Work in Progress - A Mixed-Methods Study of the Effects of First-Year Project Pedagogies on the Motivation, Retention, and Career Plans of Women in Engineering

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Abstract – **Our research project compares two first-year engineering course project pedagogies to identify approaches that enhance the likelihood of women continuing in engineering majors and entering engineering careers. Specifically, we compare the problem-based learning (PBL) model to a more general experiential learning approach centered on the engineering design process, referred to here as the traditional engineering design model (TED). We hypothesize that the PBL model, with extensive faculty facilitation, will increase the likelihood of women persisting in an engineering degree, achieving higher grades in future classes, and going into engineering careers. Our research is grounded in motivational theory, and particularly in a model that integrates aspects of existing theories including participation-identification, expectancy-value, and self-efficacy. We are testing this integrated model and the research hypothesis through a longitudinal, mixed-method analysis, with data collected from five cohorts at two large research universities.**

Index Terms – First Year Course, Gender, Problem Based Learning, Retention

INTRODUCTION

Despite the growth of design projects in first-year courses, little research to date examines the pedagogies appropriate for such courses or seeks to understand in detail how such pedagogies affect women's experiences in engineering. Broad studies of retention data do show promising results for women in project-based courses [1]. However, given the wide variations in the way such projects are implemented, engineering educators need a richer understanding of how specific project-oriented pedagogies affect students', and particularly women's, beliefs about engineering and their intended career plans. We focus on women because of the continued underrepresentation [2] and the associated need to insure effective retention efforts in the midst of a movement to enact large-scale curricular transformation in engineering.

To address this gap, we use an experimental design over three years to investigate the problem-based learning (PBL) model in comparison to a more general experiential learning approach centered on the engineering design process, referred to here as the traditional engineering design model (TED). The comparison will enable us to identify elements of the model most likely to better support the persistence of women in engineering. Using a longitudinal, mixed-methods approach, we address the question: **How does applying the PBL principles of problem definition and team facilitation to first-year design courses affect women's beliefs about engineering and their persistence in engineering when compared to traditional engineering design project pedagogy?** We will use qualitative results from observations and interviews in conjunction with patterns demonstrated through quantitative survey analysis. This paper describes the overall research project and the current status. In this first year, we are collecting baseline data from PBL and TED applications.

THEORETICAL FRAMEWORK

Our theoretical framework integrates several relevant motivational theories, including participation-identification [3], expectancy-value [4], and the self-efficacy [5], into a single model. Research provides evidence for each of these three theories separately as affecting students' choices to engage and persist in academic and career related activities, yet none is sufficient in itself to completely explain retention and career choices of women. In combination, however, they provide a more integrated and comprehensive model to explain both short- and long-term outcomes. Figure 1 illustrates elements of our integrated model, and our hypothesis that facilitated PBL learning in the short term leads to increased sense of belongingness, value for engineering related activities, and expectancy which in turn leads to higher retention, career choices in engineering fields, and achievement. We predict that 1) the facilitation aspect of PBL will increase women's opportunities to succeed and foster women's belongingness to engineering; 2) women will be less likely to drop out of engineering and

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more likely to choose a career in engineering as a result of increased value in engineering-related activities associated with PBL; and 3) PBL will increase women's expectancies in engineering because of success during the learning activities resulting from both the active learning orientation and the work of the facilitators.

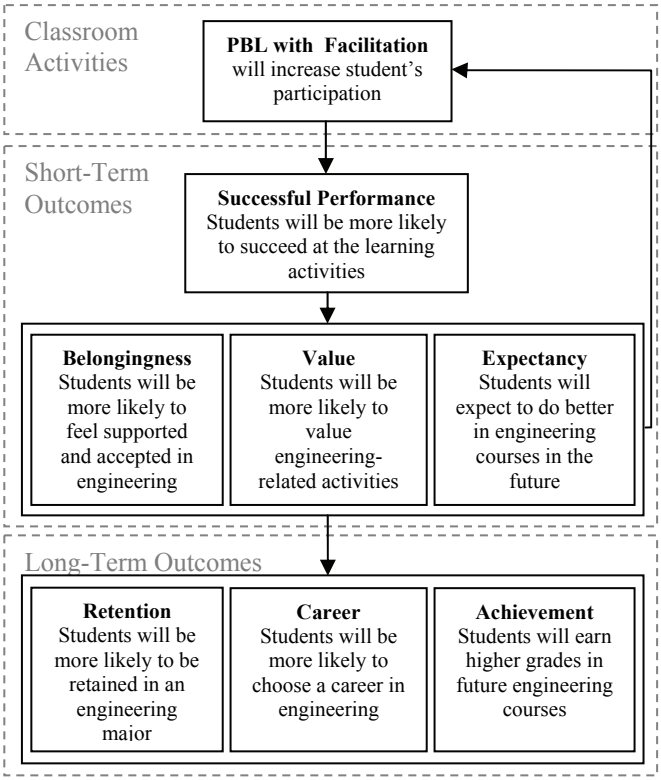

FIGURE 1
CONCEPTUAL MODEL OF THE RELATIONSHIPS AMONG THE PRIMARY ACTIVITIES AND THE MAJOR PROJECT OUTCOMES

METHOD

Using mixed-methods, this study compares first-year engineering course pedagogies at two universities. At State U1, students enter specific engineering departments in their first year. A well-defined PBL model has been employed successfully in the first-year program in biomedical engineering (BME) for several years. At State U2, students enter a large general engineering program that uses a more general project-based TED approach to integrate design projects into the first-year curriculum. Our study examines each model individually, and then creates interventions at State U2, to test the effects of both the project definition and team facilitation practices from the PBL model.

Data collection includes surveys, interviews, and observations for each of five cohorts of students. The quantitative data (surveys) predominates, with qualitative data (interviews and observations) providing explanations for quantitative trends. Table I shows the five cohorts of students in the study. Data collection on Cohorts 1 and 2 began this year (Year 1) and provides baseline data. An intervention at U2 in Year 2 will create experimental groups, including Cohort 3 having TED with facilitation (TED+F), Cohort 4 having PBL-style projects, and Cohort 5 having PBL projects with facilitation (PBL+F). This design allows us to isolate and compare effects of problem-design and facilitation. We will collect pre- and post-intervention survey data and conduct observations and interviews. We will follow-up with participants from all five Cohorts in Year 3 of the study to look for longer-term effects.

TABLE I
STUDY COHORTS

Cohort	*Setting*	*Data Collection*
1	U2 (TED)	Start of Semester Survey (Year 1) Observations (Year 1) End of Semester Survey and Interview(Year 1-3) GPA (Year 1-3)
2	U1 (PBL+F)	Start of Semester Survey (Year 1) Observations (Year 1) End of Semester Survey and Interview(Year 1-3) GPA (Year 1-3)
3	U2 (TED+F)	Start of Semester Survey (Year 2) Observations (Year 2) End of Semester Survey and Interview(Year 2-3) GPA (Year 2-3)
4	U2 (PBL)	Start of Semester Survey (Year 2) Observations (Year 2) End of Semester Survey and Interview(Year 2-3) GPA (Year 2-3)
5	U2 (PBL+F)	Start of Semester Survey (Year 2) Observations (Year 2) End of Semester Survey and Interview(Year 2-3) GPA (Year 2-3)

U1=UNIVERSITY 1 (BIOMEDICAL ENGINEERING); U2=UNIVERSITY 2 (GENERAL ENGINEERING; TED=TRADITIONAL ENGINEERING DESIGN; PBL=PROJECT BASED LEARNING; F=FACILITATION

CURRENT STATUS

All students enrolled in a specific first-year BME course at U1 and a specific first-year general engineering course at U2 were invited to participate in an online survey during the first several weeks of class. The response rate at U1 was ~35% while the response rate a U2 was ~50%. At the end of the semester, students were invited to take the survey again to measure changes over the semester. During the semester, we observed regular meetings of 6 project/design teams each for Cohorts 1 and 2. At the end of the semester, we also interviewed approximately 10 men and 10 women from the observed teams in each Cohort. We will use quantitative and qualitative data analysis outcomes in designing the Cohorts 3-5 interventions.

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