AC 2011-2445: SPECIAL SESSION: DISCOVERING IMPLICATIONS OF THE ACADEMIC PATHWAYS STUDY FOR YOUR CAMPUS

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Discovering Implications of the Academic Pathways Study for YOUR Campus

Introduction

This special session offers participants the opportunity to forge connections between research findings from the Academic Pathways Study (APS) of engineering undergraduates and sound educational practices on their campuses. Participants will use a set of “local inquiry questions” developed by the APS team in a guided format to explore unique aspects of the engineering programs, college cultures, and student bodies on their campuses. It is expected that the session will assist engineering educators (including faculty, administrators, engineering curriculum developers, policy makers, and student affairs specialists) in achieving a broader understanding of their campuses using the results and analysis tools (specifically the “local inquiry questions”) generated by the APS. The Academic Pathways Study was part of the Center for the Advancement of Engineering Education (CAEE), a national research center funded by NSF from 2003 to 2009 (ESI-0227558).

Selected Findings from APS: Student Learning and Pathways to Engineering

- Engineering students are as likely as students in other disciplines to **persist** in their majors.
- Students remain **uncertain** about what it means to be an engineer, even in their fourth year.
- Top **motivational** factors for engineering students are behavioral, psychological, social good, and financial.
- Students who stay in engineering are **similar** on many measures to those who switch out.
- Male engineering students start college with higher **confidence** than women in math/science and open-ended problem solving, and this difference does *not* change over the four years of their education.
- In their approaches to an open-ended design problem, women considered problem **context** more broadly than men did.
- Some students struggle with the **shift** from “book problems” to open-ended problems.
- College students navigate through engineering programs in ways that display large and consequential **variation**.
- Seniors are less satisfied with **faculty and TAs** than first-year students are, although seniors interact with faculty and TAs more.
- Seniors’ use of **language** becomes more engineering design-specific.
- Today’s engineering graduates think more about a **“first job”** than about a lifetime career choice.
- A sizeable fraction of engineering graduates are considering a future **outside** the field of engineering.

- Many newly hired engineers do not anticipate the high level of **social and organizational** influence on their work.

Appendix A provides an overview of the various APS study components, including participant populations, primary research questions, and duration of each study segment. A detailed presentation of results and discussion of the entire scope of APS (as well as the other components of CAEE's research) can be found in the CAEE Final Report, *Enabling Engineering Student Success*.[2] The report is available for download on the CAEE web site at http://www.engr.washington.edu/caee/.

Goals of the Special Session

In this interactive special session, we invite all who are interested in engineering education to consider the implications that APS findings have for their campuses. The session will offer participants a chance to think about connections between APS research findings and sound educational practices on their campuses, given campus-specific engineering programs, college culture, and student body. Participants will be introduced to a selection of APS results and a set of "local inquiry questions" that have been informed by the APS research. These questions will be used in the session to probe educational issues of interest to the participants.

Overview of the Special Session

The special session consists of three parts: (1) an overview presentation by the APS team; (2) smaller group discussions and guided activities around the local inquiry questions; and (3) a concluding discussion among all participants. APS researchers will lead the guided activities and answer audience questions about the study as needed.

Part 1 (20 minutes): Overview of results and local inquiry questions.
APS researchers will introduce a selection of local inquiry questions and present key research results that form the foundation for these questions. For more detailed, comprehensive coverage of APS, attendees will be referred to the CAEE final report, as published on the CAEE web site.

Part 2 (40 minutes): Considering priorities and formulating answers.
The session attendees will break into four groups based on each of the APS findings presented by the team. In small-group discussions and guided activities, participants will be asked to consider and prioritize the local inquiry questions appropriate for their campus, to exchange ideas about gauging their campus' effectiveness in answering a local inquiry question, and to suggest potential interventions to improve engineering education in this situation.

Part 3 (30 minutes): Taking it to your campus.
In the large group, participants will report out and discuss next steps for translating APS research to practice on attendees' campuses.

Special Session Details: Agenda, Content, and Examples

Part 1 (20 minutes): Overview

Part 1 provides an introduction of the local inquiry questions and presents key research results that form the foundation for the questions.

The Academic Pathways Study resulted in a large set of data, with results and analysis included in over 100 papers and articles, and the goal of this special session is not to try to cover all of the work. To accomplish the primary goal of engaging participants in use of the local inquiry questions, members of the APS research team will present a selection of findings and link them to the local inquiry questions in ways that are illustrative of potential uses on other campuses. Attendees will be provided a summary handout by the APS team.

Introducing the Local Inquiry Questions

The "local inquiry questions" were developed as part of the analysis and discussion of APS results. These questions were first presented as part of Section 2 (Student Learning Experiences) in the CAEE Final Report. Subsection 2.10 of the report places these questions in the context of relevant APS findings summaries.[2]

The local inquiry questions are grouped in the six categories shown below with examples of the kind of questions in each category. The complete list of the local inquiry questions is included in Appendix B.

1. Welcoming Students into Engineering (questions about topics like recruiting, admissions processes, new student support)
2. Understanding and Connecting with Today's Learners (questions about topics like getting feedback from students, attending to diversity, identifying and encouraging students' passions)
3. Helping Students Become Engineers (questions about topics like developing students' professional identity, design learning, knowledge integration)
4. Developing the Whole Learner (questions about topics like helping students get the most from their *whole* college experience, providing opportunities for significant learning)
5. Positioning Students for Professional Success (questions about topics like assuring that students have the necessary skills to enter the workforce)
6. Welcoming Students into the Work World (questions about topics like helping students transition into the workplace)

Linking Selected Findings with the Local Inquiry Questions

The four examples below match a selection of APS findings with appropriate local inquiry questions to illustrate how the questions can be used to help guide a process of discovery to learn more about students on a particular campus.

Example #1: Aspects of the Engineering College Experience[7, 14, 18]

- Seniors were less satisfied with instructors than were first-year students.
- Seniors interact with instructors more than first-year students.
- Seniors were less involved academically in their courses than as first-year students.
- Identification with engineering is a significant component of persistence in engineering.

Local Inquiry Questions that can help illuminate issues of student satisfaction, involvement, and identification with engineering:

Listening: How do you get feedback from students about the effectiveness of various elements of your program? Do faculty listen to students about the effectiveness of their teaching? What mechanisms can be put in place to encourage more timely and effective use of teaching evaluations by instructors? How can what is learned through evaluations be better aligned with program improvement? Do you provide an environment where students listen to each other?

Student Identity as an Engineer: Do the students you teach know what engineers really do? Do they identify themselves as engineers? How does your program help them do this? Can they articulate what they are bringing to the engineering profession? Do faculty and administrators think about a student's engineering identity as an element of student development in the undergraduate years?

Learning Environment: How would you characterize the learning environment on your campus? Is there an atmosphere of students in competition with each other? Do students feel overloaded by a demanding curriculum? Do all students feel that your institution would like them to succeed? Do your students develop confidence in their abilities as engineers? Are your students excited when they graduate, or do they seem to be just sticking it out to the end?

Example #2: Learning about Engineering over Four Years[13, 18, 19, 20]

- Engineering students' knowledge does grow over the four years, but many seniors did *not* report gaining knowledge of engineering from school-related experiences.
- Co-ops and internships build knowledge of engineering.
- Some students remain uncertain about what it means to be an engineer even in their fourth year.
- Importance of and preparedness with engineering skills and knowledge (seniors' low knowledge of contemporary issues, business, global context, societal context)
- In a survey question asking seniors to rate the most important engineering skills and knowledge, they chose Problem solving, Communication, Teamwork, and Engineering analysis; the least selected items included Contemporary issues, Societal context, and Global context.
- Seniors self-rated preparedness responses mostly mirrored their importance responses, with the lowest preparedness ratings for Contemporary issues, Business knowledge, Global context, and Societal context.

Local Inquiry Questions that can help guide thinking about aspects of student learning:

Student Identity as an Engineer: Do the students you teach know what engineers really do? Do they identify themselves as engineers? How does your program help them do this? Can they articulate what they are bringing to the engineering profession? Do faculty and administrators think about a student's engineering identity as an element of student development in the undergraduate years?

Informed Decision Making: Does your college offer courses or programs (such as speaker series) that reveal to students the range of jobs and careers within the engineering field? How are students encouraged to integrate a variety of experiences into informed decision making on majoring in engineering? Do they have an accurate and sufficient understanding of the field of engineering and their place in it? How is re-examination of their decisions to stay in engineering supported through advising?

Pathways: What is the range of pathways that your students take through your curricula? Where do they find support? What organizations, faculty, student groups, and peers help students navigate through the institution? Does your institution support varied pathways through the undergraduate experience?

Student Passion: What motivates students on your campus to choose an engineering program? What can they be passionate enough about to keep them in an engineering program? Does your program include elements that will ignite and sustain student passion?

Significant Learning Opportunities: How does your institution provide learning opportunities that students consider significant, including experiences that connect with what students find meaningful, present students with a challenge, ask students to be self-directed learners, give students ownership over their learning, and facilitate development of a broad vision of engineering?

In-Depth Learning Opportunities: Do your students have opportunities to have learning experiences that help them extend their understanding of engineering, e.g., internships, co-ops, research or international experiences, and project-based learning? Do you help your students reflect on these experiences and integrate them into their understanding of the engineering profession? How might these reflections be integrated into program assessment and improvement?

Example #3: Engineering Design: Knowledge and Confidence[1, 4, 8, 9, 15]

- Conceptions of design shift during the undergraduate years and vary with gender and institution.
- Neither beginning nor advanced engineering undergraduates consider design problems in temporal context.
- Men report higher confidence and course preparation with design than women, in spite of reporting equal engagement with the design activities in coursework.

Local Inquiry Questions that can help those involved with teaching and curriculum development better understand students' conceptions of design and issues of confidence:

Variability/Commonality: How are students in your college of engineering similar to one another? How are they different from one another? How well do faculty and policy makers on your campus understand similarity and variability in your students' motivation, background, interests, learning challenges, confidence, and future plans?

Designing in Context: Do your graduates have the design skills they need? Do your students consider the broad context of engineering problems as they solve them? Do they think about the users and other stakeholders of an engineered solution, and all aspects of the life cycle? Are they considering global, environmental, societal, economic, and cultural context in engineering design?

Learning Environment: How would you characterize the learning environment on your campus? Is there an atmosphere of students in competition with each other? Do students feel overloaded by a demanding curriculum? Do all students feel that your institution would like them to succeed? Do your students develop confidence in their abilities as engineers? Are your students excited when they graduate, or do they seem to be just sticking it out to the end?

Example #4: Newly Hired Engineers Encounter many Challenges in the Workplace[3, 10, 12]

- Teamwork is much different in the workplace compared to what students experience during their undergraduate years.
- Many different players and processes can affect decisions in the workplace.
- The problems faced by engineers in practice are often extremely complex, ill-structured, ambiguous, and dependent on the social and organizational contexts.
- Support received from managers and company training efforts for new hires can vary from being very helpful to insufficient.

Local Inquiry Questions that can help shed light on the challenges that newly hired engineers face and how these could be addressed during their school years:

Ability to Practice: What challenges do your graduates face when they begin practice or graduate school? What helps facilitate their transition? Do they know how to seek out the information and advice they need? Are they prepared for a career or just their first job? Can they effectively communicate their ideas to multiple audiences in the many modes they need to?

Interdisciplinary Respect: Do your graduates understand the value of skills and perspectives from individuals in fields other than engineering? Do they respect both other fields and the individuals who practice in these fields? Are they able to work with these individuals?

Practicing Engineering: What challenges do your newly hired engineering graduates face when they begin a job? What can you do to help facilitate their transition? Are they supported when they need to seek out information and advice? Are they given appropriate orientation, support and mentoring from others in the organization?

Working in Diverse Teams: Are the new hires able to work with a wide variety of coworkers and customers or clients in different roles and settings? Do they understand the value of skills and perspectives from individuals in fields other than engineering? Do they understand that decisions can often incorporate more factors than those that pertain only to the engineering aspects?

Communicating Effectively: Do the new hires have an appreciation for the needs of different audiences when talking about their work or a problem? Are they able to listen to others and effectively incorporate input? Can they communicate their ideas to multiple audiences in the many modes they need to?

Part 2 (40 minutes): Considering Priorities and Formulating Answers

In small-group discussion and guided activities, participants will be asked to consider and prioritize local inquiry questions, deciding which areas are of key interest in their role as a teacher/administrator/program planner/etc. and what questions they would most like to pursue the answers to. The four discussion groups will be formed around each of the example findings.

Participants will be given time to reflect and exchange ideas with others in their group about how to gauge the effectiveness of their campuses in any of the areas described above, and to brainstorm potential interventions to improve their engineering education. Participants will also discuss how similar they believe the students on their campus are to the students in the APS.

Part 3 (30 minutes): Taking it to your campus

Part 3 is a 30-minute discussion in the large group led by APS team members. The small-group discussions of Part 2 will provide the basis for descriptions of how the local inquiry questions can be used by different audiences and on different campuses.

In the large group, we will report out and discuss ideas for using the local inquiry questions, linked with APS (or other) research findings, to understand and affect practice on attendees' unique campuses. The small-group discussions of Part 2 will provide the basis for these discussions of possible uses of the local inquiry questions by different audiences on different campuses. The audience will be encouraged to share their thoughts on how the findings and answers to the local inquiry questions might impact them as engineering education researchers or as teachers.

One possible focus of discussion will be the use of the findings about undergraduates by engineering teaching faculty. This discussion thread will build on the research framework and findings on faculty teaching decisions that have been generated by the Studies of Engineering Educator Decisions (SEED), another important part of CAEE's research.[2, 21, 22]

Participants will also be asked to think broadly about the potential for use of the local inquiry questions (and implications) by engineering deans and department chairs, student advisors and support team members, and policy makers in general.

As time permits, the session will conclude with discussion on the questions, “What questions are left unanswered?” and “What other questions should be asked?”

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Appendix A: Academic Pathways Study Description

The Academic Pathways Study (APS) examined the engineering student experience as a large component of the Center for the Advancement of Engineering Education (CAEE). CAEE was funded by the National Science Foundation from 2003 through 2009 (Grant ESI-0227558).

The APS research involved over 130 faculty, research scientists, graduate and undergraduate research assistants, and staff representing 12 universities and six national organizations. Research design began in early 2003 and data were collected during the 2003–04 through 2007–08 academic years. NSF provided supplemental funds to enable two additional years of work (2008–2009) beyond the original five-year grant period and data analyses continued into 2010.

APS Research Questions

The APS research questions focused on student skills and knowledge, development of identity as an engineer and engineering student, the personal and institutional aspects of the students’ education, and the skills needed for a successful transition into the workplace.

- Skills: How do students’ engineering design skills and understanding of engineering practice develop and/or change over time?
- Identity: How do students come to identify themselves as engineers? How do these identities change as they navigate their education?
- Education: What elements of students’ engineering educations contribute to changes examined in the skills and identity questions above?
- Workplace: How do students conceive of their careers? What skills do early-career engineers need as they enter the workplace?

Data from three key APS research efforts are used in this Special Session. These are the Longitudinal Cohort, the Broader National Sample, and the Transition to the Workplace.

The **Longitudinal Cohort** (2003–2007) consisted of 160 undergraduate engineering students (40 at each of four diverse campuses) who participated in the study beginning with their first year in college and into their fourth year.

The initial sample comprised approximately 61% men and 39% women. Just under 60% of the participants were white or Asian-American, with the rest being from underrepresented racial/ethnic minority (URM) groups. These proportions were the result of oversampling to increase the number of participants from underrepresented groups in engineering.

The APS research team used four primary data collection methods for the Longitudinal Cohort: surveys, structured and semi-structured (ethnographic) interviews, and short engineering design tasks.[17]

The **Broader National Sample** (2008), also known as the Academic Pathways of People Learning Engineering Survey or APPLES, was a cross-sectional survey of over 4,200 engineering undergraduates at 21 campuses of varying size, location, student demographics, and mission. The survey was administered in late winter through early spring of 2008.

The APPLE Survey is a shorter version of the Persistence in Engineering (PIE) survey used for the Longitudinal Cohort. The Broader National sample included approximately 16% underrepresented minorities (URM) in engineering. Women and men represented approximately 35% and 65% of the sample, respectively. Race/ethnicity and gender data were obtained from a multiple-choice question on the APPLE Survey. Additional details about the Broader National Sample (APPLES) survey are provided by Sheppard *et al.*[18] and Donaldson *et al.*[5, 6]

The **Transition to the Workplace Studies** (2006–2009) focused on the early career experiences of recently-hired graduates. The studies involved over 100 early career engineers and 15 of their managers employed in a range of private companies and public agencies. Six distinct data sets were collected using interviews and observations. Sheppard *et al*.[16] provide more details about the data sets and interview protocols.

In addition to the three research studies discussed above, three other studies were part of APS but are not directly used in this special session: the **Single-School Cross-sectional study**, the **Broader Core Sample**, and the **Difficult Concepts study**. Additional information and findings specific to these studies are provided in Section 2 of the CAEE Final Report,[2] which is the most comprehensive summary of APS findings. A detailed year-by-year look at the design and implementation of the APS is provided by *An Overview of the Academic Pathways Study: Research Processes and Procedures.*[16]

Appendix B: Local Inquiry Questions

The following local inquiry questions were generated to facilitate reflection and discussion on an individual campus or in an individual classroom. These local inquiry questions are based on findings from the CAEE studies and questions that came up during data analysis. The full set of local inquiry questions is shown below with questions grouped under six broad topics.

B.1 Welcoming Students into Engineering

- **Informed Decision Making:** Does your college offer courses or programs (such as speaker series) that reveal to students the range of jobs and careers within the engineering field? How are students encouraged to integrate a variety of experiences into informed decision making on majoring in engineering? Do they have an accurate and sufficient understanding of the field of engineering and their place in it? How is re-examination of their decisions to stay in engineering supported through advising?

- **Migration in:** Are there opportunities in the first years of college at your school (such as "introduction to engineering" seminars or courses) that allow students to explore engineering? How much migration in is happening at your institution? How might this pathway be expanded? Are there institutional barriers that discourage students from transferring into engineering?

- **Pathways:** What is the range of pathways that your students take through your curricula? Where do they find support? What organizations, faculty, student groups, and peers help students navigate through the institution? Does your institution support varied pathways through the undergraduate experience?

B.2 Understanding and Connecting with Today's Learners

- **Listening:** How do you get feedback from students about the effectiveness of various elements of your program? Do faculty listen to students about the effectiveness of their teaching? What mechanisms can be put in place to encourage more timely and effective use of teaching evaluations by instructors? How can what is learned through evaluations be better aligned with program improvement? Do you provide an environment where students listen to each other?
- **Student Passion:** What motivates students on your campus to choose an engineering program? What can they be passionate enough about to keep them in an engineering program? Does your program include elements that will ignite and sustain student passion?
- **Variability/Commonality:** How are students in your college of engineering similar to one another? How are they different from one another? How well do faculty and policy makers on your campus understand similarity and variability in your students' motivation, background, interests, learning challenges, confidence, and future plans?
- **Supporting Diversity:** Do individuals from traditionally underrepresented populations feel supported and included in the engineering community on your campus? Do faculty, students, and administrators recognize and support the important voices brought to engineering from individuals of all backgrounds?

B.3 Helping Students Become Engineers

- **Student Identity as an Engineer:** Do the students you teach know what engineers really do? Do they identify themselves as engineers? How does your program help them do this?

Can they articulate what they are bringing to the engineering profession? Do faculty and administrators think about a student's engineering identity as an element of student development in the undergraduate years?

- **Connecting Across the Years:** Does your college connect the early learning experiences in the first two years (math- and science-focused) to the more engineering-focused experiences in the later years? How do design experiences in upper-division courses build on design experiences in early courses?
- **Learning Engineering:** How do you confirm that students have learned and retained the basic skills of engineering? Have your students acquired the language of engineering? Have they mastered the concepts that are difficult to understand? Can they define and solve engineering design problems? Do they have the skills and confidence to meet society's grand challenges?
- **Well-Rounded:** How broadly do engineering students on your campus conceptualize engineering? How many areas beyond math, science, and analysis would students list as important components of engineering? How skilled are your graduates in the many aspects of the engineering profession?
- **Designing in Context:** Do your graduates have the design skills they need? Do your students consider the broad context of engineering problems as they solve them? Do they think about the users and other stakeholders of an engineered solution, and all aspects of the life cycle? Are they considering global, environmental, societal, economic, and cultural context in engineering design?

B.4 Developing the Whole Learner

- **Balance:** Are your students satisfied with their undergraduate experiences as engineering students? Are they able to balance between their engineering and non-engineering extracurricular activities? Is there balance between individual and team experiences, well-defined and open-ended problems, and design and analysis experiences? Are your students able to find balance between the academic and social aspects of their lives?
- **Significant Learning Opportunities:** How does your institution provide learning opportunities that students consider significant, including experiences that connect with what students find meaningful, present students with a challenge, ask students to be self-directed learners, give students ownership over their learning, and facilitate development of a broad vision of engineering?
- **In-Depth Learning Opportunities:** Do your students have opportunities to have learning experiences that help them extend their understanding of engineering, e.g., internships, co-ops, research or international experiences, and project-based learning? Do you help your students reflect on these experiences and integrate them into their understanding of the engineering profession? How might these reflections be integrated into program assessment and improvement?
- **Learning Environment:** How would you characterize the learning environment on your campus? Is there an atmosphere of students in competition with each other? Do students feel overloaded by a demanding curriculum? Do all students feel that your institution

would like them to succeed? Do your students develop confidence in their abilities as engineers? Are your students excited when they graduate, or do they seem to be just sticking it out to the end?

- **Asking Questions:** Do your graduates recognize when they do not know something? Do they have the skills to find the answers to their questions? Do they feel enabled to continue the learning process after they graduate?

B.5 Positioning Students for Professional Success

- **Post-Graduation Plans:** What resources are available at the department, college, and institution levels for guidance in job and career planning? Do your students feel enabled to enter a variety of professions? Are they prepared to be effective in those professions? What plans do your graduating students have? Are they considering a career in engineering, another field, or both? Work in industry or the public sector? Graduate school in engineering or another field?

- **Ability to Practice:** What challenges do your graduates face when they begin practice or graduate school? What helps facilitate their transition? Do they know how to seek out the information and advice they need? Are they prepared for a career or just their first job? Can they effectively communicate their ideas to multiple audiences in the many modes they need to?
- **Interdisciplinary Respect:** Do your graduates understand the value of skills and perspectives from individuals in fields other than engineering? Do they respect both other fields and the individuals who practice in these fields? Are they able to work with these individuals?
- **Meet Grand Challenges:** How prepared are your graduates to take on the wide range of roles—in government, industry, and academia—required for engineers to address the grand challenges that face the globe and its inhabitants?

B.6 Welcoming Students into the Work World

- **Practicing Engineering:** What challenges do your newly hired engineering graduates face when they begin a job? What can you do to help facilitate their transition? Are they supported when they need to seek out information and advice? Are they given appropriate orientation, support and mentoring from others in the organization?
- **Working in Diverse Teams:** Are the new hires able to work with a wide variety of coworkers and customers or clients in different roles and settings? Do they understand the value of skills and perspectives from individuals in fields other than engineering? Do they understand that decisions can often incorporate more factors than those that pertain only to the engineering aspects?
- **Communicating Effectively:** Do the new hires have an appreciation for the needs of different audiences when talking about their work or a problem? Are they able to listen to others and effectively incorporate input? Can they communicate their ideas to multiple audiences in the many modes they need to?

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