four main categories emerged that impact the classroom climate and teaching practices in Dr. Campbell’s classroom.

- Significant factors influencing course decisions
- Technology usage
- Instructional methods
- Classroom community

The first theme or category reveals how personal experience strongly plays a major role in Dr. Campbell’s pedagogical approaches. That he is largely influenced by how and what he was taught is not surprising for this term is a widespread and common phenomenon known as “apprenticeship of observation” [12]. His belief, however, that a teacher is “somewhat an entertainer” and that students are often passive in the classroom, results in some disconnect for him. Given that research supports active learning “instructional activities involving students in doing and thinking about what they are doing” and he promotes active learning with out-of-class projects, he struggles how to create an actual student-centered classroom. As the professor with the knowledge he maintains the metaphor of students as “sponges” and therefore class time is mainly devoted to teacher talk.

It seems obvious that involving instructors in the development, selection, and use of instructional support materials results in more acceptance of such materials. The technology implemented in this study was developed with considerable input from Dr. Campbell yet he initially viewed Polaris as student-driven resource and one that would be used in non-interactive format. In order to analyze the use of technology within his instructional delivery, four subcategories emerged: traditional technology, show-and-tell, Polaris, and class projects. In general, Dr. Campbell’s use of technology in ME338 conveys the importance of doing engineering, developing mechanical intuition, and connecting the big ideas in the discipline. For him, using technology such as a PowerPoint does little to promote student learning, “I don’t need PowerPoint to talk about a bolt. Here’s a bag of bolts…pass them around and we just talk about it.” In his classes he brings in physical examples of bolts, bearings or gears to show to students and to pass around the room. His reasoning for doing this is aptly described by his comments, “You want to be able to see it… I remember learning about journal bearings as an undergraduate. I was just like, ‘…Journal bearing? It is a hole in this shaft. A shaft and a hole? Where is it? What does it look like?’ A lot of faculty might have a tendency to jump right to what the phenomena is, what it’s solving, the equations. But you really need to sort of see it, hold it in your hands, pass it around to get a sense you know it.”

The notion of artifacts being relevant to instruction extends to how Dr. Campbell sees the use of a portfolio tool. He draws upon the analogy of a fine arts portfolio when he describes how engineering students can connect their educational experience and present their skill sand talents as engineers. When presented the idea to extend Polaris’ abilities to provide online space for shared comments, gathering feedback, and recording group progress rather than just serving as a depository site for group projects, Dr. Campbell was enthusiastic. The projects are designed to provide students realistic situations in which engineers are confronted with a problem they might know little about and are unaware of the necessary information and data. Students
have to first figure out what they need to know and then how to locate and use the data. One of the dilemmas Dr. Campbell faced with the project groups is how well they functioned as teams and how to provide timely, instructive feedback.

Transitioning the projects to Polaris involved analysis of the written detailed instructions provided for each of the three projects. Students self-select their groups and no direct instruction on how to function effectively in teams was provided. While no additional class time could be devoted to teaming, links to online resources were added to the project requirements hand-outs. Although students were provided directions with a step-by-step process, peer-to-peer learning only existed within groups. With Polaris, a great sense of community and peer learning was promoted with a feedback cycle added that included required intra-group reviews that were posted electronically. Additionally a second feedback cycle was added to evaluate other group’s revised efforts. This iterative feedback cycle gave students chances to not only further their own understanding with their projects, but to question assumptions made by their peers. Polaris is a home-grown environment that allows for ongoing changes and this flexibility proved instrumental in adapting Polaris to meet his instructional expectations.

“Showing them” is not all there is to teaching although many professor, such as Dr. Campbell (as evidenced by his comments and classroom practice) have a tendency to equate teaching with lecturing. The organization of class activities, examples, assessments, questioning techniques, and so on all fall under the broad category of instructional methods. He describes class preparation and planning as, “In terms of lecture, I mean lecture is not all of it, but that’s where most of my energy goes. I guess I’m thinking in terms of my lectures because 90% of my efforts go into doing the lectures two times a week.” His class time is mainly spent with in lecture and very little pre-planned or spontaneous peer-to-peer interactions and collaborations occur. The majority of the communication flows from the teacher to the student with occasional student questions interspersed throughout the lecture.

Attempts to gauge student understanding with questions are infrequent and less than half of these questions are specific, directed, and allow for adequate student response time. Class time it appears is a time for students to listen and to take notes. Not only are his questions infrequent, but students seldom asked questions.

While his questioning techniques are limited, he thrives on continually modeling problem solving strategies. He diagrams and models his thinking as he works through calculations to support his conclusions. He carefully emphasizes abstractions, generalizations, and the higher organizing concepts of engineering. He provides both a conceptual and visual framework for his students. He is concerned about the balancing act between working realistic problems and being overcome by the complexities of the problem. He works hard to provide adequate contextual relevance for his students for he keeps in mind, “The real goal for the class, if you are not designing elementary components (such as gears), but you’re building things out of them, is for you to know, to look at, how they work.”

Fundamental to his lecturing is the use of visuals such as diagrams, charts, pictures and graphs. He routinely draws pictures because that “is such an important skill for an engineer, to know you can simplify it, to be able to do it.” Charts are used to illustrate design procedures and to help students organize their thinking. Students are not asked, however, to practice this type of thinking when they are in class.

The final category to emerge from this study is the idea of community. Two clear, yet conflicting views of community exist. The community inside the classroom can be categorized as teacher-director with is largely a result of instructional strategies and learned student behaviors. The community outside the classroom is being encouraged by the use of technology and posted projects augmented by required peer feedback. Promoting cooperation and not just competition among the groups is an issue that Dr. Campbell questions. Until he saw first hand the quality of the feedback and the insights these students shared with each other, he felt more confident that students were capable of promoting each other’s progress and thinking. He reflected on how his feedback after multiple semesters of this course can at times be a bit “stale” and how students, with their fresh sense of understanding, see things in a unique perspective. Furthermore, the “public” posting (posted within a class restricted environment) allowed students to review multiple projects which often deepened their own thinking and questioning. For those curious students desiring to know more, Polaris gave them a forum.

CONCLUSIONS

Although there is currently much discussion in education on the efficacy of technology in instruction, it is useful to go beyond the effectiveness issue and take a look into actual instructional settings to see the factors at play in the integration of technology to higher education instructional practice. Since this paper provides an in-depth look at a single professor, there are limitations to any generalization of these findings. An initial study like this one provides insights into instructional philosophy and attributes that contribute to the ability or the inability to institute change. As discussed in this paper, classroom climate and teaching practices are highly influential in this process and by scrutinizing the beliefs, strategies, and resources involved, it allows us to provide formative feedback in an instructional cycle as well as to contribute topics for further study. With the professor and instructional elements described in this paper, consistency and integration between instructional activities, assignments, and personal beliefs are still somewhat conflicted. Creating a classroom collaborative...
environment that still allows for lectures and teacher directed activities can be perplexing. In ME 338, a dichotomy exists between two distinctly different notions of class community and interaction within the classroom and outside of class activities. The diagram in Figure 1 is titled “A Case of Contradictions” because of the apparent conflict between the underlying goals of a more reformed-based use of instructional technology, teaching and active learning environments, and his current instructional practice.

With the advances from the last couple of decades, we have greatly increased our understanding of learning and its developmental, cognitive and social aspects. Yet it is recognized dilemma to put into practice researched-based educational advancements. In this paper, an educational graduate student collaborated with and studied a professor’s pedagogical decision making in order to facilitate change. It was encouraging that the professor willingly reflected on his teaching and could so in a critical manner. He began to questions his assumptions and in this process discovered some need re-examination. His awareness of some contradictions between good teaching practices and what his model has led him to more actively explore what is recommended best practice and to continue to utilize Polaris to expand students’ social and cognitive activities.

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REFERENCES


