

## The Freshman Engineering Experience: The Student Voice

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### Introduction

Discussions between program officers from the GE Fund and faculty in the Schools of Science, Education and Engineering that began in September, 1996 eventually lead to a multi-year commitment to support an examination of the Freshman Engineering Program at Purdue University, as a first step toward a re-examination of the process by which engineers are educated at that institution. Faculty and representatives from the Dean's Offices in both Science and Engineering became involved in this project because a significant fraction of the "freshman engineering experience" is delivered by faculty in the Departments of Chemistry, Mathematics, and Physics within the School of Science. From the beginning of this project it was clear that the first step toward making significant, worthwhile, and lasting changes in the freshman engineering experience involved obtaining a better understanding of the lived experience of freshman engineers from the perspectives of both the students, the faculty who teach courses taken by these students, and the faculty who teaches courses that build on this foundation. A significant fraction of the first-year's effort was therefore devoted to a self study.

### Significance

The significance of this study revolves around five issues.

- This study provides an example of the difference between the research paradigms known as *phenomenology* and *phenomenography*.
- It provides an example of how research methodologies developed for use in science education can be adapted for institutional research that provides a basis for the self-study required by accrediting agencies such as NCA (The North Central Association Commission on Institutions of Higher Education) and ABET (Accreditation Board for Engineering and Technology).
- It provides an example of cross-discipline curriculum reform efforts that involve not only coordinated efforts within a given school at the tertiary level — e.g., among faculty in Chemistry, Mathematics and Physics — but involve interactions between faculty who deliver

instruction in introductory courses and faculty who teach the capstone courses that build on this introduction.

- It provides another glimpse at the difference between the lived experiences of the students enrolled in a course and the faculty who teach these courses.
- Most importantly, perhaps, it provides a better understanding of the lived experiences of freshmen students who select engineering as their major.

### **Theoretical Underpinnings**

*Phenomenology* is a naturalistic research paradigm that guides research concerned with understanding the meaning of human experience (Marton, 1996; van Manen, 1990). It is a philosophical research tradition that has been influenced by the work of Husserl, Schutz and Merleau-Ponty (Polkinghorne, 1983; van Manen, 1990). This grounding in philosophy means that issues concerning the truth of research results are central to phenomenology. An alternative research framework known as *phenomenography* has been proposed that, at first glance, might appear a special case of phenomenology. Phenomenography arises from an empirical research tradition, however, and is concerned with the utility of research results rather than considerations regarding the “truth” of those results. The two frameworks also differ with regards to the structure of the results produced: phenomenology seeks a singular universe essence of a particular phenomenon, phenomenography looks for multiple different conceptions of a particular phenomenon.

The term *human experience* is a broad one, and there are many aspects of experience on which one could focus: behaviors associated with the experience, individual’s attitudes toward the experience, or cultural norms that influence the experience. What phenomenology and phenomenography have in common is that both perspectives seek to understand the meaning of a particular experience. One of the distinctions between the two frameworks, however, centers around the question of “whose meaning are you talking about?” Van Manen argues that “to do phenomenological research is to question the way *we* experience the world (1990, p.5). van Manen’s uses “we” to signify that phenomenology seeks to understand the universal meaning of experience, the meaning that is true for all people, including the researcher, as well as everyone who was not a participant in the study.

Phenomenography does not have such philosophically lofty goals. Rather than being concerned with describing a universally applicable meaning, phenomenography seeks to capture the meaning that the particular experience has for the research participants. Marton (1981, p. 178) describes this as a “second-order perspective” because the researcher makes “statements about [other] people’s ideas about the world (or their experience of it).” Phenomenography is not concerned with making broad statements about human nature, but rather it is concerned with making more narrow statements about the experiences of a particular group of individuals.

### **Design and Procedure**

In-depth interviews were conducted with 31 faculty and staff in the Schools of Engineering and 15

faculty and staff in the School of Science who represented approximately 750 years of combined teaching experience at Purdue. These interviews were transcribed and analyzed to provide a perspective of the freshman engineering experience among the faculty who provide the courses that contribute to this experience and the faculty who teach courses that build upon this experience. Assertions concerning noted changes in the students and the curriculum, needed changes in students and curriculum, and students strengths will be distributed to the Dean's Office, for discussion at the weekly Deans and Heads meeting.

The core of this study was a set of interviews with 97 freshman engineering students collected over the course of the 1998-1999 academic year, from shortly after the first set of exams in the Fall semester until just before final exams in the Spring. These interviews were transcribed to yield a data set of roughly 1500 pages of single-spaced transcripts. Analysis was done, in part, with the QSR Nud.ist program to examine eight nodes: students' experiences in high school; their reasons for choosing to come to Purdue; their reasons for choosing to major in engineering; their perception of student life at Purdue; academics at Purdue — with particular emphasis on their chemistry, mathematics, physics and engineering courses; their perception of academic responsibilities of both students and their instructors; their perception of the women in engineering and minorities in engineering programs; their perception of the overall engineering program; their perceptions of studying, including how and how long they study and differences in the way they study for different courses. Analysis of interviews was recently completed and discussion of the results of these interviews will dominate meetings of the faculty team from Science and Engineering for the Fall semester.

Survey data were obtained from a sample population of 805, roughly half of the total population of freshman engineering students during the Fall, 1998 semester to probe students' perceptions and views about a variety of issues including their academic preparation for college and the first-semester experience at Purdue. The analysis of responses was broken down into thematic sections: background variables such as student perceptions of how well high school prepared them for college work and the reasons why they chose to come to Purdue; their perceptions of the general academic and social support provided through orientation programs and interactions with their academic counselors; their expectations and experiences during course work; and their study habits, such as how and how long they studied for exams. Secondary statistical analysis was applied to examine variations in responses by demographic variables of GPA and predicted GPA.

### **Selected Results from the Quantitative Data**

A summary of the survey data and the conclusion that were drawn from these data are listed below. These data provide insights into the experience of the freshmen.

- A clear majority of the students felt reasonably confident about their general academic preparation for college work; they felt best prepared for their mathematics courses, then English, chemistry, and physics, respectively.
- Although most students reported having participated in one or more orientation programs, their response suggested that these programs were not perceived as helpful, other than

- providing students with basic information about campus layout and facilities.
- While the majority noted that they had no trouble getting the courses they needed, a significant fraction said there were courses they wanted to take but couldn't because there was no room in the curriculum for course that do not count toward an engineering degree.
- When asked to list attributes of effective instructors the three most common responses were: knowledge of course material, concern for students, and the personality of the instructor. When provided with various descriptions of a professor's role and asked to rank the different roles, more than 90% expected professors to take didactic roles, in which they present and explain material.
- When provided various descriptions of a student's role, responses were once again consistent with a didactic teaching model, in which students played traditional recipient roles.
- When asked to list the most difficult or most challenging course, slightly less than half responded: chemistry. Slightly more than a quarter responded: math.
- When asked how frequently their professors tried to relate their course material to concepts learned in other classes, most students reported occasionally, at best. When asked how often students, themselves, perceived connections between concepts taught in different courses, most students responded "occasionally" or "never."
- When students who had taken a course that used cooperative learning were asked to evaluate their experiences, their evaluations divided on most dimensions. The only thing we can conclude is that students' cooperative learning experiences are varied and uneven.
- When asked to rank various ways of studying for tests, students reported using more passive recall enhancing strategies than active reprocessing strategies.
- About a third of the students reported spending 8-15 hours a week outside of class on academic work. Slightly more than a quarter estimated spending 15-20 hours a week and another quarter reported spending more than 20 hours a week, while only about 10% spent less than 8 hours a week.

### **Selected Results from the Qualitative Data**

Significantly more time and effort were devoted to collecting qualitative data from interviews with almost 100 students. It was therefore only fitting that these data provided us with significantly better insight into the students' experiences. Some of this insight is provided in the following assertions.

- In terms of content, these students seem well prepared. Most of them have had calculus and multiple years of science courses including chemistry, physics, and biology. In terms of learning skills, however, these students seem woefully unprepared. The overwhelming majority either described high school as easy or admitted to not having studied at all. It appears that these are very bright students who did not have to apply themselves prior to arriving at Purdue.
- Family, particularly fathers, play an important role in influencing incoming students' decisions to become engineers, which may explain why so many students drop out of engineering as freshman. Engineering majors are also likely to enjoy math and science, and have some previous experience or hobby that deals with this interest. Some students are influenced by

- teachers and councilors to major in engineering, but not many.
- Overall, students do not find the transition from high school to college to be shocking or surprising. Their concerns centered on the academics, the social life, and the freedom and independence they would gain. There is no evidence that the first semester is academically overwhelming for most students. Students appear to have had an easier time finding friends than they expected. Freedom and independence is an important part of the first-semester experience.
  - Overall, the students seemed very happy with the Purdue experience. Finding friends was not difficult, the campus is pretty, most faculty were better than expected, and the classes were interesting.
  - Most students seem to have adjusted easily.
  - The results of the interviews were consistent with the results of the freshman survey when students were asked to describe the roles of the professor and the student. Students overwhelmingly expect professors to take didactic roles, in which they present and explain material to students.
  - The review of the content in the remedial math course taken by some students may be a good idea for these students. However, the students don't seem to differentiate this course from high school classes, and may not be prepared for the studying challenges that will face them when they move on to calculus.
  - The interview data provided useful insight into the quality of the placement that was being done in the different calculus options.
  - Chemistry is viewed as a review of high school, but a necessary review. Unlike some of the math courses, the students don't have trouble with the content of the course. It is often one of the most challenging, however, in terms of the work load. The major source of complaints were the exam format (multiple choice) and the professors (more than one was mentioned). Some students believe it is a "weed-out" course for engineers; others have heard rumors to this effect but aren't having difficulty themselves.
  - Physics 152 (Introduction to Mechanics) has a powerful reputation for being a difficult course. First-semester students are aware of and afraid of the course even before enrolling in the course.
  - Useful insight was also provided by the students' responses to the engineering courses they take during their freshman year that can be used to improve these courses in the future.
  - When asked how classes were going in general, far more responded that classes were going well than said they weren't going well.
  - About a quarter of the students commented on foreign TA's being a problem, but many students had positive things to say about their TA's.

Insight into "freshman engineering experience" was also provided by the in-depth interviews with slightly less than 50 faculty from the School of Science or the Schools of Engineering who teach freshman courses or who teach courses that build on the freshman experience. Some of this insight is provided in the following assertions.

- Students come to the university with expectations about the behavior of the instructor, the

amount and kind of course work that will be required, and the amount and kind of work they will be required to do to be successful. Instructors who do not meet students' expectations often find them uncooperative.

- There is little that can be done to change the students' expectations before they come to the college classroom. However, their expectations should be challenged early and often, particularly in their first year of college.
- The chronological gap between the presentation of basic concepts and their application is often too long. Students should have problems to solve that are not well defined earlier in their academic careers.
- Students are typically told that they would do well in engineering because they have done well, or have a knack for, math and science courses in high school. Some students may find that they do not want to study a particular type of engineering, or engineering at all. However they may not feel as though they have any other options, and they would be letting their family, friends, and teachers down if they changed their minds.
- Many students come to Purdue with the feeling that they have to make it on their own, and only on their own. Many students have real difficulty with course work for the first time in their academic careers. Students would benefit from having early and frequent contact with faculty. Many students need direct, one-on-one encouragement to seek out help from available resources.
- Many faculty have experienced disrespectful or unethical student behavior, or know someone who has.
- Students are not coming into the class room with the same skills that they were a generation ago, but there has been a larger change in the ethnicity and gender of the student population than there has been in the level of ability of this population.
- There is a need for departments and schools to make a concerted, deliberate effort to inform faculty of the content students should know and to train faculty in appropriate pedagogical methods.
- It is frightening how little engineering faculty know about the course content of their students' freshman year.
- Students are quick to perceive whether or not an instructor is taking the job of teaching seriously. Students remember good teachers not so much for the amount of content that was presented, but the overall quality of the classroom experience.
- Students come to the university trained to employ, and therefore often expect, a mechanical approach to learning in which facts delivered in lecture one day appear on the exam several weeks later; where the only task that matters is increasing the power of the algorithms one can apply to routine exercises one encounters in homework problems and on exams to obtain the "correct" answer. If the structure of the freshman engineering experience is designed to confront these expectations, the students don't notice it.
- Student's preconceived notions about classroom expectations of themselves need to be challenged in the freshman year. Teachers must change the way they teach, and possibly what they teach, in order to adequately challenge student's thinking and conceptions.
- There is evidence of dedicated efforts to improve the educational experiences of freshman engineering students while they are enrolled in required courses in the School of Science.

These efforts are not coordinated among the departments, however. Furthermore, they are entities whose existence and implementation often depend upon the faculty involved in teaching the courses.

- Using collaborative/active learning techniques is more likely to challenge students beliefs about their role in the college classroom than traditional pedagogical methods. Challenging students' beliefs about their role can lead to students taking ownership in the concepts that they learn, and taking on personal responsibility for they work that they do. When the instructor relinquishes the aspects of ownership and responsibility to the students, more realistic, open-ended, design oriented tasks can be developed for the students to work through.
- Instructors should teach less, better.
- Students need more experience doing problem solving & using critical thinking skills.
- Students are currently working in an environment where there is too much structure. Students need less structure to help develop their problem solving abilities and thinking and judgement skills. Non-realistic, algorithmic, exercise-completing experiences produce non-realistic, algorithmic, exercise-completing, thinking in students. Instead of covering all available material, thus allowing the knowledge base to drive instructional methods, instructors should choose a few critical concepts and "go deep" with them. The interest should be in teaching students how to learn, which lasts "20 years", as opposed to learning technical information which is fleeting.
- Real world judgement experience is difficult to capture in the confines of the classroom, but it can be accomplished to some degree. Instructors should relinquish the notion that instruction begins and ends by the ringing of the classroom bell, and challenge their students to do the same.

## **Conclusions**

The evaluation effort that was undertaken has provided a great deal of insight into the current freshman program at Purdue University. The collaborative effort between engineering, science and education has opened lines of communication that may be as valuable as the data itself. The data has reinforced the strengths of the experience the freshmen have and pointed out opportunities for improvement. Students have a relative easy time adjusting to campus and assimilate quickly. Freshmen do not see the connections between courses in science and engineering. That has prompted discussion of how to integrate and/or coordinate topics taken in the common courses. The student reactions to the cooperative learning experiences they encounter in the freshman year vary significantly reflecting the diversity of these experiences. The faculty of the engineering schools felt disconnected from the freshman year. The faculty from science and engineering felt that more critical thinking and problem solving was important to introduce into the classrooms.

The findings of these data and continual assessment have rekindled discussions of how to best serve the freshman engineering students. As opportunities for change arise, the student voice will be included in the decision process.

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