An Overview of the Academic Pathways Study:

Research Processes and Procedures

Technical Report #CAEE-TR-09-03

Summer 2003 – Fall 2008

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

August 2009
revised May 2010

Overview of APS Research Processes and Procedures
Table of Contents

Figures and Tables

Reader's Guide to *APS Processes and Procedures*

The Center for the Advancement of Engineering Education (CAEE) began in January 2003 with a grant from the National Science Foundation (ESI-0227558). Two NSF Directorates, Engineering and Education and Human Resources, oversee the Center's work. The Academic Pathways Study (APS) is part of the Scholarship on Learning Engineering element of the CAEE.

This document provides a picture of APS study design and implementation activities. Descriptions of the APS analysis methods, findings, and the more technical aspects of the research such as methodological background, sampling calculations, statistical methods, etc. are being reported elsewhere. An up-to-date listing of papers and reports emanating from the APS research as well as contact information can be found at http://www.engr.washington.edu/caee/.

The chapters in this document progress more or less chronologically. The following descriptions of each chapter provide a quick overview to orient the reader to the content of this document.

- Chapter 1 presents the overall goals and background for the APS research. This chapter includes information such as research and leadership team description, study design, participating school descriptions, data storage and analysis plans, and study terminology.
- Chapters 2 through 5 cover the longitudinal portion of the study, one chapter for each of the four years of longitudinal research on a cohort of 160 engineering undergraduates. These chapters contain information on recruitment, study group assignments, changes to original study design, data collection using four primary methods, and miscellaneous notes and reflections.
- Chapter 6 covers the Broader Core Sample (800+ students from the schools participating in the longitudinal study) and Chapter 7 covers the Broader National Sample (4200+ students from 21 institutions around the country). These two chapters describe CAEE's use of the APPLE (Academic Pathways of People Learning Engineering) survey to confirm findings from the longitudinal work discussed in Chapters 2 through 5. The two chapters include information about IRB approval, recruitment, sampling plan, data collection/survey deployment, and miscellaneous notes and reflections.
- Chapter 8 covers the school-to-work transition with the Workplace Cohort, describing the general methodology and the three threads of workplace data collection and analysis.
- The extensive appendices listed at the end of this document include study materials ranging from data access guidelines to sampling plans to data collection instruments.

It is important to acknowledge the incredible team of APS researchers and staff, many of whom continued with the project for its entire six-year run, with time on either end of that period for ramping up and wrapping up. This document represents our collective knowledge about the APS research. It is offered as the foundational underpinnings of the Academic Pathways Study, and as a set of practices and strategies that may be of use to future researchers.

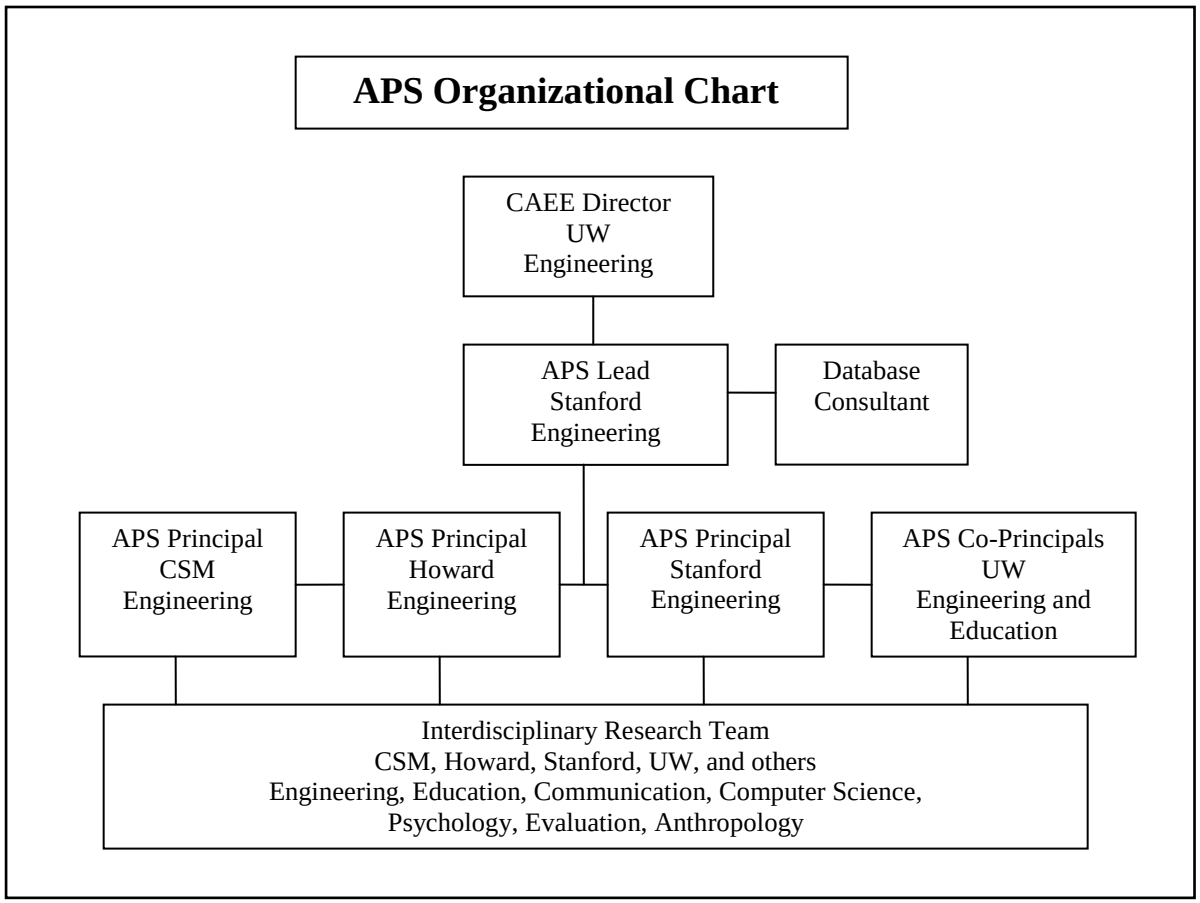
1 Background and General Information

1.1 CAEE and APS Overview

In 2003 the National Science Foundation funded the Center for the Advancement of Engineering Education (CAEE), dedicated to advancing the scholarship of engineering learning and teaching. CAEE is a collaboration of five schools: Colorado School of Mines, Howard University, Stanford University, University of Minnesota, and University of Washington.

The largest component of CAEE was the Academic Pathways Study (APS), a multi-method study to describe how people navigate their undergraduate education to become engineers. The Academic Pathways Study was led by a senior researcher from Stanford University, with the principal co-investigator from each of the four core partner institutions serving on the leadership team (Figure 1.1).

Figure 1.1 APS Organizational Chart



As a working body, the APS leadership team had several major categories of responsibilities:

- Developing policies, standards and procedures for handling the data, reporting findings (including publication and authorship protocols), dissemination, etc.
- Coordinating the development of the research methods and their consistent implementation on the various campuses
- Leading the data collection process, including Institutional Review Board applications
- Monitoring the effectiveness and progress of the APS research team

Each principal co-investigator was responsible for supervising the APS researchers at his/her school and championing a set of research instruments to be used across schools. In this capacity, each principal co-investigator oversaw the development, training, data processing and data analysis related to their instrument(s) for all campuses. Howard University served as champion for structured interviews, the UW for the ethnographic tools and engineering design tasks, Stanford for survey instruments, and the CSM for academic transcript information (to verify majors and provide data about coursework).

Monthly conference calls and periodic face-to-face meetings facilitated the work of the APS leadership team.

The full research team was drawn primarily from the four core partner institutions, and also included area-experts from other institutions. Although specific campuses were designated to lead different components of the research, the team collaborated on all aspects of the project including subject recruitment, instrument design and implementation, and data processing and analysis. Teamwork was fostered by face-to-face workshops of the entire APS research team, as well as smaller targeted cross-institutional meetings and conference calls. Such collaboration contributed to the robustness of research processes across campuses, domains and perspectives.

1.2 Academic Pathways Study Design

APS research was focused on the following questions:

1. How do students' engineering **skills and knowledge** develop and/or change over time?
2. How does one's **identity** as an engineer evolve? More specifically, how does student appreciation, confidence, and commitment for engineering change during the undergraduate educational experience? How do these changes impact student decisions about pursuing engineering after graduation?
3. What elements of engineering **education** contribute to the students' skills/knowledge and identity? What do students find difficult and how do they deal with the difficulties they face?
4. What skills do early career engineers need as they enter the **workplace**? Where did they obtain these skills? Are any skills missing?

To address these research questions, the overall study design included four cohorts and a variety of data collection methods. The study design as originally conceived is shown in Table 1.2, with notes indicating later modifications to the design. Figure 1.3 shows the design for the

Longitudinal Cohort research. In addition to the data sources listed in the figures, key statistics such as SAT scores and major status were collected for the Longitudinal Cohort.

It is important to note that certain aspects of the study design changed over the course of the study to maximize the use of resources and respond to conditions and lessons that surfaced along the way. These changes are described throughout the document, as they occurred.

The primary goals for each cohort* were:

- Longitudinal Cohort – Identify and characterize the pathways and decisions involved in becoming an engineer
- Broader Core Sample – Validate Longitudinal Cohort findings with a broader set of engineering students at the same institutions
- Broader National Sample – Validate Longitudinal Cohort findings at a broader set of institutions nationally
- Workplace Cohort – Learn what goes into becoming an engineer that is not taught or learned as part of the academic training

Table 1.2 Design of the Research Cohorts (Original Design with Modifications)

Longitudinal Cohort: Students who expressed interest in majoring in engineering upon admission at four institutions, followed from their freshman through junior years (2003-2006). *Later modified to extend through senior year (2007).*Study group n=160 (40 per school, including 8 for ethnographic study)

How do students' engineering **skills and knowledge** develop and/or change?	• Interviews* (once per year) • Surveys (twice per year) • Skill and concept-based tests and interviews (once per year) • Ethnographic observations of a subset of students in classes (variable)
How do students develop an **identity** as an engineer?	• Interviews* (once per year) • Surveys (twice per year) • Ethnographic observations of a subset of students in various environments (variable)
What **education** challenges do students face? What resources do they draw upon?	• Interviews* (once per year) • Surveys (twice per year) • Ethnographic observations of a subset of students in various environments (variable)

Broader Core Sample: Engineering undergraduates at the four Longitudinal Cohort institutions who are not in the Longitudinal or Workplace Cohorts, at one point in time (2006-07); n>2000 (original design). *Actual number of participants: 842. Survey administration in April 2007.*

Are Longitudinal Cohort findings representative of other engineering students at the school?	• Cross-sectional surveys developed from the evolving research results

* In some APS publications the cohorts are numbered: cohort 1 is the Longitudinal Cohort, cohort 2 is the Workplace Cohort, cohort 3 the Broader Core Sample, and cohort 4 is the Broader National Sample.

Broader National Sample: Undergraduate students from engineering programs at approximately 20 institutions across the country, at one point in time (2006-2007); n>=3000 (original design).
Later modified to n>1080; actual number of participants: 4266. Survey administration at 21 institutions during January to March, 2008.

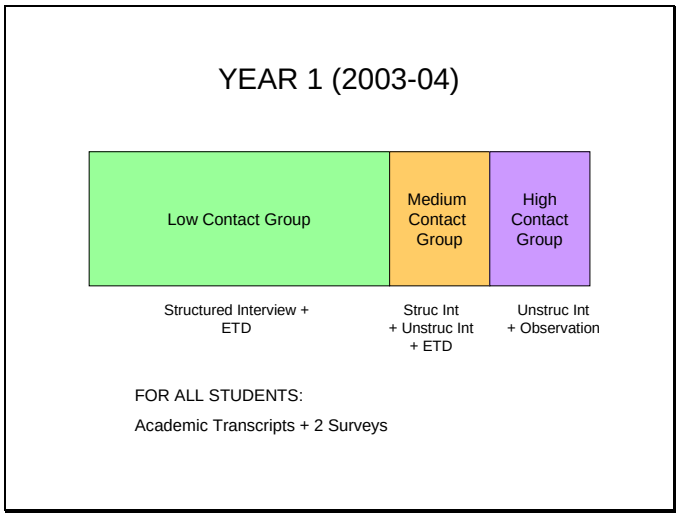
Are Longitudinal Cohort findings representative of other schools?	• Cross-sectional surveys developed from evolving research results

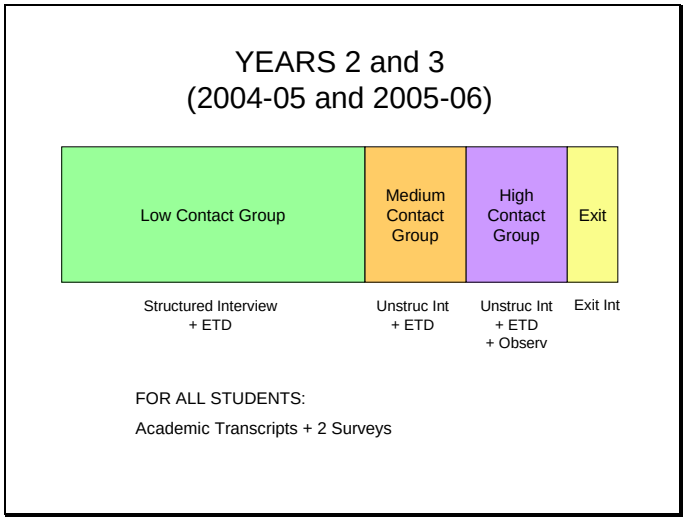
Workplace Cohort: Students majoring in engineering at two institutions, from the end of their junior year through their first two years post-B.S. (2005-2007); n=16, 8 in each of two schools (original design).
Later modified to be a cross-sectional investigation of new professional engineers employed in various settings; actual number of participants: 111.

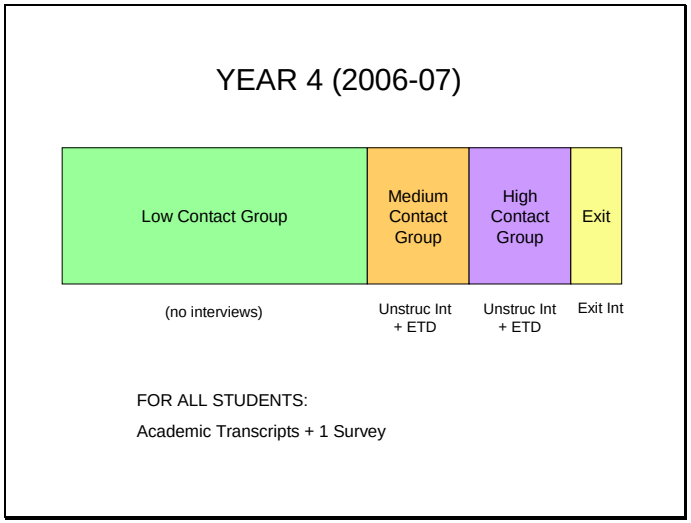
What skills do early career engineers' need as they enter the **workplace**?	• Ethnographic observations and comparative analyses of skills and knowledge used in school and at work. • Interviews
How do students develop an **identity** as an engineer?	• Interviews

* To help researchers gain deeper insights, a subset of Longitudinal Cohort participants was designated to receive semi-structured ethnographic interviews, in lieu of the structured interviews most participants received.

Figure 1.3 Longitudinal Cohort research design (see Study Terminology in Section 1.9)







1.2.1 Participating Institutions

Four diverse institutions provided the student base from which subjects were recruited for the Longitudinal Cohort and Broader Core Sample. A fifth institution provided subjects for the Cross-sectional Cohort which was added to the original APS design and conducted in 2005-2006. The five schools, identified by pseudonym, are described below.

Use of School Pseudonyms

Pseudonyms were adopted to describe the participating schools for use in publications and presentations (including this document). The rationale for using pseudonyms was to protect these institutions from any possible negative implications or perceptions that might come out of the research. Pseudonyms evolved over the course of the research with the final decision being to use pseudonyms that were broadly descriptive and not easily traceable to the real school names. School pseudonyms include Technical Public Institution (TPub), Urban Private University (UPri), Suburban Private University (SPri), Large Public University (LPub), and Large Midwestern Public University (LMPub).

Participating Institution Pseudonyms and Descriptions

Technical Public Institution (TPub) is a public research university devoted to engineering and applied science (2004 Carnegie Classification: Specialized Institution-Engineering). In 2004-2005, 75 percent (2,500) of its 3,350 students were enrolled in undergraduate programs, with approximately 600 of those being entering freshmen. Students face a rigorous curriculum and high academic standards. In 2002, TPub graduated a total of 539 undergraduates, 440 of whom received degrees in engineering majors (i.e., Chemical Engineering, (General) Engineering, Geology and Geological Engineering, Geophysics, Metallurgical and Materials Engineering, Mining Engineering, Petroleum Engineering, and Engineering Physics).

Urban Private University (UPri) is a comprehensive, historically Black private university (2004 Carnegie Classification: Doctoral Research-Extensive). UPri offers an abundance of extracurricular associations and activities, promoting a sense of family among the student body. Of the 10,000 students at UPri in 2004-05, approximately 1400 were freshman, with 180 entering the engineering program each year. Freshmen are accepted into the engineering program upon enrollment. Engineering majors offered include Chemical, Civil, Systems and Computer Science, Mechanical, and Electrical Engineering. In 2002, UPri graduated a total of 108 students from engineering programs.

Suburban Private University (SPri) is a private research university, with an enrollment of about 14,000 students, divided equally between graduate and undergraduate students (2004 Carnegie Classification: Doctoral Research-Extensive). SPri attracts students from around the nation and the world, with fifty percent of students classified as non-Caucasian. Of the 1600 freshmen entering each year, 320 to 350 self-identify as being interested in engineering. (Entering freshmen do not formally declare majors.) In 2002, a total of 373 students graduated from undergraduate engineering programs, including 154 students in Computer Science.

Large Public University (LPub) is a very large public research university (2004 Carnegie Classification: Doctoral Research-Extensive). Over 40,000 students attend LPub. The main campus offers a variety of outdoor activities in close proximity. Students tend to form associations and friendships based on shared academic interests. Of the 7,000 entering freshmen each year, approximately 650 are designated pre-engineering prior to their arrival. Admission into the highly competitive undergraduate engineering program typically occurs during the summer before the junior year and many potential applicants move into other fields before then. In 2002, undergraduate engineering programs at LPub graduated a total of 659 students.

Large Midwestern Public University (LMPub) is a very large public research university (2004 Carnegie Classification: Doctoral Research-Extensive) with over 50,000 students (2008). Seven engineering departments are combined with mathematics and the physical sciences under the umbrella of one technical college. First and second year engineering students take foundation math and science courses in this technical college. At the end of their second year they must petition for admission to the upper division and a specific engineering department. In 2008, approximately 3,300 of 4,600 undergraduates in the technical college were engineering students.

1.2.2 Ensuring Diversity

Including students from diverse backgrounds was a key element of the research plan. In the Longitudinal Cohort, we paid special attention to understanding how underrepresented students navigate their initial years in engineering education. We accomplished this by employing over-sampling strategies for gender (male/female) and underrepresented minority[*] students, including African American/Black, American Indian/Alaska Native, Mexican American/Chicano, Puerto Rican, other Latino groups. In the Broader Core and National Samples, recruitment targets for females and underrepresented minorities, plus strategic recruitment efforts, ensured that diversity considerations carried through to these cohorts also.

1.2.3 Protecting Identities of Participants

Longitudinal Cohort participants were assigned study ID codes that contained no personal identification information. These IDs consisted of the school code, the cohort code (01), a single-digit gender code (M or F) and a five-digit number assigned by the local research team. In addition, the students who participated in the ethnographic study were assigned pseudonyms for ease of reference among the research team. To avoid influencing how these participants may be treated by advisors and faculty, participants were not identified to faculty or other students, including those involved in the research.

Participants in the Broader Core and National Samples submitted data anonymously. The only identifying information was the email address subjects provided in order to claim their incentive. These addresses were released only to the payments coordinator for the purpose of issuing incentives.

[*] We defined underrepresented minorities as those traditionally underrepresented in engineering education relative to their representation in the general population. See Chubin, D., May, G., and Babco, E. "Diversifying the Engineering Workforce" *Journal of Engineering Educatio*n, Vol. 94, No. 1, 2005, pp. 73-86, and May, G., Chubin, D. "A retrospective on Undergraduate Engineering Success for Underrepresented Minority Students*" Journal of Engineering Education*, Vol. 83, No. 1, 2005.

1.2.4 Incentives to Participate

Students in the Longitudinal Cohort received $175 per year of participation. In Year 1, they also received a donated scientific calculator. Students designated for the control group (described in section 1.9) were to receive $25 annually, but the group was disbanded in Year 2. Subjects in the Broader Samples were offered $4 through a popular online financial transaction company.

1.3 Data Storage, Organization and Access

APS employed a database consultant to oversee all aspects of data storage, organization, security and access. Data were stored on secure servers on one of the partner campuses. The database consultant participated fully with the research team to stay abreast of research activities and generally ensure the smooth functioning of all data-related systems.

1.3.1 Technology Infrastructure

APS used an online collaboration system, the APS Workspace that functioned as a secure database allowing team members to coordinate data collection activities and share datasets and analysis activities. Consistent with IRB privacy concerns and the sensitive nature of the data, access and sharing were facilitated and carefully controlled to maintain security. A secure, web-based infrastructure built on wiki technology enabled researchers to quickly view and share information from anywhere via the internet. Furthermore, the Workspace was organized in a fashion that allowed it to grow organically, making it possible to add file storage areas, blogs and private workspaces.

1.3.2 Security and Backup

Like most research, the value of the APS is inextricably tied to the data. Accordingly, extreme care and attention were devoted to data security and backup. On an hourly basis, data from the APS Workspace were backed up to a primary computer and a secondary backup computer. Nightly backups were made to a secure off-site storage machine.

1.3.3 Data Collection and Inventory

The APS utilized a detailed file naming convention that included codes for school, cohort, gender, individual ID, research method, and more (Appendix 1-A). This file naming system allowed researchers to quickly identify a file's origin, purpose and status. Given the different needs of the different research methods, not all data were stored in a single database. As a result database queries were possible within a given database, but not system-wide or across databases.

1.3.4 Access Policy

To protect the privacy of APS participants and facilitate adherence to Institutional Research Review Board (IRB) procedures and obligations, access to APS research data was governed by criteria set forth in the APS Data Access Guidelines, included in Appendix 1-B. The goal of these guidelines was to minimize the likelihood for accidental data sharing with those for whom data access may constitute conflicts of interest or violate IRB approved research protocols and privacy laws.

Basically, researchers from each of the core partner schools had access to their school's data, and members of each method team had access to their method's data. Beyond that, researchers could request data according to the Guidelines, whereby the "owner" of the data (either the school or the method lead) granted access.

1.4 Data Analysis Plan and Processes

APS generated a number of distinct data sets corresponding to different data collection instruments and different cohorts. For all data sets, the first line of analysis was instrument-specific; only data from that instrument were used in the analysis. The champion institution (i.e., the one leading development and implementation of the instrument) also led the instrument-specific data analysis for all schools.

A second line of analysis extended across instruments and methods, utilizing data from more than one APS data set.

Access to and sharing of data was managed through the online APS Workspace with a secure database system. Access to APS data was carefully controlled to ensure that IRB guidelines were observed and data was used appropriately.

1.5 Study Terminology

Below is a listing of terms as they apply to the APS.

APPLES	Academic Pathways of People Learning Engineering Survey (APPLES), derived from the PIE Survey. This web-based survey was the primary data collection instrument for the Broader Core and National Samples. Also called the **APPLE survey**.
Control group	A sub-group of the Longitudinal Cohort who would not receive surveys or interviews. Due to unanticipated difficulties in recruiting adequate numbers of study participants, the control group was disbanded in Year 2. Also called the **comparison group.**
Core (partner) institutions	The four educational institutions that conceived and executed the APS research.
Engineering design task	Short problem-oriented question administered to subjects in the Longitudinal Cohort as part of the annual interview. Responses contributed to the ETD data set. Also called **scoping task**, **performance task** or **engineering task**.
ETD	The Engineering Thinking and Doing (ETD) component of the APS research, designed to uncover frameworks students bring to engineering problem-solving. ETD included the engineering design tasks and specific survey questions focused on engineering design.

Ethnographic methods	Semi-structured ethnographic interviews, field observations, and informal conversations.
Exit interview	An ethnographic interview administered to Longitudinal Cohort participants who declared a non-engineering major.
High Contact Group	A sub-group of Longitudinal Cohort participants who were studied using ethnographic observations and semi-structured ethnographic interviews, in addition to surveys. This group was also referred to as the **Ethnography group**, the **Ethno 8** (8 students per school) or the **Ethno 32** (total of 32 students in the group).
Low Contact Group	A sub-group of Longitudinal Cohort participants consisting of 24 students from each school who participated only in structured interviews, engineering design tasks and surveys (i.e., no semi-structured ethnographic interviews or observations). Also called **The 24.**
Medium Contact Group	The eight Longitudinal Cohort participants at each school who received semi-structured ethnographic interviews but no ethnographic observations. Because these students received both structured and semi-structured ethnographic interviews in Year 1, they were sometimes called the **combo group**.
Participating institutions	Universities from which student participants were drawn for the Longitudinal Cohort, Broader Core Sample, and Cross-sectional Cohort.
Persister	A student who had entered university with intent to study engineering and whose declared major at the end of the study period was in the school of engineering at that student's institution. Engineering majors varied by institution (e.g. some schools placed computer science in the school of engineering while others did not). See Appendix 1-C for related definitions.
PIE survey	Persistence in Engineering (PIE) survey, patterned after existing surveys of engineering students for web-based administration to Longitudinal Cohort participants.
Non-persisters	Individuals who declared a non-engineering major after indicating intent to major in engineering.
Structured interview	A series of questions designed to address specific research topics. Structured interviews were used with Longitudinal Cohort participants who did not receive the semi-structured ethnographic interview. Also called **formal interview**.

Semi-structured ethnographic interview	A series of questions or prompts open-ended in nature designed to elicit free-flowing accounts of participants' perspectives and experiences. The questions were designed to enable students to reflect upon their past, present, and future life-world experiences related to engineering. Semi-structured, ethnographic interviews were used with the High and Medium Contact Groups. Also called **informal interview, unstructured interview** or **ethnography interview.**
Underrepresented ethnic groups	Ethnic groups traditionally underrepresented in undergraduate engineering programs in the U.S., including African American/Black, Latino/a, and Native American. Also called **underrepresented minorities** or **URM**.

2 Research Year 1: Fall 2003 – Spring 2004

2.1 Tasks and Goals

The main tasks for Year 1 were to:

- Recruit and enroll 320 freshmen (160 in the study group and 160 in the control group) at the four core institutions. Students would be followed through the end of their junior year.[*]
- Administer surveys (winter and spring) and interviews (spring) to all Longitudinal Cohort participants, and conduct ethnographic observations of the High Contact Group throughout the academic year.

2.2 Recruitment

2.2.1 Methods

Recruitment activities varied at each of the four institutions, as described below. Recruitment efforts were tied to school calendars, with the semester schools (Technical Public Institution and Urban Private University) beginning in late summer and the quarter schools (Suburban Private University and Large Public University) starting up in early fall. Recruitment activities continued throughout the first school term.

All study participants were required to sign a consent form approved by the Institutional Review Board (IRB) at their institution (see Appendix 1-D). To boost recruitment, a national electronics company donated scientific calculators to give to study participants in Year 1, in addition to the $175 incentive per participant per year.

<u>Technical Public Institution</u>

Recruitment efforts began during summer 2003, at four summer campus events that constituted "Explore TPub":

- The Information Fair in August
- Two campus events sponsored by the Minority in Engineering Program (MEP)
- An event sponsored by Society of Women Engineers (SWE)
- An all-campus event held in the first two weeks of school.

Once classes had begun, a member of the TPub research team made presentations at Chemistry lectures attended by all first-year students. She also met with residence hall assistants. Further outreach was planned through fraternity and sorority houses, but this step was not needed.

<u>Urban Private University</u>

Recruitment activities included:

- A presentation about the study in July at a summer program for incoming freshmen ("Pre-Freshmen Summer Experience"). Interested students submitted information forms.

[*] In September of 2005, the National Science Foundation provided supplementary funds to allow researchers to follow participants in the High and Medium Contact Groups for an additional year.

- Presentation and brochures at student orientation in August, where more student interest forms were collected.
- Advertisement of the APS informational session in September through:
    - Flyers in the Engineering and Architecture buildings
    - Invitational emails to students who had previously expressed interest in the study
    - An announcement in the "Intro to Engineering" class, which all engineering students attend
- A second recruitment drive in October consisting of:
    - A table with flyers and brochures in the Engineering Building
    - A follow-up visit to the "Intro to Engineering" class
- Contacting students who had previously expressed interest, via phone and e-mail, through mid-November.

Students who decided to participate in the study signed consent forms at the information session in September, or in the course of recruitment activities during October and November. For students under 18, parents were contacted to sign the consent form.

Suburban Private University

Potential participants were contacted using the following methods:

- Personalized letters to students who had listed engineering as a preliminary academic interest (September)
- New Student Orientation presentations (September)
- Flyers in dorms, classrooms, libraries, engineering buildings, etc. (September)
- Group information session (October)
- Individual e-mails to students who had expressed interest in engineering and/or in the study (November)
- Mass e-mails to campus engineering societies and freshman engineering seminars (October, November, and December)
- Individual information sessions (October, November, and December)
- Engineering society meetings (October and November)

Consent forms were signed at group and individual information sessions.

Large Public University

The initial attempt to recruit Longitudinal Cohort participants took place from late October through mid-November 2003. Activities included:

- In-class presentations for courses in the math sequence, chemistry sequence, and physics sequence, as well as in ENGR 100, an introductory engineering class open to freshmen. Interested students completed "statements of interest."
- Notices posted to the email list-server for pre-engineering students (weekly posts during November).
- Information sessions, to which interested students from the above two activities were personally invited. Information sessions were held several times a week throughout November and into early December, drawing from one to four students.

2.2.2 Diversity Considerations

A recruitment objective of APS was to over-sample certain populations to gain information about a broad range of students. To this end, sampling goals were set forth, including:

- Obtain a **gender** balance of 50/50 (equal numbers of women and men)
- Adjust sampling to include at least 25% **underrepresented** ethnic populations (African Americans, Native Americans, and Latinos)
- Over-sample students who exhibit a **keen interest** in engineering (i.e., possess indicators that they are very likely to succeed and be retained as engineers). The intent was to maximize the number of persisters in the study.

The original sampling plan for the Longitudinal Cohort is shown in Appendix 2-A.

Urban Private University, which is predominately African-American, drew about 20 percent of its freshman engineering class from international (non-U.S.) students. The sampling goal for underrepresented students at UPri was to obtain a 50/50 balance of U.S. and non-U.S. students.

At TPub and LPub, initial recruitment efforts yielded fewer women than men. At both schools, targeting women via e-mail communications helped increase the number of female participants. TPub researchers used e-mail to invite female students to two additional information sessions, while LPub researchers increased their female participation with a list-server announcement targeting women. Relatively few women study engineering at SPri and this was reflected in SPri's recruitment numbers.

No African-American students attended information sessions at TPub. In fact, there were only six African American students in the freshman class of 750, and only five of them were eligible for APS. Various remedial strategies for recruitment were considered, including having upper-class students contact these first-year students. However, it was decided not to pursue them for fear of making students uncomfortable. Furthermore, since there were few females at TPub from ethnic minority groups, ethnic-minority males were over-sampled instead.

Figure 2.1 illustrates the gender breakdown of the 160 students who began the study, while Figures 2.2 and 2.3 show the ethnic make-up of the 156 students who completed the first survey.[*] Gender and ethnicity data were obtained from demographic questions on the survey; non-responders are not represented in the figures. Further demographic details are included in Appendix 1-E.

[*] Ethnicity data was obtained from a multiple-choice question that was periodically included as part of the APS survey. Students could select multiple responses. For purposes of this document, Mexican American /Chicano, Puerto Rican, and Other Latino have been combined into one category, "Latino".

Figure 2.1 Gender distribution (Year 1)

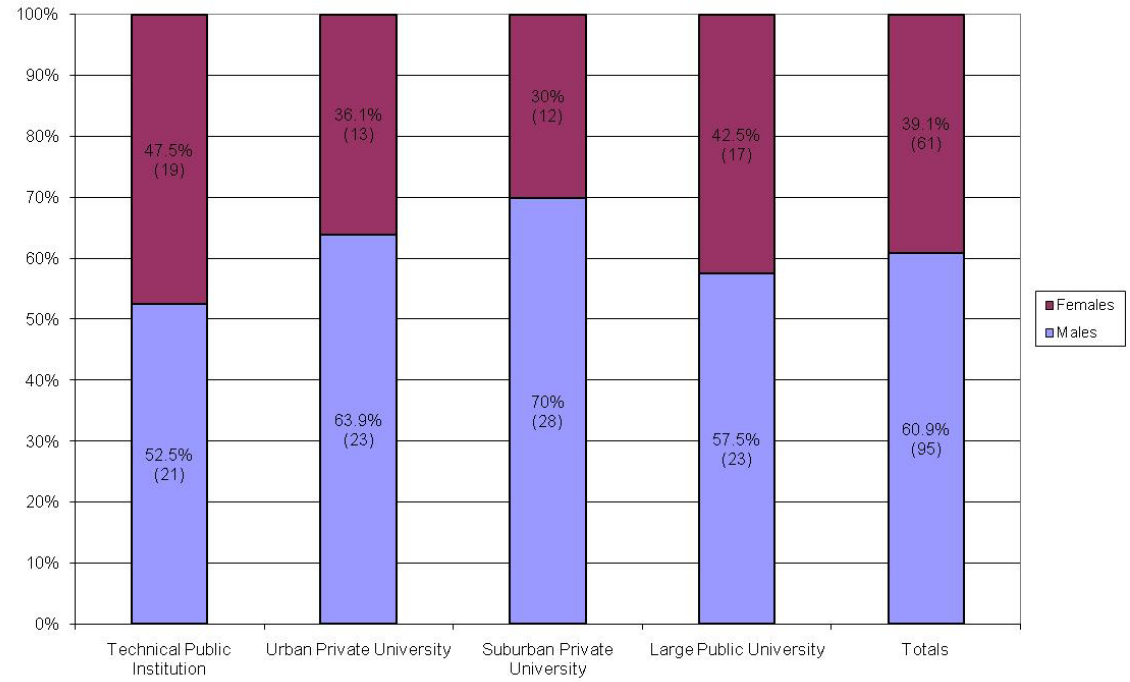


Figure 2.2 Ethnicity distribution by school (Year 1)

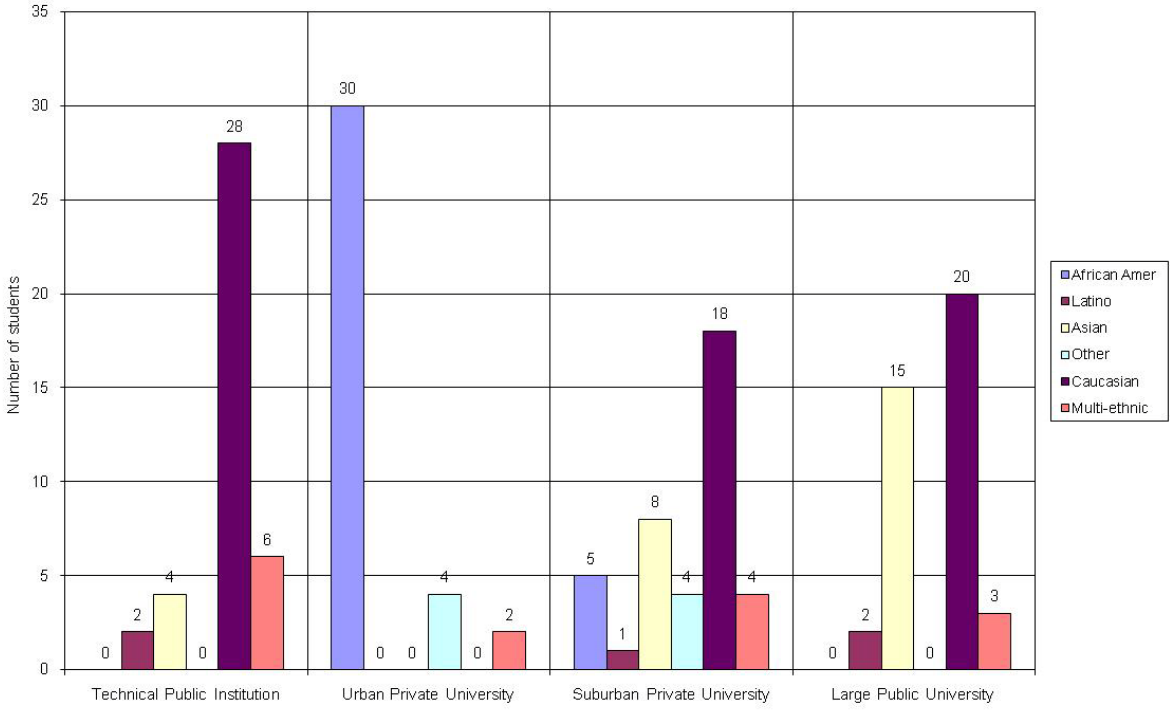
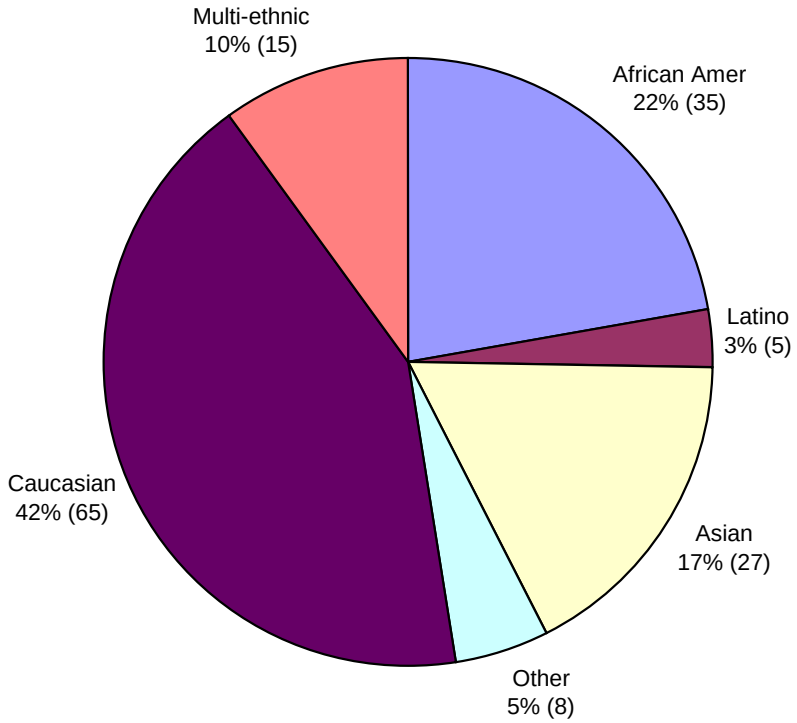


Figure 2.3 Ethnicity distribution for all schools (Year 1)



2.3 Group Assignments

Each school was responsible for randomly assigning participants to control and study groups, bearing in mind sampling goals with respect to gender, ethnicity, and likelihood for persisting in engineering. The original research design called for:

- A study group of 40 students per school
    - 8 students assigned to a High Contact Group (survey, semi-structured ethnographic interview and ethnographic field observation)
    - 32 students assigned to a Low Contact Group (survey, structured interview and engineering design task)
- A control (comparison) group of 40 students

Academic transcripts and declared major would be collected for all groups.

Prior to beginning data collection, the research team decided to increase the number of participants receiving the semi-structured ethnographic interview (see section 2.4.1). As a result, 8 students from the Low Contact Group were reassigned to form a new group, the Medium Contact Group, which did both structured and semi-structured ethnographic interviews in Year 1, as well as surveys and the engineering design task.

Of the four schools, only TPub was able to recruit enough participants in Year 1 to fully populate a control group. This resulted in a decision not to have a control group as part of the Longitudinal Cohort at any school.

2.3.1 Methods

Each of the four institutions developed their own procedure for assigning participants to the various Longitudinal study groups.

Technical Public Institution

Thirty Caucasian male participants were selected from a sample of 56 students. The first division was geographical (out of state, Big City metropolitan, other State areas). The next division was based on the questionnaire students had completed assessing their level of interest in the study. Students were eliminated if (a) their primary motivation was the cash incentive, or (b) they preferred a limited level of participation (i.e., monitoring of academic records only). One student was eliminated who had missed several recruiting sessions despite confirming by email beforehand. Finally, the remaining students were geographically balanced for metropolitan Big City area of origin and other State areas. Because one major city was heavily represented, these students were also balanced by major.

Of 32 Caucasian female students, one student was eliminated whose questionnaire indicated preference for a limited level of participation, and one more student was eliminated who had a non-engineering major, resulting in a group of thirty white females for the study.

For ethnic minority participants (male and female), the initial sample population consisted of 14 minority males and 8 minority females. One student was eliminated because of several eligibility factors which could not be verified: U.S. citizenship, ethnicity, and gender. Two ethnic male students were eliminated because they listed “money” as the primary motivation for participating in the study. Students who did not choose to be a participant in the “whole show” were also eliminated.

Urban Private University

The dataset of 62 student names was sorted by 1) participation in Pre-Freshmen Program, 2) citizenship, and 3) gender. The objective was to have 31 students in the detailed study group and 31 students in the control group. Each group was to contain three Pre-Freshmen participants (two males and one female) and 28 non Pre-Freshmen participants (ten male and seven female U.S. citizens, eight male and three female non-U.S. citizens).

A systematic method was used to assign students to the study group and control group. Working from a numbered list, students with odd numbers by their names were placed in the control group and the even numbered students were placed in the study group, resulting in 31 study participants and 31 control participants.

The eight participants for the High Contact Group were systematically selected from the study group. The objective was to obtain two Pre-Freshmen participants (one female, one male), two U.S. citizen participants (one female, one male), and four non-U.S. citizen participants (two female, two male). The only female Pre-Freshmen participant and first male were selected from

the Pre-Freshmen participants. For U.S. citizen participants, the first female and the fourth male were selected. For non-U.S. citizen participants, the first and third female and the second and sixth male were selected.

With equal participants in the detailed study and control group, it was recommended that nine students in the control group be added to the study group, to bring the total to 40. A systematic method was employed. From the Pre-Freshman Program, the first male was selected (no female students remained to be selected). From the U.S. citizen pool, every third female was selected, for a total of two females, and every fifth male was selected, for a total of two males. From the non-U.S. citizen pool, the first and third female was selected, for a total of two females, and every fourth male was selected for a total of two males.

Suburban Private University

A total of 44 students signed consent forms, including one student who declined to participate in the study. Forty students were selected to participate in the study group, and the remaining 3 were assigned to the control group.

The 3 students assigned to the control group were not selected randomly. One student declined to participate in any of the research methods, with the exception of the collection of the student's academic information. Two students had not responded to updating their consent forms.

Participants were selected for the High Contact Group based on the following criteria:

- Gender representation: 4 females, 4 males (desired 4/4)
- Ethnic representation: 2 ethnic minority students (desired 2-4)
- Engineering Bridge Program: 1 student who participated in the SPri Summer Science Engineering Academy program during the summer before their freshman year (desired 1-2)
- Academic intent: Which majors has this student indicated an interest in based on individual meetings with research team and preliminary academic interest information:
    - Engineering only: 6 (desired 5-6)
    - Engineering or Computer Science: 1 (desired 0-1)
    - Engineering or Physical Sciences: 1 (desired 0-1)
    - Engineering or Social Science/Humanities: 0 (desired 0-1)

Additional qualities of the group were considered to help decide between multiple students who clustered together after the initial criteria were considered:

- Extracurricular activity: students involved in a time-intensive extracurricular activity such as athletics: 2 selected (1 walk-on athlete, 1 varsity athlete)
- Residential assignment: students from a freshman dorm or other special residential considerations: 2 selected (1 freshman/sophomore dorm, 1 whose roommate is also in the study)
- Engineers in family (students whose parent is an engineer): 1 selected
- Relationship with ethnographer: all selected students had some connection to ethnographer
- High School academic information: student who had lower Math SAT scores (below 700) than others in the group

Large Public University
Initially, students had been randomly assigned to the study group and to the control group. However, because of drop-outs and lack of response from some students in the study group, all students who expressed interest in participating in the study were eventually selected for the study group.

During information meetings, students were asked to indicate in which groups they would be interested in participating. Five women and 15 men expressed an interest in being considered for the High Contact Group.

Of the five women, two indicated they are members of underrepresented minority groups, and were immediately invited to participate in the High Contact Group. Two of the remaining three women were randomly selected for invitations to this group. One accepted and one declined so was reassigned to the Low Contact Group. The remaining woman also declined. In mid-January, a woman who had been assigned to the study group was asked if she would consider switching to the High Contact Group, on the basis of her enthusiasm for the study. She accepted, resulting in four women being assigned to the High Contact Group.

Of the 15 men, two Caucasian males were selected for the High Contact Group on the basis of the researchers' judgment that they would make good ethnographic informants. A third, an Asian-American, was chosen because he was the only Asian male to volunteer for the High Contact Group. The fourth, a direct admit to the Electrical Engineering department, was invited because it was expected that the experiences of directly admitted students would differ from those of students competing for admission to departments.

2.3.2 Numbers

Table 2.4 shows gender and ethnic breakdowns by school and study group.

Table 2.4 Gender and Ethnic Breakdowns (Year 1)

Citizenship and Race/Ethnicity data were obtained directly from subjects' responses on Survey 1 (Winter 2004). Total N=156 (4 of the original subjects did not take Survey 1 and are therefore not represented in these tables)

	Gender		Citizenship		Race/Ethnicity							
	Female	Male	US Citizen	Non-Citizen	Afr-Am/ Black	Native Amer	Asian Amer	Latino*	Cauc	Other	Multi	URM**
TPub	19	21	40	0	0	0	4	2	28	0	6	2 5%
UPri	13	23	21	15	30	0	0	0	0	4	2	30 83%
SPri	12	28	34	6	5	0	8	1	18	4	4	6 15%
LPub	17	23	35	5	0	0	15	2	20	0	3	2 5%
Total	61 39%	95 61%	130 83%	26 17%	35 22%	0 0%	27 17%	5 3%	66 42%	8 5%	15 10%	40 26%

	Gender		Citizenship		Race/Ethnicity							
	Female	Male	US Citizen	Non-Citizen	Afr-Am/ Black	Native Amer	Asian Amer	Latino*	Cauc	Other	Multi	URM**
High Contact	16	16	26	6	8	0	5	3	14	0	2	11 34%
Medium Contact	16	16	25	7	9	0	5	1	11	2	4	10 31%
Low Contact	29	63	79	13	18	0	17	1	41	6	9	19 21%
Total	61	95	130	26	35	0	27	5	66	8	15	40 26%

* Latino combines Mexican, Puerto Rican and other Latino

** URM = underrepresented minority groups including African American/Black, Native American, and Latino

2.3.3 Replenishing Study Groups

Each school developed a plan for replenishing study groups in case of attrition in future years of the study.

TPub planned to replace students in the study groups, as needed, with students from the control group. Because of the time-intensive nature of recruiting and uncertain value of maintaining a control set, students in the control group would not be replaced. During Year 1, TPub replaced two male students who left the study with two male students from the control group. One of these was selected because he stood out as being especially talkative during the recruitment process. The other replacement student had expressed specific interest in being in the study when he was assigned to the control group.

UPri planned to post flyers advertising the study in the College of Engineering, Architecture, and Computer Sciences. Brochures would be distributed to students and faculty, and members of the research team would make presentations in sophomore level physics and engineering courses. Also, the study would be publicized during the weekly meetings of student engineering societies, such as the National Society of Black Engineers, the Society of Women Engineers, American Society of Mechanical Engineers, and American Society of Civil Engineers.

SPri planned to recruit subjects for the control group who in turn could replace subjects in the study group if needed. There were concerns about the demographics of the study group and whether there would be at least 30 study participants with declared engineering majors at the end of year 2. The recruitment plan included 1) contacting professors of targeted courses and introductory seminars, 2) posting flyers in key building areas on campus, 3) emailing of announcements to engineering societies and sophomore dorm mailing lists, 4) announcements during class lectures and society meetings, and individual meetings with interested students.

LPub planned to replenish subjects in the High Contact Group with ones from the Medium Contact Group, and subjects in the Medium Contact Group with ones from the Low Contact Group. If further replacements were needed, they would be drawn from the control group. The primary consideration in selecting students would be their willingness to participate and a sense that the student would be a good informant. Within this plan, attempts would be made to replace withdrawing subjects with demographically similar subjects. Additional recruitment was planned if more subjects were needed.

2.4 Changes to Study Design

During the recruitment phase of the study, several unanticipated developments caused the research team to reexamine and ultimately modify certain aspects of the original study design. These changes included:

- Designating a Medium Contact Group
- Ending recruitment efforts before the full 80 students per school had been recruited

The rationale and implications for these changes are discussed below.

2.4.1 Medium Contact Group

Researchers became concerned about losing participants from the High Contact Group, which would diminish this very rich source of data. In order to offset any such losses, eight students from the Low Contact Group at each school were designated to constitute a new group of participants – the Medium Contact Group – which would receive both structured and semi-structured ethnographic interviews. These students would not receive ethnographic observations except in cases where a student from the High Contact Group migrated out of the study and was replaced by a student from the Medium Contact Group.

2.4.2 Recruitment Goals

All schools except TPub experienced difficulties in identifying and recruiting adequate numbers of APS eligible students. Recruitment efforts were extended into November 2003 in hopes of increasing participant numbers. This was successful to a point. Each school was able to recruit at least 40 students—enough to comprise a study group. Rather than prolong the recruitment period further, the research team decided to cease recruitment activities at this point and commence with the data collection phase of the study.

2.5 Data collection

2.5.1 Methods

The APS used multiple methods to collect data on participants. The main methods included survey, structured and semi-structured ethnographic interviews, engineering design tasks and ethnographic field observations. Surveys, structured interviews, and engineering tasks provided data on a large set of participants, while ethnographic methods (e.g., semi-structured ethnographic interviews and field observations) yielded deeper, richer information on a more limited number of students. In addition, academic transcripts were collected for all subjects. Each method provided a set of insights that informed the other methods and allowed emerging findings to be explored with the broader study population. Interpreted and analyzed together, data from the various methods resulted in rich descriptions of students' academic pathways, as well as the critical factors, challenges, and strategies related to navigating these pathways.

The APS survey – also called the **Persistence in Engineering (PIE) survey** – was used to identify and characterize the fundamental factors that influenced students' intentions to pursue an undergraduate engineering degree and, upon graduation, practice engineering as a profession. It covered a broad range of issues including students' attitudes about engineering, confidence in their abilities, aspirations, perceptions about the engineering education climate, and perceptions of their behaviors and experiences inside and outside the classroom.

Survey design began with development of conceptual constructs and survey questions generated from a review of engineering education literature and previous national surveys of undergraduate education. The development team piloted the survey and conducted internal consistency analyses to validate survey constructs. In the course of the APS longitudinal research, survey items and constructs were iteratively evaluated and refined as successive survey administrations revealed new information.

There were 26 specific survey constructs, which included persistence in engineering, motivation, satisfaction with collegiate experience, curriculum overload, and more. PIE survey constructs are delineated in Appendix 4-B.

The web-based PIE survey was administered to all 160 Longitudinal Cohort participants twice per academic year for Years 1 through 3 of the study, and once during Year 4. Based on findings from the Longitudinal Cohort, the survey was refined and shortened for administration to the Broader Core and National Samples. Copies of the PIE surveys are included in Appendix 4-A.

Structured interviews had a set format with pre-defined questions, allowing for collection of specific information related to engineering education and identity and skills development. Interviewers could prompt participants to expand on their answers, thereby adding depth and texture to individual responses. While interviewers controlled the content of the interview, students were able to provide as much information and detail as they needed to tell their stories. Structured interviews were administered once per academic year to the Low Contact participants; interviews were recorded and transcribed. The interview was approximately one hour in length. Copies of all structured interview protocols are included in Appendix 3-A.

Engineering Design Tasks provided data specific to skill development. These tasks were problem-oriented activities administered in written form. The Year 1 task consisted of a free-response question asking respondents what factors they would consider in approaching a specific engineering design problem. Then an interviewer asked respondents a number of follow-up reflection questions. Data gathered from this activity were used to assess how broadly students perceived basic engineering problems, and how this changed over time. An engineering design task was administered annually at the end of the structured interview.[*] Copies of all engineering design tasks and administration protocols are included in Appendix 3-B, along with a table of other data sources that contribute to Engineering Thinking and Doing (ETD).

Ethnographic methods allowed for collection of rich, in-depth descriptions of the culture and experience of engineering education through the eyes of students. By capturing individual student narratives, researchers were better able to discover and describe student perceptions and motivations, and how these contributed to educational decisions and pathways.

Ethnographic methods helped APS researchers answer questions relating to identity development in undergraduate engineering majors, including the role engineering education plays. Identity has been cited as a key factor in retention of students in the discipline.

- **Ethnographic field observation** of participants occurred during activities that were significant to their educational experiences such as: project work in lab-type engineering courses; examination periods; senior design/capstone projects; and extra-curricular activities. To get a sense of the day-to-day experiences of students, researchers conducted "day in the life" observations of students. Observations were conducted by trained APS researchers and recorded principally as field notes for subsequent analysis. Originally, each High Contact participant was to be observed for approximately 30 hours per

[*] After Year 1, an engineering design task was administered to all study participants after either the structured or semi-structured interview.

academic year – a goal that was later modified due to the time intensive nature of the activity (see section 2.6.4).

- **Semi-structured (ethnographic) interviews** used interviewing methods that enabled researchers to glean aspects of culture and everyday life experiences through open-ended questions. APS researchers developed ethnographic interviews to reflect engineering student perceptions about past, present and future experiences. This approach allowed students to describe the culture of engineering education through their own eyes and impart what meaning it had for them. The annual semi-structured ethnographic interview was approximately 2 hours in length. Interview guides for conducting semi-structured interviews are included in Appendix 3-D.

- **Informal conversations** were conducted throughout the study, to varying degrees at each of the four schools. Informal conversations allowed researchers to check in with students as needed to stay abreast of any changes in student status. These conversations added to the understanding and description of individual participants.

Academic Transcripts were collected for all subjects from their respective institutions. Academic transcripts were the final determinant of major(s) and persistence in engineering. Transcripts also provided information about coursework, GPA and date of graduation.

2.5.2 Interview Protocols and Training

During the fall and winter (2003-2004), the research team compiled a manual and detailed protocols and guides for conducting interviews (Appendix 3-C), tailored to the institution and type of interview (structured vs. semi-structured/ethnographic). In addition, members of the research team who would be serving as interviewers underwent a group training in February 2004 and several practice sessions before conducting interviews with study participants.

All interviews (structured and semi-structured) were recorded, uploaded to the database, and transcribed.

2.5.3 Ethnography Observation Training

In summer (2003) APS researchers participated in ethnography observation training. The two-day training was conducted by CAEE researchers, and included practice observations and write-ups that were reviewed as a group.

2.5.4 Summary of Data Collected

Table 2.5 summarizes Year 1 data collection activities, including numbers of participants engaged in each method. Academic transcripts were collected but are not included in the table.

Table 2.5 Data collection summary by school for Year 1 (2003-2004)

	Surveys (n=40)		Structured Interviews (n=32)				Semi-structured Ethnographic Interviews (n=16)				Ethno Obs (n=8)	
	Dates	#	Dates	#	Length (min.)	# Eng. Act'y	Dates	#	Length (min.)	# Eng. Act'y	#	Hours spent
TPub	1/20-2/19/04	40										
	4/1-5/3/04	40	3/11-4/22/04	32	19-51	32	3/11-4/6/04	16	n/a	0	34	34
UPri	1/20-3/8/04	36										
	4/7-6/16/04	36	3/23-5/4/04	28	20-55	28	3/23-5/11/04	16	45-105	0	15	30
SPri	1/20-2/9/04	40										
	5/10-5/23/04	40	4/9-4/30/04	32	18-60	32	4/17-5/12/04	16	54-165	0	30	34.5
LPub	Winter '04	40					Dec '03	2 (pilot)				
	Spring '04	40	Apr-May '04	32	n/a	32	Apr-May '04	16	n/a	0	55	85+

2.6 Notes and Reflections on Year 1

2.6.1 Recruitment Challenges

Recruiting students into the study proved more difficult and time-consuming than expected. The specific challenges varied by school, as described in reports submitted by each school's primary recruiter.

Technical Public Institution

The principal challenge at TPub was recruitment of African-American students. The goal was to have at least one female and one male High Contact participant who was African American. However, researchers at TPub were unable to recruit any African Americans into the study.

A secondary challenge at TPub was recruiting adequate numbers of women into the study. Although exactly forty women signed consent forms to proceed with the study, two were eliminated because of ineligible majors or lukewarm interest. Furthermore, there were insufficient ethnic minority females to meet sampling goals. As a result, the subject pool at TPub included more minority men and fewer women overall.

Urban Private University

The main challenge at UPri was recruiting a relatively large number (80 students to fill both study and control groups) from a small incoming class (107 engineering students). It was difficult to generate interest among this small student pool.

It was also difficult getting students to come in to sign the consent forms. Of the 85 students who initially expressed interest in participating, only 62 signed consent forms.

Suburban Private University
Students were more available (responsive) during the very beginning of the quarter and at the end of the quarter, just before leaving for break. In between, it was difficult to reach freshmen because attendance at extracurricular activities and response to mass emails diminished greatly.

Arranging individual meetings with the students was time-consuming but paid off in the long-run. The individual meetings allowed the students to ask questions and establish a connection with the research team.

Large Public University
Surprisingly few students expressed an interest relative to the number of freshman engineering and pre-engineering students. It was very difficult to arrange meetings with students, both for the information sessions and for signing informed consent. What was expected to be a month-long recruitment process took nearly 3 months.

2.6.2 Consistency of Methods and Procedures across Schools

Because of the inherent differences between the four core schools, study methods and procedures were not completely consistent across schools. Some of these institutional differences included:

- **Academic calendars.** TPub and UPri operated on the semester system, while SPri and LPub used the quarter system. This meant the timing of study activities was slightly different at each of the four schools.
- **Freshman orientation activities.** Recruitment plans for this study took advantage of freshman orientation activities to publicize the study and recruit students. However, differences in orientation schedules and programs among the schools meant that recruitment methods and timelines had to be customized per school.
- **Entry into engineering.** The identification of engineering students for the study was complicated by the fact that the four schools followed different timelines and procedures for declaring majors. TPub and UPri students could declare an engineering major at any point during their freshman and sophomore years. SPri students typically did not declare a major during the freshman year, but rather named a broadly defined area of interest. At LPub, students must apply and be accepted into the engineering program (typically following the sophomore year) and many students are turned away. Recruitment and eligibility criteria were adjusted to accommodate these differences.
- **Diversity.** The participating schools differed in terms of ethnic and gender mix among their students, making diversity goals difficult to achieve across all schools. UPri students were predominately African-American with a high percentage of international students. Therefore, UPri introduced diversity into their study population by over-sampling students who were not U.S. citizens. TPub had less ethnic diversity compared to the other schools, while SPri had relatively fewer female students in engineering.

2.6.3 Non-Random Assignment to Study Groups

Random assignment of participants into study and control groups as defined in the original sampling plan (Appendix 2-A) was possible only at TPub and UPri, where sufficient numbers had been recruited. At SPri and LPub, virtually everyone who signed a consent form was

assigned to the study group in order to reach the goal of 40 study (non-control) participants per school.

Since the goal of the Longitudinal Cohort was to describe a range of academic pathways for engineers, students were not randomly assigned to the high, medium or low contact groups. Instead, group assignments were based on a variety of factors, of which ethnicity and gender were only two.

Students who were unique in some way, or had a proclivity for sharing their stories, were considered desirable candidates for the high and medium contact groups. This approach was intended to yield a wide and rich array of personal stories.

Another consideration when making group assignments was whether the student was likely to stay in engineering for the duration of the study. In order to achieve study goals, it was important to have a large majority of participants graduate with an engineering degree. On the other hand, it was desirable to also include the stories of students who left the field; who were they and what factors drove their decision to leave?

2.6.4 Insufficient Ethnography Resources

By the end of Year 1, it became apparent that resources for scheduling, conducting and recording field observations were limited at most campuses. Maintaining contact and scheduling observations with students in the High Contact Group was more difficult and time-consuming than anticipated. In addition, each hour of observation in the field required two to three more hours of writing up field notes. As a result, virtually no field observations were conducted in spring 2004 when researchers were conducting interviews.

2.6.5 Recording and Transcribing Semi-structured Ethnographic Interviews

Following the first year of data collection, the ethnography group at LPub hired a transcriber to transcribe the semi-structured ethnographic interviews from all four partner schools. Over the four years of data collection, the research team used a variety of individual transcribers and businesses to process the raw files.

3 Research Year 2: Fall 2004 – Spring 2005

3.1 Tasks and Goals

The main tasks for Year 2 were to:

- Manage the Longitudinal Cohort study pool to maintain size and diversity of the study groups as much as possible
- Administer surveys (fall and spring) and interviews (spring) to all participants in the study group
- Conduct exit interviews with students who declared majors other than engineering

3.2 Changes to Study Design and Procedures

3.2.1 Control Group

Because of the unforeseen difficulty of recruiting adequate numbers of students for the study, the research team decided not to further pursue or maintain a control group whose only purpose was to provide demographic comparison with the study subjects. Existing control subjects were tapped to offset attrition of the study groups, as described in Section 3.3. The remaining controls were disbanded in the fall of 2004, as described here:

Technical Public Institution

After replenishing the study group, students remaining in the control group were sent a letter informing them they would no longer be followed as part of the study. The text of the letter appears below.

> *Dear Academic Pathways Participant:*
>
> *The Control Group for the Academic Pathways Study will no longer be followed after November 3, 2004, the expiration date for our current signed consent. Thank you for your participation in our research. We hope to keep your name on file; if our research plan changes we will invite you to participate again. If you wish to be removed from our mailing list, please reply to this email.*
>
> *Thank you again for your participation.*

Urban Private University

Only 12 of the 22 control subjects returned to sign consent forms in the fall of 2004. All 12 of these students were placed into study group slots vacated by departing study group subjects.

Suburban Private University

In anticipation of attrition among study group participants, the three control group subjects were invited to join the study group. One student agreed, increasing the study population at SPri to 41. Of the other two control students, one declined to participate further and the other did not respond, ending their participation.

Large Public University
There were no control subjects to disband at LPub.

3.2.2 Types of Data Collected

The research team decided that in Year 2 and beyond, structured interviews would not be administered to subjects in the Medium Contact Group. (This group had received both semi-structured ethnographic and structured interviews in Year 1.) Since there was considerable overlap between the two interviews, this move was intended to reduce undue burden on participants and interview staff.

In Year 2 and beyond, the engineering design tasks were administered to all participants, including those in the High Contact Group. (Students in this group did not do an engineering design task in Year 1.) Data gathered from engineering tasks would help researchers analyze how students' perceptions of engineering and approaches to engineering problems developed as they progressed through the college years. In Year 2, the engineering task was administered immediately following the spring interview.

3.2.3 Transcription of Structured Interviews

Beginning in Year 2, the research team at Howard University took over the responsibility for transcribing structured interviews, except for the engineering task, which would be transcribed by a consultant.

3.3 Migration between Study Groups

There were three main reasons for migrations of study participants between groups:

- **Departures** from the study caused by students declining to complete surveys and interviews, or leaving school.
- **Reallocation** of students among study groups as a result of departures.
- **Switching** to non-engineering majors, which triggered an exit interview.

As can be expected, the APS study pool experienced some attrition during Year 1. A total of eighteen students left the study after Year 1, four of whom had never provided data. Since the number of subjects was not large to begin with, researchers drew from their control group subjects to replenish study groups during Year 2. These and other migrations are described in section 3.3.1.

3.3.1 Year 2 Migration and Replenishment

Technical Public Institution

Five students left TPub and the study.* One was in the Medium Contact Group, and the four others were in the Low Contact Group. Five students from the control group were reallocated to fill the vacant slots, maintaining gender and ethnic diversity as much as possible.

Urban Private University

Eight students left the study before the 2004-2005 academic year, in addition to four who failed to take even the first survey. Of the eight who left, one student transferred to another school, two declined to participate further, and five declared non-engineering majors. This created a total of twelve open slots that were filled with students from the control group.

Suburban Private University

All 40 study participants returned for Year 2 in their original groups. In addition, one student from the Control Group was added to the Low Contact Group, bringing the total number of participants in that group to 25.

Large Public University

One student (Asian-American female) switched to a business major and left the university. Her slot was not refilled in Year 2.

3.3.2 Exit Interviews

Exit interviews were administered to participants who declared a major in a field other than engineering. There was institutional variation in which majors were considered engineering. Data from exit interviews contributed to understanding why and how engineering was not meeting student needs, or conversely, why and how other majors may be better at meeting those needs. The exit interview guide is included in Appendix 3-G.

During Year 2, Urban Private University conducted 5 exit interviews. UPri participants who exited the field of engineering in Year 2 were dropped from the study. (This procedure changed for Year 3, as described in section 3.5.1.)

By the end of Year 2, 14 SPri participants had declared non-engineering majors and received exit interviews. All of these students were retained in the study in their original study groups.

3.3.3 Study Group Demographics

Figures 3.1, 3.2 and 3.3 show the gender and ethnicity distributions of study participants in Year 2. For subjects who were added to the study in Year 2, ethnicity was determined from an item on the spring 2005 survey. Subjects continuing from Year 1 retained the ethnicity identification they had indicated the previous year. Additional demographic details are included in Appendix 1-E.

* Because the Technical Public Institution is focused exclusively on engineering and applied science, study participants who wished to pursue other majors had to transfer to another institution

Figure 3.1 Gender distribution (Year 2)

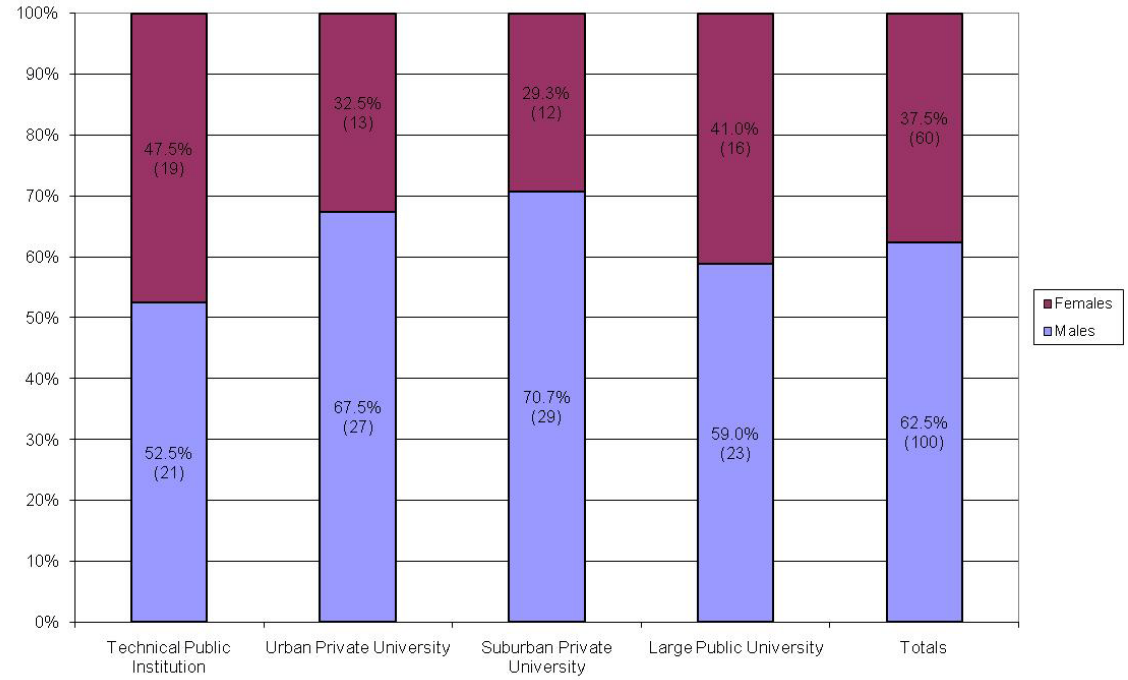


Figure 3.2 Ethnicity distribution by school (Year 2)

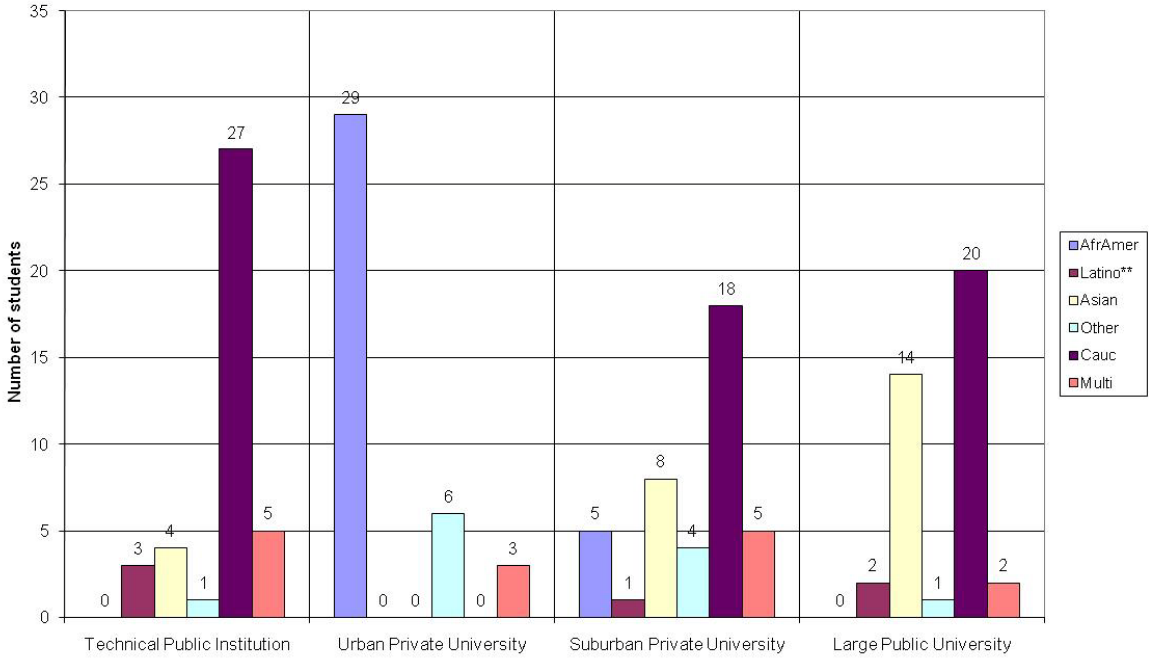
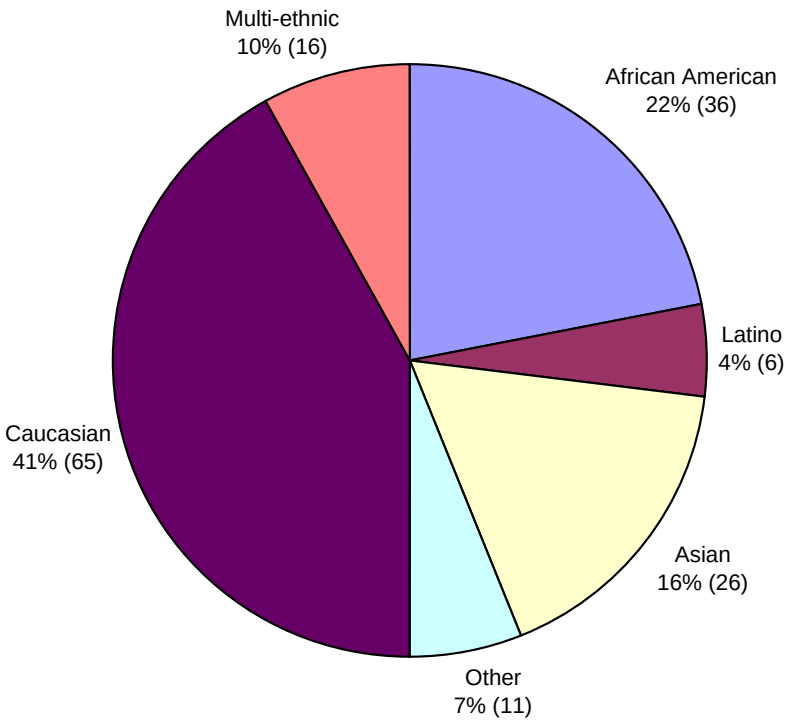


Figure 3.3 Ethnicity distribution for all schools (Year 2)



3.4 Data Collection

3.4.1 Methods

The methods for data collection in Year 2 followed similar protocols as were used in Year 1. Informed consent was obtained from each participant before any surveys, interviews, or observations were conducted. Copies of representative consent forms are included in Appendix 1-D.

Minor revisions were made to the Year 2 interview protocols and guides based upon questions emerging from Year 1 findings. These changes were reflected in an updated interviewer manual (Appendix 3-C). Similarly, the survey was refined to improve internal consistency (Cronbach's Alpha scores) of the variables.

3.4.2 Summary of Data Collected

Table 3.4 summarizes what data was collected by each school during Year 2. Academic transcripts were collected for Year 2 but are not reported in this table.

Table 3.4 Data collection summary by school for Year 2 (2004-2005)

	Surveys (n=40)		Structured Interviews (n=24)				Semi-structured Ethnographic Interviews (n=16)				Ethno Obs (n=8)		Exit Interv
	Dates	#	Dates	#	Length (min.)	# Eng. Act'y	Dates	#	Length (min.)	# Eng. Act'y	#	Hours spent	#
TPub	Fall 2004	40											0
	Spring 2005	40	n/a	24	27-59	24	n/a	16	71-179	16	25	25	0
UPri	Fall 2004	39											5
	Spring 2005	38	3/10-5/12/05	23	30-60	23	3/9-5/5/05	14	73-102	14	0	0	0
SPri	Fall 2004	41											
	Spring 2005	41	4/18-5/13/05	25	31-74	25	4/18-6/8/05	16	88-163	16	16	22	11
LPub	Fall 2004	39											0
	Spring 2005	39	4/18-5/20/05	23	40-120	23	Apr-May '05	14	90-120	14	40	120	0

3.5 Notes and Reflections on Year 2

3.5.1 Non-engineering Majors

In Year 2, five students from Urban Private University switched from engineering majors at the beginning of the academic year and were dropped from the Longitudinal Cohort. The one student from LPub who switched majors mid-year was also dropped.

To better understand or characterize students who declared non-engineering majors, researchers sought to retain participants who exited engineering during Years 3 and 4.

- Students in the Low Contact Group would receive an exit interview and surveys.
- Students in the Medium and High Contact Groups would receive exit interviews, surveys, semi-structured ethnographic interviews and engineering design tasks.

The above procedures were applied to the 14 SPri students who declared non-engineering majors in spring 2005.

3.5.2 Non-enrolled Students

Two SPri participants were on leave for one academic term for personal reasons. However, this did not impact data collection.

3.5.3 Missing Data

Failing to complete a survey or interview did not automatically eliminate a participant from the study. Students who studied abroad fell into this category, as did others. Following a single participant for the duration of the study period was deemed valuable even if one or more data points were missing. Students who missed surveys or interviews because of disinterest or other factors were dropped at the discretion of each school's research team, on a case-by-case basis.

4 Research Year 3: Fall 2005-Spring 2006

4.1 Year 3 Tasks and Goals

The main tasks for Year 3 were to:

- Manage study pool to maintain size and diversity of the study groups as much as possible
- Administer surveys (fall and spring) and interviews (spring) to all participants in the study group
- Conduct exit interviews with students who declared majors other than engineering
- Plan for the Workplace Cohort and the Broader Core and National Samples
- Begin analyzing data

4.2 Changes to Study Procedures

4.2.1 Non-engineering Majors

Study participants who declared majors other than engineering were interviewed about their decision in an exit interview (Appendix 3-G). These students were not dropped from the study, as had been the case during part of Year 2. Instead, they continued in their assigned groups and participated in surveys and interviews, although many chose not to.

4.2.2 Transcription of Semi-structured Ethnographic Interviews

By the beginning of Year 3, it became apparent that the transcription of semi-structured ethnographic interviews was lagging. To help deal with this backlog, transcription responsibilities were distributed among the CAEE research groups.

4.2.3 Extended Data Collection and Analysis

In addition to supplemental NSF funds awarded in September 2005, another NSF supplement was awarded in September 2006. These two awards, totaling about $2,000,000, allowed Longitudinal Cohort data collection and analyses to extend to Year 4. The Longitudinal Cohort would be followed during the 2006-2007 academic year with one survey for all participants (spring 2007), plus semi-structured ethnographic interviews and engineering design tasks for the High and Medium Contact Groups, also in spring 2007.

4.3 Migration between Study Groups

4.3.1 Year 3 Migration and Replenishment

<u>Technical Public Institution</u>

Two students left the study during Year 3:

- One Caucasian student from the High Contact Group transferred to a different institution to study engineering in a more diverse environment. A non-Caucasian student from the Low Contact Group was moved into the vacated slot, creating a vacant slot in the Low Contact Group that was not filled.
- One student from the Low Contact Group left TPub. This student was not replaced.

One student from the Medium Contact Group transferred to another institution after Year 3 to pursue a teaching degree. This student remained in the study for all of Year 3, and completed an exit interview at the end of the year.

Urban Private University
A total of six students left the study during Year 3:

- Two students did not enroll at UPri: one from the Low Contact Group and one from the High Contact Group
- Three students, all from the Low Contact Group, did not respond to survey/interview requests
- One student from the High Contact Group declined to participate because she was studying abroad

Vacancies created by these departures were not filled.

Suburban Private University
One student from the Low Contact Group withdrew from the study and was not replaced.

Large Public University
A total of seven students left the study during Year 3:

- Six students were either not accepted into engineering or switched out of the program
- One student was lost to follow-up (failed to respond)

Of the seven students who left the study, three were from the High Contact Group and four were from the Low Contact Group. Three students from the Medium Contact Group were moved to the High Contact Group to fill the vacancies there. No other replenishment occurred.

4.3.2 Exit Interviews

Technical Public Institution
Exit interviews were difficult to obtain because students who do not declare an engineering major typically leave TPub. Of the five participants who left TPub between Year 2 and Year 3, only two were reachable for exit interviews, and those were conducted in January and March of 2006.

One participant informed researchers of her intent to transfer after Year 3, and completed her exit interview prior to leaving.

Urban Private University
Exit interviews were conducted for three students who declared majors other than engineering. Two interviews were done in December 2005, and one in April 2006.

Suburban Private University
Exit interviews were completed for three students in March 2006. One study participant who had declared a non-engineering major in Year 2 returned to engineering in Year 3.

Large Public University
Six exit interviews were completed in October 2005, for students who had declared non-engineering majors, including some who had applied but not been accepted to an engineering major.

4.3.3 Study Group Demographic Summary

The gender and ethnic distribution of subjects remained fairly consistent between Year 3 and previous years. There was only modest attrition and no new subjects were added to the sample. Demographic details are included in Appendix 1-E.

4.4 Data Collection

4.4.1 Methods

The methods for data collection in Year 3 followed similar protocols as in previous years. Informed consent was obtained from each participant before any surveys, interviews, or observations were conducted. Copies of representative consent forms are included in Appendix 1-D.

Minor changes were made in the interview guides and are reflected in an updated interviewer manual (Appendix 3-C). The spring survey was modified to include questions that had arisen as a result of the dozen or so exit interviews completed prior to that point. To prevent the survey from becoming too lengthy, several items deemed less central to the APS research were dropped from the survey in order to accommodate the new questions (see Appendix 4-A).

4.4.2 Summary of Data Collected

Table 4.1 summarizes the data collected at the four core schools during Year 3. As in previous years, academic transcripts were collected but are not reported in this table.

Table 4.1 Data collection summary by school for Year 3 (2005-2006)

	Surveys		Structured Interviews				Semi-structured Ethnographic Interviews				Ethno Obs		Exit Interv
	Dates	#	Dates	#	Length (min.)	# Eng. Act'y	Dates	#	Length (min.)	# Eng. Act'y	#	Hours spent	#
TPub	Fall 2005	38											2
	Spring 2006	38	3/6-5/24/06	22	n/a	22	3/9-4/20/06	15	65-168	15	0	0	1
UPri	Fall 2005	32											2
	Spring 2006	32	4/10-5/25/06	18	25-55	17	4/13-5/24/06	12	60-120	11	12	24	1
SPri	Fall 2005	40											
	Spring 2006	40	3/23-6/26/06	17	26-74	17	3/26-5/25	15	87-209	12	3	4	3
LPub	Fall 2005	34									20	60	6
	Spring 2006	34	4/24-5/20/06	19	60-90	19	Apr-May '06	13	90-150	13	40	120	0

As mentioned earlier, one SPri participant who had completed an exit interview in Year 2 returned to engineering. A "return to engineering" protocol was developed, and administered to this student at the same time as his structured interview.

4.4.3 Cross-sectional Cohort

As a result of collaborative relationships between APS researchers and colleagues at the Large Midwestern Public University (LMPub), LMPub researchers adopted the PIE survey for use with a cohort of engineering students there. This group became the Cross-sectional Cohort. Although the LMPub project was not formally part of APS, the two groups maintained a cooperative and mutually beneficial relationship.

The goal for the Cross-sectional Cohort was to recruit 40 students from each undergraduate class (freshmen, sophomore, junior, senior), for a total of 160 participants. Students were recruited via e-mail, using enrollment lists from the engineering school. Rather than following students longitudinally, LMPub students were offered two discrete opportunities to participate: fall 2005 and spring 2006. The fall survey included only those students who had entered LMPub as freshmen. The spring survey was offered to additional students including transfer students. Participating students received a gift card at the LMPub book store in the amount of $15 for one survey and $25 for both (fall 2005 and spring 2006).

LMPub researchers customized the APS survey to reflect majors at LMPub. Two questions directed at transfer students were added to the spring survey (Appendix 4-E). Otherwise, the LMPub protocols were very similar to those used for Longitudinal schools during Year 3.

As already noted, the main differences between the APS Longitudinal Cohort and LMPub Cross-sectional Cohort were that the sampling at LMPub was cross-sectional rather than longitudinal, and it allowed for the inclusion of transfer students.

Figures 4.2 and 4.3 summarize the gender and ethnicity distributions of the Cross-sectional Cohort.

Figure 4.2 Cross-sectional Cohort gender distributions

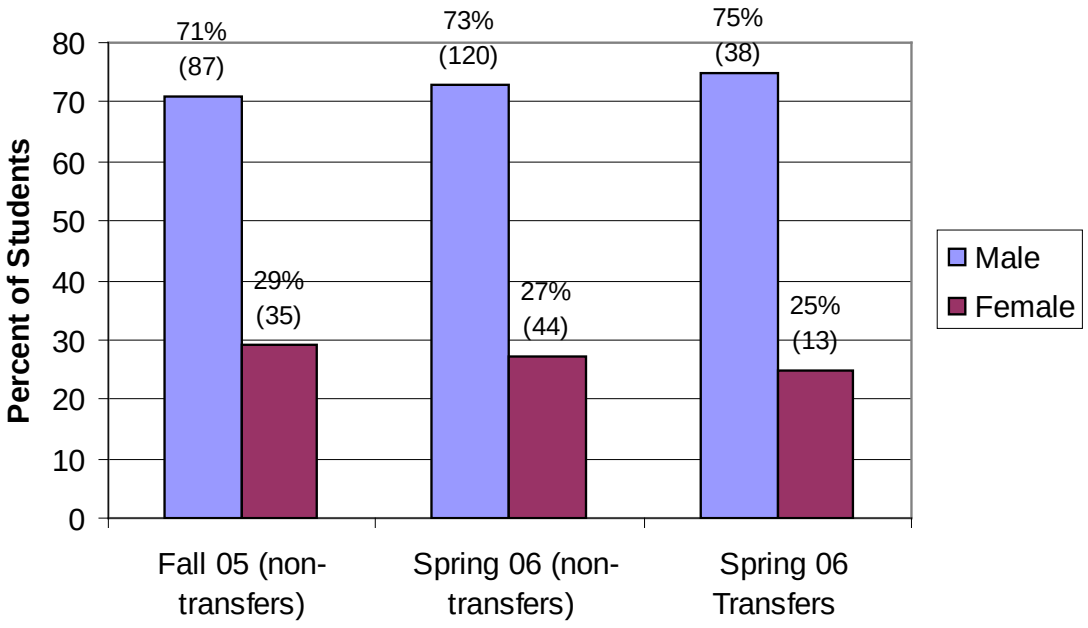
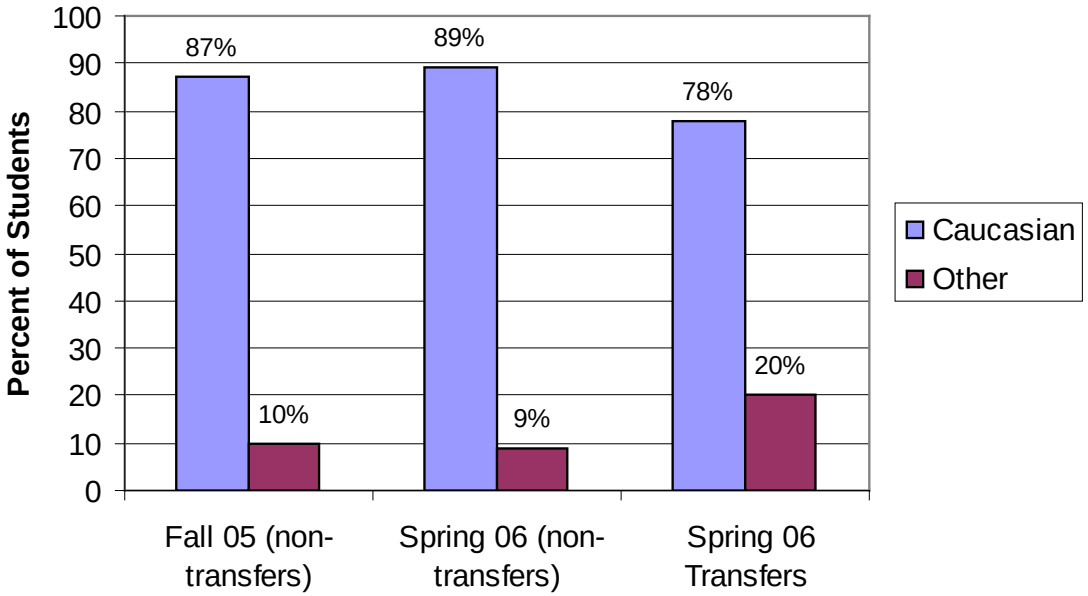


Figure 4.3 Cross-sectional Cohort ethnicity distributions

Note: Some respondents chose not to provide ethnicity data, so totals may not equal 100%.



4.5 Notes and Reflections on Year 3

4.5.1 Difficulty Securing Exit Interviews

Obtaining exit interviews with participants who declared non-engineering majors proved difficult because these subjects either lost interest in the study or failed to provide alternate contact information, especially if they left the university.

4.5.2 Students Absent from Campus

Several SPri students were not present on campus during Year 3. One took a term off for personal reasons, and another took the entire academic year off to work. Both students were able to complete their surveys and interviews as usual. Four other SPri students went abroad during the spring term and completed surveys remotely; two of them completed their interviews before leaving and two received semi-structured ethnographic interviews by phone while they were away. In sum, data collection was not impacted by the absences.

4.5.3 Structured Interview Transcriptions

Structured interviews were transcribed as in previous years of the study. However, the digital versions of the transcriptions were lost and had to be recreated by scanning working copies in paper version.

5 Research Year 4: Fall 2006-Spring 2007

5.1 Year 4 Tasks and Goals

The main tasks for Year 4 were to:

- Administer one survey (spring) to all participants in the Longitudinal Cohort
- Conduct informal conversations (fall-winter) and semi-structured ethnographic interviews (spring) with students in the Medium and High Contact Groups (Longitudinal Cohort)
- Conduct exit interviews with Longitudinal Cohort students who declared majors other than engineering
- Intensify efforts to analyze data and report findings
- Conduct Workplace Cohort interviews (see Section 6)
- Recruit Broader Core Sample participants and administer survey (see Section 7)
- Plan for Broader National Sample and begin recruiting schools (see Section 8)

5.2 Changes to Longitudinal Cohort Procedures

5.2.1 Extended Data Collection

As previously mentioned, supplemental NSF funds made it possible to extend Longitudinal Cohort data collection to Year 4. All Longitudinal Cohort participants received one survey (spring 2007). Students in the High and Medium Contact Groups received semi-structured ethnographic interviews and engineering design tasks in spring 2007, as well as informal conversations during the preceding fall and winter months. Low Contact participants did not receive structured interviews in Year 4.

NOTE: Structured interviews were conducted at UPri but not as part of APS activities.

5.2.2 Informal Conversations

Informal conversations allowed researchers to check in with subjects as needed to stay abreast of changes in student status. Such conversations occurred as needed in prior years of the study but were not recorded in the APS database. In Year 4, researchers had the option of uploading informal conversations to the database.

Informal conversations were arranged with students in the Medium and High Contact Groups, and generally focused on the question, "How are things going for you at this point?" The goal was to hear from students about their classes, feelings about engineering, life at their institution, and life in general.

5.3 Data Collection

5.3.1 Methods

The data collection methods in Year 4 followed similar protocols as in previous years. As already mentioned, informal conversations were just that: loosely defined one-to-one

conversations about how things were going for students in the Medium and High Contact Groups.

As in previous years, informed consent was obtained from each participant before any data were collected.

5.3.2 Summary of data collected

Table 5.1 summarizes Longitudinal Cohort data collection in Year 4.

Table 5.1 Data collection summary by school for Year 4 (2006-2007)

Shaded cells indicate time periods when no data collection of that type was scheduled or conducted.

	Surveys		Informal Conversations		Unstructured Interviews				Exit Interv	Acad Trans
	Dates	#	Dates	#	Dates	#	Length (min.)	# Eng. Tasks	#	#
TPub			10/12-10/19/07	8					0	
	Spring 2007	35			3/20-4/25/2007	12	69-192	12	1	34
UPri*			---	0					0	
	Spring 2007	21			4/6-5/4/2007	11	25-92	11	0	22
SPri			10/13/06-1/19/07	14					0	
	Spring 2007	39	3/15-4/8/07	11	5/4-6/5/2007^	16	91-289	16	0	38
LPub			10/2-10/30/2006[+]	13					0	
	Spring 2007	31			4/16-5/23/2007	13	120	13	0	31
Total		126		46		52		52	1	125

* UPri did not conduct informal conversations.

[+] One of the informal conversations at LPub was conducted on January 22, 2007.

^ One of the unstructured interviews at SPri was initiated early (March 26, 2007) because the student was going overseas.

5.4 Data Analysis

A workshop in September 2006 brought APS researchers together to stimulate discussion of possible analyses across instruments and institutions. The meeting resulted in a number of papers reporting cross-instrument findings. Method-specific analyses continued to generate findings that were reported in papers and presentations. (See http://www.engr.washington.edu/caee/ for an up-to-date listing of papers and reports from the APS research.)

5.4.1 Data Sets Used for Analysis

The overall APS data set consists of data from surveys, interviews, engineering design tasks, ethnographic observations and academic transcripts. A detailed student-by-student accounting of

all longitudinal data (Years 1-4) is available from the APS database, as are the total numbers of students for whom data is available in each dataset, by year and by institution.

The portions of this overall data set used in a particular analysis vary depending on the focus of the analysis. For example, one analysis may focus on data associated with a particular method, whereas another may focus on data associated with a particular study group (such as high contact vs. low contact subjects). As such, the numbers of APS subjects reported in various documents and papers may differ.

5.4.2 Processing of Academic Transcript Data

Following the completion of the spring 2007 term, the four core institutions submitted cumulative academic transcripts (i.e., 2003-2007) for longitudinal study participants. Academic transcripts were collected in previous years also, but the final collection was used for analysis.

Academic transcripts were processed to normalize the data between institutions.

- At the two schools (SPri and LPub) operating on the quarter system, credit hours were converted to semester units by multiplying by a factor of two-thirds (i.e., 3 quarter units = 2 semester units.)
- All grades were mapped to a 5-point scale (A, B, C, D, F).
    - TPub and UPri both use a 5-point grading system so no conversions were necessary.
    - At SPri, which issues plus/minus grades (A+, A-, B+, B-, etc.) in addition to straight letter grades (A, B, C, D), the plusses and minuses were dropped. So A+ and A- converted to A; B+ and B- converted to B; and so on. SPri's grade of NP (not passed) was converted to F.
    - LPub uses a 0 to 40 grading scale. These grades were converted to the 5-point scale as follows: 35-40=A, 25-34=B, 15-24=C, 7-14=D, and 0-6=F.
- Each course listed on transcripts was categorized as:
    - Engineering (eng)
    - Science, medicine (sci/med)
    - Humanities, social sciences, fine arts (hum/ss/fa)
    - Math, computer science (math/cs)
    - Physical education, freshman success seminar, etc. (other)
- Courses were also assigned a design code whereby: 0 indicates no design elements; 1 means non-engineering design (e.g., art classes); 2 denotes some engineering design (such as a class project); and 3 indicates a major focus on engineering design (e.g., courses defined by a single class project.)

Academic transcripts were used to determine persistence in an engineering major, and the semester during which non-persisters declared non-engineering majors.

5.4.3 Engineering Persistence Data

Persistence in an engineering major was determined from academic transcripts; persisters were those whose transcript listed a major or minor in an engineering field at the time of graduation,

or in spring 2007, if they had not yet graduated. Non-persisters were those who declared a non-engineering major after initially intending to study engineering.

The question of persistence in engineering was a central focus of the APS. Tables 5.2 and 5.3 provide a summary of engineering persistence among APS participants at the end of the study period. The categories are defined as follows:

- **Persisters** – students who entered the study with interest in engineering and whose academic transcripts at the end of the study period (spring 2007 or upon graduation) listed an engineering major or minor.
- **Non-persisters** – students who entered the study with interest in engineering but subsequently declared a non-engineering major. Some non-persisters continued in the study through Year 4 while others chose not to.
- **Other** – students who did not meet the criteria for either persister or non-persister.
- **Lost to follow-up** – students who left the study without sufficient data to determine persistence status.

Table 5.2 Persisters at end of Year 4: Subjects who enrolled in Year 1 (n=160) and Year 2 (n=18)

	Persisters	Non-persisters	Other	Lost to Follow-up
TPub	33	8	2*	2
UPri	29	8	0	15
SPri	27	13	1**	0
LPub	32	6	0	2
Total	121	35	3	19

Table 5.3 Persisters in Longitudinal Cohort at end of Year 4: Only subjects who enrolled in Year 1 (n=160)

	Persisters	Non-persisters	Other	Lost to Follow-up
TPub	29	8	1*	2
UPri	20	7	0	13
SPri	26	13	1**	0
LPub	32	6	0	2
Total	107	34	2	17

* Non-engineering students from the beginning of the study.
** Student left school to work in high-tech start-up company, with intention of returning to school eventually. He continued to participate in APS surveys and interviews but did not return to school during the study period.

Various APS analysis teams may define their data sets differently, so the numbers in Figure 5.2 may not be consistent across all APS papers and reports.

5.5 Notes and Reflections on Year 4

5.5.1 Attrition in Numbers

The Longitudinal study group was essentially unchanged from Year 3. However, attrition is apparent in the numbers of completed surveys and interviews for Year 4. Reasons include

waning interest among subjects, early graduation, and permanent or temporary leaves from school. These factors contribute to ambiguities about the number of students completing the study. As mentioned in the previous section of this chapter, different analysis teams may report different numbers depending on how they choose to define their datasets.

6 Broader Core Sample

6.1 Research Goals and Description

The goal of research using the Broader Core Sample was to confirm that findings from the Longitudinal Cohort were representative of the larger undergraduate engineering population at the four Longitudinal Cohort institutions: Technical Public Institution, Urban Private University, Suburban Private University, and Large Public University. The Broader Core Sample research pursued key questions that emerged from the longitudinal work:

1. How are students who persist in an engineering major similar and different from students who do not persist?
2. How do experiences of engineering students change as they progress through their undergraduate careers as freshmen, sophomore, juniors and seniors?
3. How do men and women differ in their experiences in engineering education?

The sole data collection tool was an online survey, the Academic Pathways of People Learning Engineering Survey (APPLES), derived from the PIE survey instrument administered to Longitudinal Cohort. A major consideration in the design of APPLES was to reduce the length of the survey while retaining comparability of the two instruments so that generalizability of PIE findings could be tested.

Because the Broader Core Sample and Broader National Sample both involved cross-sectional research to validate longitudinal findings using the APPLES instrument, these two cohorts are sometimes referred to as APPLES1 and APPLES2 respectively, although the survey instruments were not identical (see Chen et al. 2008).

Broader Sample research activities were carried out by the APS researchers at Stanford.

6.2 Institutional Review Board (IRB) Approval

Local IRB approval for (non-medical) human subjects research was required for each of the four institutions participating in the Broader Core Sample because each school had active APS researchers. The Stanford University APS team took the lead in drafting the protocols and coordinating the IRB submissions. UPri incorporated TPub into their IRB application since TPub doesn't have an Institutional Review Board.

As with the PIE survey, design of APPLES was guided by universal IRB requirements: subjects were not required to answer survey questions, and all students had access to the incentive. In other words, students could claim the incentive without completing the survey, and regardless of whether they were part of the targeted student groups. However, the survey was designed so that researchers could identify such submissions and exclude them from data analysis.

6.3 Recruitment

6.3.1 Sampling and Stratification

To address the key research questions for the Broader Core Sample, recruitment efforts targeted three groups of undergraduate students:

- **Engineering students** who had declared an engineering major or committed to engineering programs at their universities
- **Pre-engineering students** who intended to declare an engineering major
- **Non-persister students** who were interested in engineering at one time but had since decided to pursue another field of study.

Persistence, along with academic level (freshman, sophomore, junior, senior) and gender, constituted the primary strata for setting recruitment targets. Secondary strata included enrollment status (part-time or full-time), transfer status, ethnicity and citizenship. Each stratum required 10 to 25 subjects per school to run statistical t-tests. Recruitment targets were set accordingly, as shown in Figure 6.1.

A response rate as high as 30 percent per school was anticipated, based on the National Survey of Student Engagement (NSSE), a similar survey in terms of length and content, but one which offers no incentive for participation.

6.3.2 Recruitment

Each of the participating institutions named a coordinator for recruitment efforts at their school. Coordinators secured local IRB approvals with assistance from Stanford, and oversaw local recruitment during the survey deployment.

A combination of approaches was used to recruit students for the Broader Core Sample. These included:

- Posters hung in locations frequented by undergraduate engineering students (Appendix 2-C)
- Emails to students from their engineering dean, using targeted distribution lists (Appendix 2-D)
- Advertisements in the student newspaper and, for one institution, a directed advertisement on a social networking site.

All recruitment materials and communications carried a red apple logo designed for the study, and provided the dates and URL for accessing the survey. Each institution had its own APPLE Survey URL that included the institution's name to enhance credibility and avoid being mistaken for spam.

Recruitment Plans were developed jointly with the local campus coordinator and a liaison from the research team at Stanford (see Appendix 2-B). On the recruitment planning form, Plan A shows the initial strategies for the institution; Plan B delineates targeted strategies in case responses in any stratum lagged. Campus coordinators implemented Plan B only if they perceived one or more of their strata to be lagging during survey deployment.

6.3.3 Incentive for Participation

To encourage participation, a $4 electronic payment through PayPal was offered to every individual who filled out the survey. The $4 payment best met budgetary and other criteria, including:

- Broad student appeal
- Available online almost immediately
- Scalable with minimal logistical effort for large or small, geographically distributed audiences
- Redeemable without compromising student confidentiality
- Payments could be tracked to meet university disbursement requirements
- Unclaimed incentives could be returned to the project after a period of time.

Other incentive options that were considered included a chance at a raffle prize and various gift card options (books, coffee, sandwiches, music, etc.).

6.4 Data Collection

6.4.1 The Survey Instrument

The APPLE Survey is comprised of a focused subset of questions from the PIE survey used with the Longitudinal Cohort. The instrument underwent two rounds of pilot testing to ensure its effectiveness for a single cross-sectional administration that would include non-engineering majors. The first round of piloting involved 10 researchers and graduate students who were associated with the project. The goal was to refine the survey questions for clarity and identify questions that could be eliminated. The second round of pilot testing involved 58 undergraduate students from five external institutions (i.e., schools not affiliated with APS). This round of testing was aimed at paring down the survey so it would take only ten minutes to complete, as compared to the 30-minute completion time for the PIE survey.

The resulting APPLES1 instrument consisted of 52 questions, representing 26 constructs (also called variables) and five demographic items. These constructs are described in detail in Appendix 4-B, which also maps the three APS survey instruments (PIE, APPLES1/Broader Core Sample, APPLES2/Broader National Sample) against one another. The survey is included in Appendix 4-C.

6.4.2 Survey Administration

APPLES1 was deployed at all four campuses from April 2 through April 9, 2007. The deployment period was extended two-and-a-half weeks (until April 27) at Urban Private University in an attempt to better meet strata targets with its small pool of engineering students and infrastructure constraints in reaching students by email.

Response to the online deployment was monitored in real time, allowing for remedial measures to be taken to attract survey-takers in strata that might be lagging. Response reports were sent daily to institution liaisons in the late afternoon. A sample report is included in Appendix 5-A.

6.4.3 Summary of Data Collected

There were a total of 914 survey responses from the four schools, of which 842 were included for analysis. The 72 submissions that were omitted were determined to be ineligible (i.e., submitted by graduate students or students from non-participating universities) or fraudulent. Fraud was defined as "blind clicking" or otherwise attempting to claim the incentive without filling out the survey, and represented approximately 3 percent of submissions. Blind clicking was assumed for submissions with completion times of less than five minutes, a cut-off derived from pilot testing.

Table 6.1 provides a summary of the cleaned (eligible) data set by strata and by institution.

Table 6.1. Summary of Broader Core Sample Response Targets and Eligible Responses

Strata	*Target per school*	TPub	UPri	SPri	LPub	Totals
All	*140*	239	67	217	318	**842**
Freshmen*	*25*	67	14	77	31	**189**
Sophomore*	*25*	60	15	33	49	**157**
Juniors*	*25*	48	14	62	122	**246**
Seniors*	*25*	56	20	38	90	**204**
5th Yr Senior or more	*(not set)*	8	2	6	25	**41**
Transfer students	*10*	24	9	8	74	**115**
Returning or Non-traditional student	*(not set)*	12	2	1	17	**32**
Non-persisters	*25*	12	13	36	28	**89**
Male students*	*70*	157	35	124	223	**539**
Female students*	*25*	81	31	91	93	**296**
Ethnic minority students[+]	*25*	21	57	37	19	**134**
International students^	*25*	11	23	22	45	**101**
Part-time students	*10*	5	0	1	4	**10**

* Primary strata

[+] Ethnic groups traditionally underrepresented in undergraduate engineering programs in the U.S., including Native American, African American/Black, Hispanic/Latino

^ Students who do not hold U.S. citizenship

Of the total 914 survey responses, 137 declined the incentive. Ultimately, 562 subjects (72 percent of subjects who accepted the incentive) collected the $4 incentive.

Response rates, i.e., the number of respondents relative to the undergraduate engineering enrollment, were as follows:

TPub	10%
UPri	12%
SPri	34%
LPub	21%
Overall	17%

6.5 Notes and Reflections

6.5.1 Pilot Testing

Pilot testing proved to be an invaluable resource for refining the survey instrument. For this reason, piloting of the APPLES instrument was extended to two rounds despite short timelines. In addition to providing feedback about readability and comprehension, pilot data helped guide the difficult decisions about which items and constructs to keep or delete so respondents could complete the survey in ten minutes. Comparable surveys, including the National Survey of Student Engagement (NSEE), strive for a ten-minute take-time to maximize response rates. Pilot testing also helped determine a minimum completion time (five minutes) below which "blind clicking" could be reasonably assumed.

6.5.2 IRB Approvals

Obtaining IRB approval took longer than expected at all institutions, and requirements were not consistent across institutions. For example, LPub's IRB called for a confidentiality disclaimer statement and UPri's IRB wanted wording changes in the recruiting materials. Although researchers had hoped to offer survey-takers the option of online or paper surveys, confidentiality requirements made this option unfeasible, particularly when it came to claiming the incentive.

6.5.3 Recruitment Challenges

None of the participating institutions met their targets for all strata. For the most part, this had to do with the particular characteristics of the schools (e.g., difficulties locating non-persisters at TPub, UPri and SPri and weaknesses in the campus email system at UPri).

Reaching non-persisters required special recruitment efforts. For example, at SPri, Longitudinal Cohort data suggested that students who had opted out of engineering commonly went into Math and Computational Sciences, Physics, Symbolic Systems and Economics. Therefore, the non-persister stratum target was successfully met by emailing students in these departments and asking them to participate in the survey. As with the recruitment email that went to engineering undergraduates, the email seeking non-persister respondents went out over the signature of a dean (Appendix 2-E).

6.5.4 Repeat Claims for Incentive

Researchers had considered limiting responses to one per IP address in order to discourage respondents from making repeat claims for the incentive. However, this would have excluded participants who may share a computer or use a computer lab. It turned out that a number of eligible survey responses from UPri came from a single IP address.

For more information about APPLES design and development, see:

Donaldson, Krista M., Helen L. Chen, George Toye, Sheri D. Sheppard. 2007. Targeting Undergraduate Students Interested in Engineering for Surveys: Lessons from the Academic Pathways of People Learning Engineering Survey. *Frontiers in Education Annual Conference, Milwaukee, WI, October 10-13, 2007*.

Chen, Helen L., Krista M. Donaldson, Ozgur Eris, Debbie Chachra, Gary Lichtenstein, Sheri D. Sheppard, George Toye. 2008. From PIE to APPLES: The Evolution of a Survey Instrument to Explore Engineering Student Pathways. *American Society for Engineering Education Annual Conference, Pittsburg, PA, June 2008.*

7 Broader National Sample

7.1 Research Goals and Description

The goal of research with the Broader National Sample was to corroborate and extend findings from the Longitudinal Cohort and the Broader Core Sample with an expanded set of undergraduate engineering students and institutions nationwide. The sole data collection instrument was the APPLE survey, administered cross-sectionally during January to March 2008. Power calculations indicated a minimum of 1,080 respondents from 18 institutions were required to ensure a nationally representative sample of undergraduate engineering students.

7.2 The Research Team

All aspects of research with the Broader National Sample were conducted by the Stanford APS research team. Each member of the Stanford team served as liaison to several (four to six) participating institutions. Liaison duties vis-a-vis their assigned schools included:

- Extending and following-up on invitations to participate
- Keeping the schools appraised of study timelines and procedures
- Working with each institution to devise and execute a recruitment plan appropriate to the school and its students
- Monitoring the school's response rates during survey deployment, including creating and sending daily response reports (see sample response report in Appendix 5-A)
- Serving as the primary contact person for and with the institution

7.3 Institutional Review Board (IRB) Approval

Umbrella IRB human subject approval was obtained from Stanford University and covered all participating students and institutions except for two institutions with APS researchers on staff. Those two institutions submitted applications to their respective IRBs, and both were approved. As it turned out, four other participating institutions voluntarily chose to obtain approval from their local IRB, and did so with assistance from the Stanford team.

7.4 The Survey Instrument

Based on results from the Broader Core Sample, the APPLES1 instrument underwent minor modifications to:

- Ensure that demographic questions were appropriate and detailed enough to capture institutional and respondent diversity
- Improve the internal reliability of several constructs
- Address intrinsic (psychological) motivation, which was mentioned in the open-ended comments from APPLES1 respondents

The resulting APPLES2 instrument was pilot tested with a sample of 52 undergraduate engineering students from three external institutions (i.e., schools not participating in or affiliated with APS research).

The survey constructs are described in detail in Appendix 4-B, which also maps the three APS survey instruments (PIE, APPLES1/Broader Core Sample, APPLES2/Broader National Sample) against one another. For a more in-depth review of the APPLES instrument, see the technical report CAEE TR-09-02, Exploring the Engineering Student Experience: Findings from the Academic Pathways of People Learning Engineering Survey (APPLES).

7.5 Sampling Plan

Schools were identified and invited to participate in the Broader National Sample according to stratification criteria that would yield a diverse pool of students for the survey. The institutional characteristics that drove the stratification process were:

1. Carnegie 2000 classification
2. Student body ethnic composition, gender balance and enrollment status (full-time vs. part-time)
3. Institution size, type (public vs. private), geographic location, presence/absence of religious affiliation and number of transfer students

The number of institutions was driven by the calculated number of respondents (1,080) needed for statistically meaningful results. A slightly higher number of institutions were recruited to provide a cushion in case of last-minute withdrawals. Tables 7.1 and 7.2 summarize the institutional sampling stratifications, as well as the numbers of institutions that were ultimately recruited in each stratum.

Table 7.1. Summary of Primary and Secondary Stratification Characteristics

Type of Institution		Required	Participated
Primary Stratifications			
	Doctoral/Research – Extensive	5	7
	Doctoral/Research – Intensive	2	4
	Specialized Institutions – Engineering	2	3
	Master's Colleges and Universities I	2	3
	Specialized Institutions – Other	1	0
	Baccalaureate Colleges – General	1	2
	Baccalaureate Colleges – Liberal Arts	1	2
Secondary Stratifications			
	Historically Black Colleges and Universities	1	2
	Hispanic-Serving Institutions	1	2
	Single-Gender Institutions	1	1
	Part-Time Student Population > 30%	1	4
	Recruiting Redundancy	3-7*	3
	TOTAL	**21-25**	**21**

*We estimated we needed to recruit 3-7 additional institutions should one or more institutions be unable to participate in APPLES late in the process.

Table 7.2. Summary of Tertiary Stratification Characteristics

Tertiary Stratification Considerations	National Picture (2007)*	Participating Institutions
Institution size (based on enrollments)	Large = 54% Medium = 43% Small = 3%	Large = 33% (7) Medium = 38% (8) Small = 29% (6)
Geographic diversity		17 states represented
Funding type	Public = 63% Private = 37%	Public = 67% (14) Private = 33% (7)
Religious affiliation	14% of institutions 4% of population	5% (1 institution)
Transfer student population	(Information not available)	Two 3+2 completion institutions

*Percentage of national sample of 319 institutions

7.6 Institutional Selection and Recruitment

Guided by the sampling plan, researchers strategically selected schools to invite into the Broader National Sample research. Invited schools were required to have at least one ABET-accredited engineering major in addition to the characteristics laid out in the sampling plan. A total of 319 institutions met these criteria. Furthermore, schools where APS researchers had personal contacts were favored in case we encountered institutional hurdles that an insider might help us understand and overcome. As previously stated, researchers sought to err on the conservative side by inviting more schools than were required by the sampling plan.

Beginning in spring 2007, the research team mailed letters of invitation to the engineering deans at 25 institutions. Stanford liaisons followed-up by telephone and e-mail to answer questions and secure commitment to participate. In addition, researchers held a special session at the American Society of Engineering Education annual conference in June 2007 to further describe the research, answer questions and secure commitments from the targeted institutions.

As an incentive to participate, each institution received a report summarizing the data submitted by its students relative to those from the other participating schools.

Twenty-one institutions accepted the invitation to participate in the Broader National Sample, as illustrated in Figures 7.1 and 7.2. Invitations were extended to three different military academies, none of which accepted, leaving us without representation from Carnegie 2000 classification *Specialized Institutions—Other*.

Participating schools were asked to appoint a local coordinator to assist researchers in understanding local campus culture, provide institutional data (such as school calendars and enrollment figures), and plan and implement local student recruitment. Appendix 2-B includes sample forms that were used to plan recruitment efforts.

7.7 Subject Recruitment

7.7.1 Diversity Goals and Strata Targets

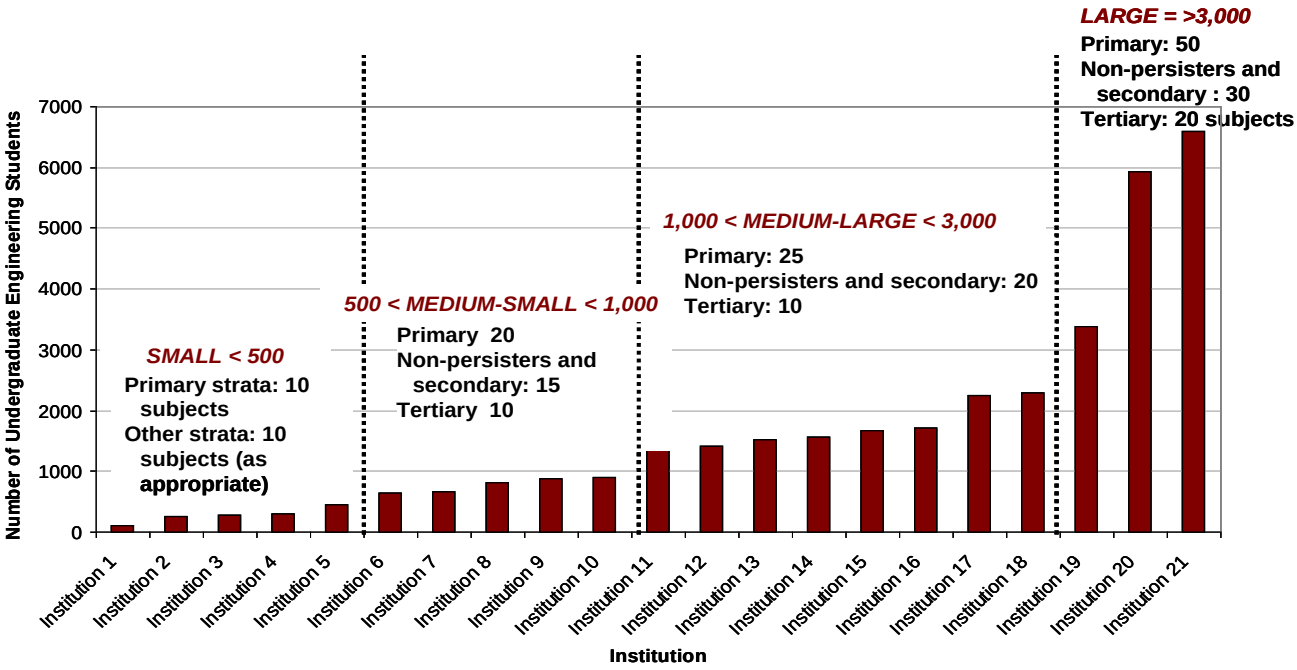
In keeping with our research goals, student recruitment was planned to ensure a diversity of participants, including over-sampling of specific groups (strata). The strata, in order of importance, were defined as follows:

- Primary strata: academic level (freshmen, sophomores, juniors, seniors), engineering persisters/non-persisters, and men/women
- Secondary strata: ethnic minority and international students
- Tertiary strata: part-time and transfer students

Ethnic minorities included those traditionally underrepresented in the undergraduate engineering population nationally: African Americans, Latinos, and Native Americans. International students were defined as those not holding U.S. citizenship.

Strata recruitment targets were set for each participating institution by visually-binning according to their undergraduate engineering enrollment: small (less than 500 students), medium-small (500-1000 students), medium-large (1000-3000 students), and large (more than 3000 students) (Figure 7.3).

Figure 7.3. Strata Targets by Institutional Undergraduate Engineering Enrollment



The local coordinator and Stanford liaison adjusted strata targets depending on the student composition of the school. For example, if a small school had fewer than ten international

students, this stratum (and target) was eliminated. Similarly, if a school had a large proportion of Latino students, the target for ethnic minorities was increased.

7.7.2 Incentive for Participation

As in the Broader Core Sample, students were offered a $4 electronic payment through Pay Pal for their participation in the Broader National Sample.

7.7.3 Recruitment Methods

The main methods for recruiting students to take the APPLE survey were:

- Email messages to undergraduate engineering students from a senior administrator (such as a dean). Coordinators were encouraged to send the email on the first day of survey deployment.
- Posters customized to the institution. Posters typically went up the weekend before deployment at locations frequented by engineering students. (See Appendix 2-C for sample poster.)

A third recruitment method, advertisement on a popular social networking site, was used as needed to bolster response rates mid-deployment. This step was required at seven (33%) of the schools.

In November 2007, prior to deployment, local coordinators developed strategic recruitment plans for strata that may be more difficult to fill, such as non-persister, ethnic minority or part-time students. Strategic recruitment was implemented based on the daily response reports prepared by Stanford liaisons during the week of survey deployment. A sample response report is shown in Appendix 5-A.

7.8 Survey Deployment

7.8.1 Deployment Procedures

APPLES deployments for the Broader National Sample were scheduled to last five days (Monday through Friday), consistent with response patterns from the Broader Core Sample deployment. Participating institutions could choose from three deployment weeks, ranging from late January to late February 2008. A fourth deployment week in March 2008 was added to accommodate two institutions that were unable to schedule deployment earlier.

The survey was "turned on" at 12:01 AM on Monday, and "turned off" at 11:49 PM on Friday. At nine institutions where response rates were low and strata targets were unmet, the survey was kept live for up to one week longer.

Participants accessed the survey using a URL that included the school name or abbreviation (e.g., schoolname.applesurvey.org). The school reference was incorporated in the URLs to enhance the credibility of the survey and encourage participation.

7.8.2 Data Collection Summary

Table 7.4 summarizes the data collected by stratum.

Table 7.4. Summary of Eligible APPLES Responses by Stratum

School	UG Eng Enrollm't	APPLES Responses	Fr	So	Jr	Sr+5th Yr Sr	M	F	Ethnic Minor'y	Int'l	Part-time
1	99	47 (47%)	13	11	13	10	0	47	5	6	0
2	251	95 (38%)	19	28	22	26	75	20	7	10	1
3	286	116 (41%)	29	21	37	29	64	51	5	7	0
4	310	87 (28%)	24	22	22	19	41	45	2	4	0
5	546	84 (15%)	25	17	20	22	71	12	9	9	0
6	634	155 (24%)	29	35	43	47	101	54	122	39	8
7	666	54 (8%)	10	13	13	18	42	12	52	1	2
8	823	131 (16%)	11	25	38	54	92	35	6	14	14
9	874	153 (18%)	30	14	41	65	109	44	43	38	18
10	896	57 (6%)	12	18	14	12	46	11	1	3	1
11	1,397	160 (11%)	41	39	49	31	89	70	7	12	0
12	1,405	261 (19%)	64	71	68	58	148	113	26	40	0
13	1,517	101 (7%)	21	24	27	28	70	28	42	48	6
14	1,563	136 (9%)	48	33	28	26	80	54	112	10	2
15	1,623	635 (39%)	177	104	148	203	481	146	19	63	15
16	1,674	361 (22%)	71	84	90	114	268	91	44	36	26
17	1,723	242 (14%)	18	96	83	45	110	131	31	19	0
18	2,245	99 (4%)	26	6	29	37	79	18	6	17	5
19	2,290	391 (17%)	57	67	99	168	303	83	26	17	3
20	5,930	445 (7%)	97	127	120	101	260	183	25	90	1
21	6,591	456 (7%)	115	112	117	111	261	194	62	39	7
Totals	33,343	4,266 (13%)	937	967	1,121	1,224	2,790	1,442	652	522	109

There were 4,597 eligible (non-fraudulent) responses in the Broader National Sample, which was reduced to 4,266 after data cleaning. Approximately 3,900 (85%) of eligible respondents indicated they wished to claim the incentive, of whom 2,958 (64% of eligible respondents) actually did so.

7.9 Notes and Reflections

7.9.1 Controlling Incentive Outlays

Prior to deployment, the research team considered the financial burden of issuing incentives in case of an unexpectedly high response rate, such as the 30 percent that the NSSE surveys garner. This concern was addressed in several ways:

- Emphasis was placed on strategic recruitment aimed at meeting strata targets, with little to be gained (statistically) from grossly exceeding targets.
- Daily monitoring of responses would allow researchers to know if numbers were getting too large, in which case the survey could be turned off once strata targets were comfortably met.

Furthermore, approximately 61 percent of respondents in the Broader Core Sample ended up collecting their incentives, and there was no reason to expect differently in the Broader National Sample.

As it turned out, response rates were similar in the two Samples (17% for the Broader Core Sample and 14% for the Broader National Sample), as were incentive collection rates (61% vs. 64%).

7.9.2 Fraudulent Responses

There were two cases of attempted large-scale fraud, defined as a large number of ineligible submissions. The first case was detected by an unexplained surge in responses halfway through the deployment week. This surge was traced to two "free money"-type websites to which the APPLES URL had been forwarded. The second case of fraud was the result of two individuals repeatedly taking the survey, one taking it 14 times and the other 38 times. Multiple submissions were detected using a combination of IP tracking and timing data. As in the Broader Core Sample, the minimum time for taking the survey without blindly clicking through fell at the five-minute mark. Submissions that were clearly fraudulent were removed from the data set.

7.9.3 Recruitment Challenges

As with the Broader Core Sample, researchers experienced difficulty recruiting non-persisters, transfer students and part-time students. Non-persisters were most successfully recruited via email sent to technical non-engineering departments such as Physics. However, not all institutions had such majors and some institutions faced internal constraints in contacting students outside engineering. Transfer students were most easily recruited at large public institutions and those that enrolled 3+2 students (i.e., students who completed three years at another institution in order to transfer to complete their last two years in engineering).

7.9.4 Lessons Learned

Despite the experience gained from the Broader Core Sample, researchers learned additional lessons about survey recruitment and deployment from the Broader National Sample.

- There were advantages to using institution-specific URLs for accessing the survey, including more thoroughly protecting the identity of participating institutions from each other; facilitating the tracking and remediation of technical problems; and allowing researchers to isolate large-scale fraud without impacting the larger deployment or data sets.
- The last question on the survey, "Is there anything else you want to tell us that we didn't already cover?" was a rich source of data. Many students revealed passions, concerns and experiences that were not otherwise captured in the survey.
- The amount of researcher attention required by the participating institutions varied. Researchers generally spent more time communicating with and assisting institutional coordinators than was anticipated. In at least one case, a researcher had to step in to locate and recruit students at a school that did not have experience or knowledge to do so themselves.
- Similarly, managing incentive payments required more time and effort than anticipated, largely due to student requests for help and demands for payment.
- Staggering deployments relieved considerable pressure on the research team to better address the needs of participating institutions, provide for last-minute survey extensions and resolve anomalies with incentive claims.

For more information about survey development for the Broader National Sample/APPLES2 please see:

Donaldson, Krista, Helen Chen, George Toye, Mia Clark, and Sheri Sheppard. 2008. Scaling Up: Taking the Academic Pathways of People Learning Engineering Survey (APPLES) National. Presented at the *38th ASEE/ISEE Frontiers in Education Conference, Saratoga Springs, NY, October 22-25, 2008*.

8 Workplace Cohort

The goal of the Workplace Cohort research was to address research questions about the school-to-work transition of new professional engineers. Of particular interest were those aspects of becoming an engineer that are not taught or learned as part of academic training. By studying new engineers and their supervisors, researchers explored technical and social factors and skills that contributed to a successful transition into the workplace.

The original design of the Workplace Cohort consisted of 16 students (8 on each of two campuses) who had participated in the Longitudinal Cohort research. The plan was to follow these 16 students from the end of their junior year through the first two years post-B.S. However, this original design of the Workplace Cohort was expanded to eventually include over 100 participants in three distinct studies. We call these sets of archived interviews:

1) The Workplace Cohort: Researcher#1. These interviews were conducted by a CAEE research scientist at the University of Washington under the supervision of a CAEE Lead at UW.
2) The Workplace Cohort: Researcher#2. These interviews were conducted by a CAEE research scientist at the University of Minnesota (at the time a CAEE-funded PhD student), under the supervision of two CAEE Leads at Stanford and University of Minnesota.
3) The Workplace Cohort: Researcher#3. These interviews were conducted by a CAEE research scientist at the University of Washington under the supervision of a CAEE Lead at UW.

Each of these Workplace Cohorts is described below.

8.1 Workplace Cohort: Researcher#1

This dataset consists of eight interviews with engineering graduates from one of the APS core schools. All eight were Longitudinal Cohort students, and completed their degrees in 2008. Three of the interviewees are female and five are male. The interviews were conducted between April 2008 and November 2008, and ranged in length from approximately 20 minutes to an hour. At the time of the interview, four of the engineering graduates were employed in medium to large sized engineering firms, three in small firms, and one was not in the workplace. The overall intent of these interviews was to explore the transition from engineering educational institutions to actual engineering workplaces. The topics of interest included: the use of mathematics in the workplace, differences in learning experience in school and work, and aspects of engineering education that were important in the workplace but not covered in school.

8.2 Workplace Cohort: Researcher#2

This dataset consists of 96 transcripts of interviews of engineering graduates employed as engineers or engineering supervisors at one of four organizations (see Table 8.1 for descriptions of organizations). The data collection was mainly focused on understanding the socialization of newly graduated engineers who had been employed at the organization from 6-12 months, addressing such questions as:

- How do newly hired engineers practice engineering in the workplace?
- How do newly hired engineers learn the specific job requirements and social norms of the workplace?
- What are the factors affecting how newly hired engineers begin practicing engineering in the organizational setting?

The interview protocol (based on a critical incidence methodology) is contained in Appendix 3-E. The interviews were conducted between January and April 2007, and were nominally an hour in length.

Table 8.1. Four organizations participated in the Workplace Cohort: Researcher #2

Organization #1—is a large, global vehicle manufacturing company. They had recently reorganized and began hiring new engineering talent primarily to develop new technologies. There was much flux in the organization and they had delegated new hire onboarding to the managers of work groups without a structured plan to follow. Therefore, each work group onboarded new hires according to the preferences and conditions of the work group—meaning that there was a high level of variance in the experiences of new hires—from good to bad.

This dataset includes semi-structured interviews with 30 newly hired engineers and 6 supervisors conducted in January and February of 2007. The new hires had from 6 months to 18 months experience at their jobs. Each supervisor had at least one of these new hires in his or her work group.

Organization #2—is a large national food manufacturing company. They had a highly structured onboarding program including a rotational program for newly hired engineers. While new hires were assigned to different production plants, the experiences were relatively similar. New hires received detailed plans for meeting with others (developing relationships and networks) and the organization explicitly expected managers at all levels to meet with new hires and expected work groups to provide learning experiences to new hires. New hires also moved across three different engineering jobs and work groups during their rotations. This structured process enabled new hires to quickly learn the culture of the company and make important contacts early, as well as learn about different processes and functions in the company.

This dataset includes semi-structured interviews with 18 newly hired engineers conducted in January through April of 2007. The new hires had from 6 months to 18 months experience at their jobs.

Organization #3—is a smaller manufacturing company of computer components. They provided a structured and systematic onboarding process comprised of training courses and meeting various experts in the company. They did not have a rotational program and the experiences of new hires depended on the efforts of the work groups to help new hires learn and integrate into the organization.

This dataset includes semi-structured interviews with 19 newly hired engineers and 4 supervisors in February of 2007. The new hires had from 6 months to 18 months experience at their jobs. Each supervisor had at least one of these new hires in his or her work group.

Organization #4—is a state-government agency for transportation. This organization had a highly structured, rotational program providing new hires with in-depth background information and the opportunities to rotate among various work groups/experiences. The experiences of new hires varied among work groups depending on the efforts of coworkers and managers to facilitate learning.

This dataset includes semi-structured interviews with 19 newly hired engineers conducted in January through April of 2007. The new hires had from 6 months to 18 months experience at their jobs.

8.3 Workplace Cohort: Researcher#3

This dataset consists of seven audio files of interviews of recently graduated engineers (all were out of school for less than 12 months at the time of their interview). The companies at which these engineers work were identified through discussions with staff in engineering departments at one of the APS core schools as companies that recruit the school's graduates.

Five of these interviews were with individuals at a county public works department. These individuals were identified and recruited through a list provided by the department's director and the head of the training program for new engineers.

One interview was conducted with an engineer at a state transportation agency who was selected from a list provided by a manager in the agency.

One interview was conducted with an engineer at a small aerospace firm, who was recruited from a list of recently hired engineers provided by one of the directors. The company is an engineering firm focused on providing innovative and entrepreneurial aerospace products to commercial, civil, and military customers.

One of the interviewees is female and six are male. The interviews were conducted between the months of November 2006 and May 2007, and ranged in length from 33 minutes to 74 minutes. The interview guide used for these interviews is included in Appendix 3-F.

Issues explored in these interviews include:

- The new engineers' retrospective views of formal education
- The degree to which their work permeated home life
- The extent to which the new engineers felt that engineering should be in the service of others
- How these engineers learned new technical skills at work
- How they learned new social skills at work
- Their satisfaction in practicing the craft of engineering

A listing of papers and reports from the Workplace Cohort research can be found at http://www.engr.washington.edu/caee/.

List of Appendices

Identifier	Name of Appendix	Cohort
1. Process Documents		
1-A	• APS File Naming System	
1-B	• APS Data Access Guidelines	
1-C	• APS Persistence Definitions	
1-D	• APS Informed Consent Forms	Longitudinal
1-E	• APS Longitudinal Cohort Demographics Table	Longitudinal
2. Recruitment Documents		
2-A	• Original APS Longitudinal Cohort Sampling Plan	Longitudinal
2-B	• Sample APPLES Institution Overview and Recruitment Plan	Broader National
2-C	• Sample APPLES Poster	Broader National
2-D	• Sample APPLES Recruitment e-mail	Broader National
2-E	• APPLES Recruitment e-mail for Non-persisters	Broader National
3. Interview and ETD Instruments/Documents		
3-A	• APS Structured Interview Protocol Example	Longitudinal
3-B	• APS Engineering Task Protocols and ETD Data Sets	Longitudinal
3-C	• APS Interviewer Manual Example	Longitudinal
3-D	• APS Semi-structured Ethnographic Interview Guide Examples	Longitudinal
3-E	• Workplace Interview Guides: BCC	Workplace
3-F	• Workplace Interview Guide: County-State-Aerospace	Workplace
3-G	• APS Longitudinal Cohort Exit Interview Guides	Longitudinal
4. Survey Instruments		
4-A	• Longitudinal Cohort (PIE) Surveys	Longitudinal
4-B	• Mapping PIE to APPLES	Longitudinal and Broader Core
4-C	• APPLES1 Survey Questions	Broader Core
4-D	• APPLES2 Survey Questions	Broader National
4-E	• Cross-sectional Cohort Survey and Focus Group Questions	Cross-sectional
5. Other		
5-A	• Sample APPLES Response Report	Broader National
5-B	• APS Research Team	