

Moving from Pipeline Thinking to Understanding Pathways: Findings from the Academic Pathways Study of Engineering Undergraduates

Authors: Cindy Atman, Sheri Sheppard, Lorraine Fleming, Ron Miller, Karl Smith, Reed Stevens, Ruth Streveler, Tina Loucks-Jaret, Dennis Lund

Source: Proceedings of 2008 American Society for Engineering Education Conference

While engineering educators have engaged in many endeavors aimed at advancing engineering education and practice, much of this work has focused on broad curricular issues. Few studies focus on what it means to be an engineer or the process of what it takes to learn to engineer. In the last decade engineering educators have begun to focus on developing the research base with an emphasis on engineering student learning.

The Academic Pathways Study (APS) was designed to build on and add to prior and ongoing research to investigate the engineering undergraduate learning experience and the transition to work. The APS is an extensive, multi-institution research project that is looking at how people become engineers over the course of their undergraduate educations and upon entry into the engineering workplace. It is part of the Center for the Advancement of Engineering Education (CAEE), an NSF-funded higher education Center for Learning and Teaching. The APS, the focus of this paper, is complemented by several other Center projects that are exploring components of engineering knowledge and practice, including decision making practices of engineering educators, and methods to build capacity and community in engineering education scholarship.

Moving from Pipeline Thinking to Understanding Pathways

The strength of the Academic Pathways Study lies in the collaboration of different campus cultures and perspectives on engineering student learning combined with the use of a multiple-method approach to gathering and analyzing data. The APS has involved over 6000 participating students at five core institutions and 21 additional institutions. In total, these 26 institutions represent to a large degree the diversity in institutional settings for the study of engineering in the U.S.

Initial findings reported in this paper effectively challenge the long-held notion of the engineering education pipeline.

The large variation in student pathways revealed by these research results is not only a function of individual students but depends on the characteristics of institutions as well. This variation demonstrates that a “one size fits all” recommendation for addressing problems in engineering education likely will not work. Institutions must examine their own student populations to determine appropriate curricular and program changes. The APS survey and interview instruments provide tools that could be used to enable other institutions to look more closely at their students.

Furthermore, the pipeline metaphor of engineering education can also neglect the huge changes that students undergo during the course of their undergraduate years. Many of these changes are related to what students learn in courses, and research or work experiences, but there are broader changes in what students think: about what it means to be an engineer; about their self-concept and identity as engineers and as members of society; and in their overall direction and goals. As analysis of the APS data continues, and as data from the Broader Samples is included, a more complete picture of engineering students is emerging, creating a picture that reflects changes over the four years of student life.

Engineering programs and their current teaching methods should be re-examined. In addition to a further examination of student experiences, an important part of that examination is to see how well students are able to make informed decisions to stay or go in their study of engineering. Students need a welcoming environment that gives them the information they need, and they need learning experiences that will enable them to build their engineering knowledge and identity as an engineer with the skills needed to succeed in the global engineering work world. Our data show that often the undergraduate experience differs greatly for different groups such as men, women, and underrepresented minorities. The engineering education community, whether policy-makers, faculty, or researchers, must not only recognize the wide variety of student pathways to an engineering degree but also encourage and support these multiple paths.

Summary of Findings

Initial findings reported in this paper effectively challenge the long-held notion of the engineering education pipeline. This metaphor loosely assumes that all engineering students enter and exit their engineering educations at the same intake and outflow points, with some students leaving engineering through various “leaky” points along the way. A pipeline metaphor also assumes a certain level of homogeneity among engineering students and can disregard the many changes that occur during the students' undergraduate careers.

APS findings to date (based primarily on data from the Longitudinal and Cross-sectional Cohorts) indicate a large variation in student pathways to an engineering degree. This variation is demonstrated by a number of factors. The reasons students give for their choice of an engineering major include things such as future financial security, the ability to contribute to society, influence of family or mentors, and that they are good at math and science. Once in the engineering major, students pathways to or out of engineering are affected by curriculum and skill development issues such as heavy workloads and stress; a competitive atmosphere, especially in the early years; a missing “vision” about engineering; and a delay in experiencing design and teamwork until later in the engineering program. Students' differing personal perspectives on diversity and gender also play a role in determining students' pathways, as can the institutional, curricular, and skill development factors associated with diversity and gender. Pathways are also affected by a student's commitment to the field of engineering that is, in turn, affected by personal situations, learning experiences, and institutional practices. These influences can lead to students re-examining their decision to be an engineer quite often. Sometimes this results in a pathway out of engineering. The decision to leave engineering can be precipitated by a variety of factors including a lack of confidence in math and science skills; a fear of losing scholarships; and a perception that engineering is too narrow and does not offer a path to contribute to social good. However, many students remain on an engineering pathway for reasons including sponsorship of student strengths and skills, satisfaction of completing a rigorous course of study, the desire to contribute to the public good, and a vision of the potential

for a financially secure lifestyle following graduation.

The results in this paper have shown that the Academic Pathways Study is providing compelling data that paint a picture of the undergraduate engineering student learning experience not only with a human face, but with a multi-faceted understanding that comes from a rich triangulation of data types and sources. The Academic Pathways Study is providing a rich set of insights and tools to support changes in the undergraduate engineering student learning experience and ultimately to strengthen effective teaching of our future engineers.

www.engr.washington.edu/caee

June 2008