Targeting Undergraduate Students for Surveys: Lessons from the Academic Pathways of People Learning Engineering Survey (APPLES)

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Abstract - **The Academic Pathways of People Learning Engineering Survey (APPLES) was deployed in April 2007 targeting cross-sectional populations from four American universities. The goal of APPLES is to validate earlier findings from the Academic Pathways Study on factors that correlate with persistence in engineering. There is minimal literature detailing the practical process and methodology for engineering education researchers to undertake thorough, statistically-sound survey research, particularly as it relates to reaching specific student groups within the undergraduate engineering population. We outline the APPLES development methodology, and specifically the lessons learned in deploying a multi-site, medium-scale survey. This paper details our process for constructing the sampling plan and the resulting design for the APPLE survey, and addresses issues relating to working with campus liaisons, subject recruitment and deployment. Finally, we share preliminary response rates and feedback from respondents to inform a model for conducting survey design and research for engineering education researchers.**

Index Terms - Cross-sectional study, Engineering persistence, Recruitment, Survey methodology.

OVERVIEW & BACKGROUND

The goal of the Academic Pathways of People Learning Engineering Survey (APPLES or APPLE survey) is to validate the longitudinal data from the Academic Pathway Study (APS) Persistence in Engineering (PIE) survey, as well as findings from other APS data collection methods [1, 2]. By the end of the 2006-2007 academic year, the web-based PIE survey will have been administered six times (over four years) to a cohort of 160 undergraduate students ("Cohort 1") at four American institutions (Coleman University, Mountain Technical Institute, Oliver University and University of West State[1]) who entered university in 2003 with intent to study engineering.

The APPLE survey will be deployed twice (we refer to the deployments as APPLES1, and APPLES2, respectively) to two different populations of American undergraduate engineering students. APPLES1 was administered in April 2007 and targeted students from the same four schools as Cohort 1. APPLES2 will be deployed in early 2008 at 18-20 universities in the United States to explore whether the Cohort 1 findings can be generalized more broadly. This paper focuses on the first administration of the APPLE survey, APPLES1.

The APPLE survey is a component of the Academic Pathways Study (APS) of the Center for the Advancement of Engineering Education (CAEE). The APS aims to provide a comprehensive account of how people become engineers by exploring key questions around skills and identity development[2]. We are particularly interested in building upon knowledge related to persistence in undergraduate engineering education in the U.S.

Due to our focus on persistence in engineering education, APPLES recruitment targeted three groups of undergraduate students: (1) *engineering students*: those who have declared an engineering major or have already committed to engineering programs; (2) *pre-engineering students*: those who intend to declare an engineering major; and (3) *non-persister students*: those who were initially interested in majoring in engineering, but have since decided to pursue a non-engineering major.

The engineering program structures at the four APS institutions differ significantly, posing a recruitment challenge for APPLES1. Recruitment methods that are successful at one institution may not be appropriate or even possible at another institution. For example, after two years of "pre-engineering" coursework at University of West State (UWest), students must apply to and be accepted by specific departments within the School of Engineering before they can officially declare engineering majors. At Coleman, on the other hand, students are encouraged to explore possible fields of study and are not required to declare a major until the beginning of their junior year – thus, identifying Coleman's pre-engineering students is a challenge. Table I characterizes the four schools and their academic structures related to identifying undergraduate engineering students.

[1] Pseudonyms

[2] See [3, 4] for CAEE APS background and overview.

TABLE I.
OVERVIEW OF THE FOUR INSTITUTIONS INVOLVED IN THE FIRST ADMINISTRATION (APRIL 2007) OF THE APPLE SURVEY. (IRB=INSTITUTIONAL REVIEW BOARD)

Institution	Profile	Academic calendar	In-house IRB?	Engineering student population
Coleman	Competitive private research university	Quarter system	Yes	Declare majors at beginning of junior year
Mountain Tech	Public research institution, devoted to engineering and applied science	Semester system	No	Predominantly engineering majors
Oliver	Comprehensive, historically Black private university	Semester system	Yes	Admitted to engineering program at admission to the university
UWest	Large public research university with three campus locations	Quarter system	Yes	Admitted to engineering program junior year after application and acceptance process

While there is significant literature on survey development in general[3], there is little literature on survey methodology for engineering education research, and none to our knowledge on the targeting of student subjects in engineering education research. Besterfield-Sacre and Atman [5] outline their development process of the Pittsburgh Freshman Engineering Attitudes Survey instrument, focusing on item-level refinement based on piloting. The APPLES instrument has already been developed and refined through six deployments; the challenge we face is how to identify and recruit subjects at four diverse institutions using a scholarly, statistically-sound and ethical methodology.

SAMPLING PLAN

In devising a sampling plan, we recognized we were under certain constraints. First, we were constrained by a *convenience sampling* method for recruitment of participants, whereby we requested targeted respondents (for example, through an email distribution list) to voluntarily take the APPLE survey, as compared to *random sampling* where we would be able to choose the subjects randomly. Second, because APPLES aims to validate longitudinal data in one survey administration, our target sample needed to be cross-sectional and include respondents from all stages of their undergraduate academic career (See Table II). Third, in delineating the analyses to be performed on the collected APPLES data, we developed a list of sub-groups (*strata*) for which we would use targeted recruitment and later perform statistical comparisons with the collected data.

A power calculation was conducted in order to estimate the sample size needed for this study. Using an alpha level of .05 and an effect size of .378 with three predictors[4], we estimated a minimum total sample size of 88 subjects necessary to yield a power of .95. The effect size was determined by a multiple regression analysis conducted with the Cohort 1 longitudinal data set.

Our other consideration for determining the sample size was the strata we would use in the analysis of the APPLES1 data. Stratification, the grouping subjects of the population before sampling, improves the representativeness of the sample by reducing sampling error. We stratified disproportionately to oversample specific sub-groups such as ethnic minorities and part-time students. The primary strata for APPLES were based on persistence and academic class (freshman, sophomore, junior, and senior). We determined that the non-persister stratum should be considered in addition to the academic class strata because analyses of the longitudinal PIE survey data suggested that there were institutional variances. Secondary characteristics considered for strata were enrollment status (part-time versus full-time, and transfer versus freshman admit), ethnicity (ethnic minority[6] and international[7] students) and gender. As a statistical rule of thumb, the minimum number of required subjects for t-tests is 10-25. We thus chose the higher minimum for the primary strata as well as gender and ethnicity and the lower minimum for enrollment status. We believed, based on the required response rates to meet the respondent targets (see Table III), it would not be difficult

TABLE II.
POPULATIONS BY ACADEMIC STANDING AND INSTITUTION TARGETED BY FIRST DEPLOYMENT OF THE APPLE SURVEY BASED ON ASEE 2004 [6][5].

	Fr	So	Jr	Sr	PT	TOTAL	Of total (%)
Coleman	1+	33+	235	412	0	**681+**	12.8
Mountain Tech	572	515	530	747	0	**2,364**	44.3
Oliver	142	103	104	122	112	**583**	10.9
UWest	34+	100+	528	834	213	**1,709+**	32.0
TOTAL	**749**	**751**	**1,397**	**2,115**	**325**	***5,337***	(100)
Of total (%)	14.0	14.1	26.2	39.6	6.1	(100)	

NOTES: SENIOR YEAR INCLUDES 5TH YEAR STUDENT DATA. THE NUMBERS OF FRESHMEN AND SOPHOMORE STUDENTS INTENDING TO STUDY ENGINEERING AT COLEMAN AND UWEST ARE HIGHER THAN SHOWN BECAUSE STUDENTS DO NOT DECLARE AN ENGINEERING MAJOR UNTIL THEIR JR YEAR. FR=FRESHMEN; SO=SOPHOMORE; JR=JUNIOR; SR=SENIOR; PT=PARTI-TIME

[3] See for example, Salient and Dillman [11].
[4] Three predictors were included in the power calculation because the other PIE variables did not meet the minimum entry criterion required by the Forward procedure. The linear combination of the three predictors was significantly related to the intention to major in engineering, $F(3,123)=26.53$, $p<.001$.
[5] The 2004 data from ASEE were the most complete at the time we developed the sampling plan (March 2006).
[6] We defined ethnic minority students as those traditionally underrepresented in engineering in the U.S.: African American, Hispanic and Native American students [7, 8].
[7] We defined international students as those who do not hold U.S. citizenship.

to recruit 25 subjects for the gender and ethnicity strata at the four institutions.

Based on the response rates for the National Survey of Student Engagement (NSSE) [9], a similar survey in terms of content and estimated length, we expected up to a 30% response rate for each institution. Looking at the required response rates from the four institutions in Table III, we recognized that Oliver would likely have the greatest challenge meeting the recruitment targets for APPLES.

TABLE III.
RESPONSE RATES REQUIRED FROM THE FOUR APS INSTITUTIONS TO ACHIEVE MINIMUM TARGETS FOR APPLES SURVEY DEPLOYMENT.

Strata	Target per institution	Estimated response rates to achieve response targets			
		Coleman	Mountain Tech	Oliver	UWest
All	140	9%	6%	32%	4%
Freshmen*	25	6%	4%	18%	3%
Sophomores*	25	6%	5%	30%	3%
Juniors*	25	7%	5%	24%	3%
Seniors*	25	7%	3%	21%	3%
Non-persisters*	25	6%	--	--	4%
Female students	25	12%	3%	23%	8%
Ethnic minority	25	9%	28%	NA	21%
International students	25	17%	28%	19%	18%
Transfer students	10	--	--	--	--
Part-time	10	NA	NA	67%	7%

NOTES: DATA BASED ON ASEE 2005, 2006 DATA. (FRESHMEN AND SOPHOMORE DATA FOR COLEMAN AND UWEST WERE ESTIMATED BY INSTITUTIONAL LIAISONS.) ASTERISKS (*) INDICATE PRIMARY STRATA; DASHES (--) INDICATE UNKNOWN DATA; NA=NOT APPLICABLE.

DESIGN FOR DEPLOYMENT

In designing the APPLES administrations, we aimed for the APPLES1 deployment to be a model for the larger-scale APPLES2. Working with us at each of the four institutions were campus liaisons, typically a senior faculty member partnered with a senior researcher. Campus liaisons assisted in securing Institutional Review Board (IRB) human subjects approvals, planning campus-specific recruitment, and coordinating local deployment. The liaisons also provided valuable insights into their institutional and student cultures, campus infrastructure, and student preferences during the development of recruitment materials and plans. For example, we asked the liaisons if it was more appropriate for their students to take a web-based or paper-based survey, or whether both options should be available. Oliver's liaison requested both options because of frequent difficulties with the institution's internet system, while other schools chose only the web-based survey.

I. Institutional Review Board (IRB) Process

IRB approval was required for each of the four institutions because all had researchers who were involved in the APS. Coleman took the lead in drafting the protocols and coordinating the sites. Because Mountain Tech did not have an IRB, Oliver incorporated Mountain Tech's work in their application. Universal IRB requirements, such as not requiring the subject to answer one or any of the survey questions, significantly guided the PIE and APPLE surveys designs [10]. Specific IRB requirements did, however, vary: Coleman's IRB requested clarification on incentive payment, UWest's IRB required a confidentiality disclaimer statement, and Oliver's IRB required some terminology changes in the recruiting material. During the IRB application preparation, Oliver's liaison recognized a paper-based survey could compromise confidentiality. As a result, Oliver later chose to deploy only a web-based survey.

II. Incentive

Informal consultations with other survey researchers suggested that recruiting engineering undergraduate students was more difficult than typical students and that we should offer an incentive for participation. We chose a $4 electronic payment for every individual who took the survey through a commonly-used online financial transaction company, PayFriend[8], because it best met our budget and requirements:

- *Broad appeal*: flexibility for the student in spending
- *Online transaction*: available immediately (or shortly after) the student's participation in the survey
- *Scalability*: appropriate for APPLES2, consistent with local laws and required minimal logistical work
- *Confidentiality*: offered and redeemed without compromising student confidentiality
- *Accountability*: ability to track payments to meet university disbursement requirements.

Together with our APPLES liaisons, we considered the following other options before selecting PayFriend: a raffle prize (IRB required the raffle be open to anyone who went to the survey website), a $5 electronic gift certificate to Books & More, a large online seller of books and other items (no items could be bought for $5, a minimum expenditure of $5,000 to be scalable, account and redemption status not transparent), giftcards for CoffeeBucks or Metro Sandwiches (not confidential or scalable), and free songs from iMusic-to-go-with-you (did not have broad appeal to students based on informal conversations).

[8] We used pseudonyms for all businesses.

We were concerned about potential respondents blindly clicking through the survey (entering no data) to repeatedly claim the $4 incentive. We considered allowing only one respondent per IP address (the numerical sequence that serves as an internet identifier for a computer or server), but decided against this because it would exclude respondents who may share a computer. To balance "blind clicking" concerns with the IRB requirement that students be allowed to not answer a question, we added an explicit option of "I prefer not to answer" to the majority of the questions. Piloting later showed that blind clicking with the addition of the "I prefer not to answer" boxes took approximately five minutes which our team determined to be the minimum acceptable amount of time to take the survey.

III. Recruitment

Salant and Dillman [11] suggest that university students' response rates to surveys depend on the students' perceived importance of the survey and the level of interest students have in the topic. Patterns of responses from the Cohort 1 respondents, who we believed to perceive the survey with moderately high levels of importance and interest, encouraged us to expand our recruitment efforts to include basic recruitment methods aimed at a larger audience: posters, emails to student distribution lists, and an ad in the student newspaper – all of which carried consistent branding of a red apple logo.

The IRBs required the survey be open to all students. However, we designed the posters to focus on our target respondents: pre-engineering, engineering, and non-persister students. We provided the APPLES liaisons with suggested text for an email invitation to be sent to the students from their engineering deans and a small (1/8th page) advertisement in the student newspaper. UWest and Mountain Tech declined the newspaper advertisement while Oliver requested two advertisements on different days to reach students with different class schedules.

Branding and credibility were important considerations in the deployment design. We sought to choose a name (APPLES) and web address that would be memorable to students if they saw a poster on campus. We had been warned by experienced survey researchers to avoid a URL that would appear spam-like; instead, it was suggested we include the university's web address, e.g. applesurvey.oliver.edu[9]. All of our recruiting materials included the apple logo, the institution's name and school-specific web address, and mention of National Science Foundation (NSF) funding along with the NSF logo.

Because the four institutions differed in terms of student demographics and when students were required to declare their majors, we set recruitment targets on a per school basis. Recruitment Plans A (Table IV) and B (Table V) cover the primary and secondary strata characteristics respectively. During survey deployment, daily reports to liaisons noted the responses for each stratum to help direct recruitment efforts. Campus liaisons implemented Plan B only if they perceived one or more of their strata to be lagging during the APPLES deployment.

We were most concerned about recruiting the non-persister students. We did not expect institutions to track specific students who had migrated from engineering to non-engineering majors. From Cohort 1 data, however, we had a sense of what majors were popular with the non-persister students at Coleman. Through Coleman's institutional liaison, we asked the Physics, Symbolic Systems, Math and Computational Sciences, and Economics departments to send an announcement to their undergraduate student distribution lists [3].

IV. Piloting

The APPLE survey underwent two rounds of piloting: a first round primarily to refine the survey questions for clarity and identify questions for elimination, and a second to streamline the final product. The length of the survey was a primary concern given the limited compensation we were able to offer prospective respondents. The average time for respondents taking the first pilot was 22.5 minutes. Using timing data that recorded how long respondents spent answering individual survey questions during the first pilot, we were able to pare down the survey instrument to our target time of approximately 10 minutes. The feedback from this initial round of piloting was particularly useful in identifying difficult questions and formatting issues. For example, open-ended questions often took a long time to answer, as did questions that asked respondents to mark their "top five choices" in a check box format.

Eliminating constructs and demographic items was a difficult exercise in trade-offs[10]. However, this process motivated the survey design team to evaluate each of the constructs and the demographic variables, and to think hard about our analysis plan and potential audiences for our findings. We purposely limited the scope of the survey so that we could be confident in presenting more detailed findings on a smaller number of constructs. The survey was first piloted internally with ten graduate students and researchers on our design team. The second pilot was conducted with 58 undergraduate students from five non-Cohort 1[11] institutions who did not receive an incentive. It was important to find students for the second pilot who represented the three primary target groups in order to further validate the survey instrument for readability, understanding, and appropriate length.

[9] Each of the APPLES institutions had separate web addresses to confirm the student's institution for tracking strata targets.

[10] The APPLE survey does not include all of the PIE constructs [1, 2] because of the differences between the administrations of the two surveys (i.e. PIE respondents were paid annually over four years to take a 25 minute survey, whereas APPLES participants received minimal compensation for their time). As a result, a shorter survey was required in order to optimize response rates.

[11] We chose non-Cohort institutions to avoid inadvertent contamination and exposure of the survey instrument.

TABLE IV.
"PLAN A": THE RECRUITING PLANS FOR THE FOUR APS INSTITUTIONS FOR APPLES DEPLOYMENT.

Strata	Min. target	Coleman	Mountain Tech	Oliver	UWest
All	140	Ad: student newspaper	Email: entire school Posters: throughout campus	Ad: student newspaper	(all targeted recruitment)
Pre-Eng students	50	Email: Eng societies, Fr/So advisors Posters: prereq bldgs Announce: dept overviews	NA	NA	Email: Pre-eng list
Eng students	50	Email: Eng list Posters: Eng. bldgs	(Email: entire school)	Email: Eng list Posters: Eng. bldgs	Email: Eng list
Non-persisters (NP)	25	Email: NP dept[12] lists Posters: NP depts	Email: students with NP majors	Email: Science, Eng and Math Society Posters: NP bldgs, student union, dorms	Email: list from dean's database

TABLE V.
"PLAN B": TARGETED RECRUITMENT IF MINIMUM RESPONSES ARE NOT ACHIEVED FOR THE APPLE SURVEY

Strata	Min target	Coleman	Mountain Tech	Oliver	UWest
Female students	25	Email: SWE (Society of Women Engineers) list, sororities	Email: SWE list	Email: SWE, BWAS (Black Women in Architecture Students) lists	Email: SWE, WISE (Women in Science and Eng) lists
Minority students	25	Announce/email: ethnic professional societies list	Email: Minority Eng program list	NA	Email: minority professional societies list
International students	25	Email: International Ctr list	Email: Minority Eng program list	Email: International Ctr list	Repeat email: all
Transfer students	10	Email: transfer list (?)	Email: transfer list	Email: transfer list	Email: list from dean's database
Freshmen (Fr)	25	Email: Fr dorms, Fr-level prereq class	Email: Fr list	Email: Fr list Posters: Fr/So dorms	Repeat email: all list
Sophomore (So)	25	Email: So dorms, So-level prereq class	Email: So list	Email: So list Posters: Fr/So dorms	Repeat email: all list
Juniors (Jr)	25	Email: Jr-level Eng classes	Email: Jr list	Email: Jr list, faculty teaching Jr-level courses	Repeat email: all list; dept lists
Seniors (Sr)	25	Email: Sr-level Eng classes	Email: Sr list	Email: Sr list, faculty teaching Sr-level courses	Repeat email: all list; dept lists
Specific eng major		Email: dept lists	Email: under-represented major(s)	Email: dept lists	Email: dept lists
Part-time students	5-10	NA	NA	Email: part-time list	Email: list from dean's database

SURVEY DEPLOYMENT

None of the institutions reached their targets for all strata. All institutions (except Oliver) had difficulties reaching their ethnic minority targets. Oliver had difficulties reaching all of their targets (except the female stratum); as a result, we extended the survey an extra two weeks at Oliver.

APPLES deployment dates at three other institutions were constrained by spring break schedules, the final administration of the Cohort 1 PIE survey, the end of the academic year at the semester institutions, and response rates. Based on response patterns (see Figure 1) and institutional scheduling constraints, we determined that 5 days (Monday through Friday) was the optimum period of deployment for a 10-12 minute survey. Our experiences from the PIE surveys suggested that students tend to respond to the survey shortly after receiving a recruitment email, resulting in participation peaks following these announcements. Figure 1 clearly shows this to be the case with APPLES response peaks following email solicitations.

We estimated that fraud, which we defined as "blind clicking" and attempts to claim the incentive without filling out the survey, represented approximately 3% of total submissions. In preparing the APPLES1 data for analysis, we discarded all cases where the respondent took less than five minutes to complete the survey (this cutoff was based on the piloting timings).

[12] Math & Computational Sciences, Symbolic Systems, Physics and Economics

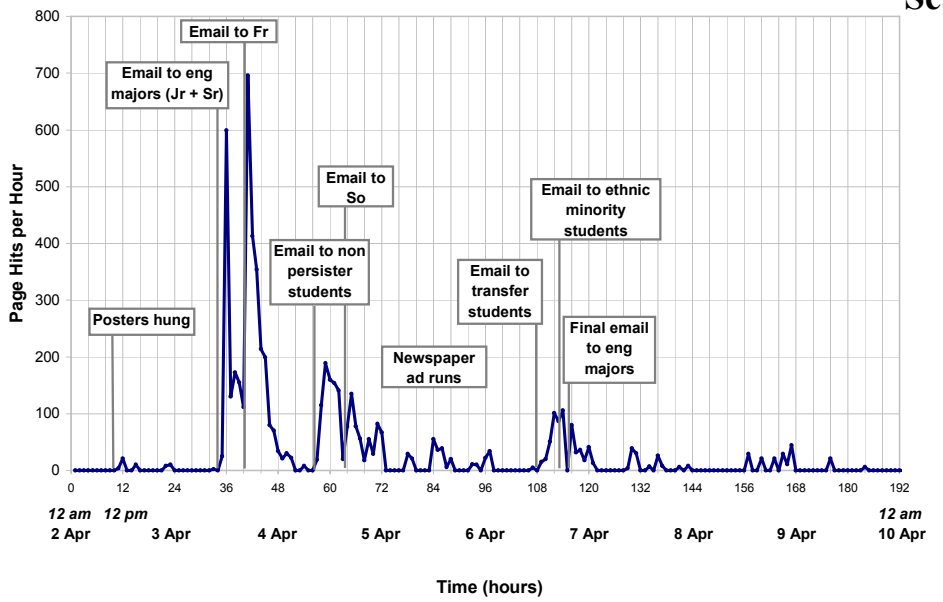

FIGURE I. RESPONSES (AS REPRESENTED BY SERVER ACTIVITY) TO COLEMAN'S APPLE SURVEY RELATIVE TO RECRUITMENT EFFORTS.

RESULTS & LESSONS LEARNED

There were 914 responses to APPLES1. For the incentives, there were 748 claims and 137 declines.

Despite our team's experience with the PIE survey deployment and comprehensive planning, we learned many lessons in the design and administration of the APPLE survey:

- **Start the IRB process at least four months prior to the planned deployment.** This is especially important for multi-site studies where multiple IRB approvals are required. The IRBs at Oliver and Coleman, for example, required changes in font size to APPLES recruitment materials.
- **Consider the different stakeholders when determining the incentive**. In addition to the potential student respondents, we recognized that incentives or other compensation may be needed for institutions' and their liaisons' APPLES participation. We will produce institution-specific reports for APPLES2.
- **Allocate resources for comprehensive piloting of the survey.** Timing of the survey instrument during piloting was particularly valuable in guiding difficult decisions about which items and constructs to keep or delete. We extended the second pilot because the timing and content feedback from the student respondents were invaluable. As part of the pilot surveys, testers were asked to give comments; from these comments we were able to improve the readability and clarity of the survey questions.
- **Emphasize sharing and learning from other recruitment plans across institutions.** Recruitment plans (similar to Tables IV and V) were shared across institutions with limited success. The feedback received from liaisons was that the framework was helpful in developing their own campus recruitment plans, but they did not fully appreciate the other institutions' plans until after the deployment. We also used an online workspace for storing materials such as recruitment letters and IRB-related documents. While this archive was valuable for the APPLES1 planning team to track information to inform future APPLES administrations, the liaisons did not use it.
- **Add survey items to weed out ineligible subjects**. Although the survey targeted undergraduate students from the four institutions, a sizable number of graduate students and students from other universities also took the survey. We used responses to the demographic questions to easily identify these cases and eliminate them from the analyses.
- **Allow multiple submissions from a single IP address**. Our decision to allow more than one submission per IP address proved to be a good one; approximately 22% of Oliver's submissions came from a single IP address. We believe this to be due to the firewall system used there.

CONCLUSIONS

The Academic Pathways of People Learning Engineering Survey (APPLES) was deployed in April 2007 to validate findings from analyses of the longitudinal data set of the Academic Pathways Study (APS) Persistence in Engineering (PIE) survey. We targeted over 560 undergraduate students who were studying engineering or had considered studying engineering at four undergraduate institutions. Our primary strata were academic class (freshmen through seniors) and persistence. Student recruitment methods varied at the four institutions, although we depended mainly on posters and email requests from deans of engineering. The incentive of $4 per individual respondent was paid through an online financial transaction company.

From the first APPLES administration, we had over 900 submissions and learned several lessons to inform future administrations, including the importance of timing data during piloting, the recognition of various stakeholders, and

the utility of sharing institution-specific recruitment plans to share ideas and build community.

APPLES will be deployed again in early 2008 at over 18 institutions in the U.S.

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REFERENCES

[1] Eris, O., H.L. Chen, D. Chachra, C. Rosca, L. Ludlow, S. Sheppard and K. Donaldson. "A Preliminary Analysis of Correlates of Engineering Persistence: Results from a Longitudinal Study" 114th Annual American Society for Engineering Education Conference Proceedings, Honolulu, 2007.

[2] Eris, O., H. Chen, T. Bailey, K. Engerman, H. Loshbaugh, A. Griffin, G. Lichtenstein and A. Cole, "Development of the Persistence in Engineering (PIE) Survey Instrument" 2005 ASEE Annual Conference & Exposition: The Changing Landscape of Engineering and Technology Education in a Global World, Vol., No., 2005, pp. 2005.

[3] Donaldson, K.M. and S.D. Sheppard. "Exploring the Not-So-Talked-About Undergraduate Pathway: Migrating Into Engineering" submission to the First International Conference on Research in Engineering Education, Honolulu, 2007.

[4] Sheppard, S., C. Atman, R. Stevens, L. Fleming, R. Streveler, R. Adams and T. Barker. "Studying the Engineering Student Experience: Design of a Longitudinal Study" American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, 2004.

[5] Besterfield-Sacre, M. and C. Atman. "Survey Design Methodology: Measuring Freshman Attitudes About Engineering" ASEE 1994 Annual Conference Proceedings, pp. 236-241, Edmonton, 1994.

[6] ASEE (American Society of Engineering Education), Profiles of Engineering Colleges, www.asee.org/about/publications/profiles/search.cfm, 2004.

[7] May, G. and D. Chubin, "A Retrospective on Undergraduate Engineering Success for Underrepresented Minority Students" Journal of Engineering Education, Vol. 83, No. 1, 2003.

[8] Chubin, D., G. May and E. Babco, "Diversifying the Engineering Workforce" Journal of Engineering Education, Vol. 94, No. 1, 2005, pp. 73-86.

[9] NSSE, (National Survey of Student Engagement), Engaged Learning: Fostering Success for All Students, Annual report, Indiana University Center for Postsecondary Research and Planning, Bloomington, 2006.

[10] United States National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research. Bethesda: The Commission, 1978.

[11] Salant, P. and D.A. Dillman, How to Conduct Your Own Survey. New York: Wiley, 1994.