# AC 2007-2392: A PRELIMINARY ANALYSIS OF CORRELATES OF ENGINEERING PERSISTENCE: RESULTS FROM A LONGITUDINAL STUDY

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# A Preliminary Analysis of Correlates of Engineering Persistence: Results from a Longitudinal Study


## Abstract

This paper outlines the preliminary findings of a longitudinal survey-based study, the Persistence in Engineering (PIE) survey. This survey was designed to identify and characterize the fundamental factors that influence students' intentions to pursue an engineering degree over the course of their undergraduate career, and upon graduation, to pursue a career in an engineering-related field, including practicing engineering as a profession, teaching, or conducting research. In addition, it is also designed to broaden our understanding of how students navigate their education and begin to form identities as engineers.

In the fourth year of the study, 76% of the 141 students enrolled in the study as first-year students are still enrolled in engineering (persisters) and 24% are no longer majoring in engineering (nonpersisters). Preliminary analyses suggest that there are some interesting similarities and differences between the persisters and nonpersisters. For example, nonpersisters are more likely to be motivated to study engineering by family influences. They also report lower levels of confidence in their math and science skills as first-year and sophomore students, as well as lower levels of engagement in both engineering and liberal arts courses as compared to their persister counterparts. These results are preliminary; even so, they begin to illustrate the many ways that persisters and nonpersisters are similar and the potentially significant ways that they are different. A more comprehensive analysis of the data is in progress.


## I. Introduction

The Academic Pathways Study (APS) of the Center for the Advancement of Engineering Education (CAEE) is building upon and extending knowledge related to retention in engineering education[1-7] by employing quantitative and qualitative approaches to establish a longitudinal research base on engineering student learning[8]. This paper reports the preliminary analysis outcomes of six of the seven planned administrations of the Persistence in Engineering (PIE) survey instrument, which was developed as a part of the APS[9].

The PIE Survey intends to identify correlates of persistence in engineering. It identifies and explores two levels of persistence: academic and professional. "Academic persistence" is operationalized as declaring an intention to major in engineering, and "professional persistence" is operationalized as declaring an intention to conduct research in, teach, and/or practice engineering for at least three years after graduating with a bachelor's degree in engineering.

The survey has been developed by an interdisciplinary team employing a mixed-methods approach. Its development process and conceptual framework has been documented in detail in a previous publication[9]. At this phase of the APS, the PIE Survey is primarily an exploratory tool. In the next phase (2007-2008), the survey will serve as the basis of a more refined national survey, APPLES (Academic Pathways for People Learning Engineering Survey), that will be administered to a stratified sample of students representing the undergraduate engineering student population of the United States. The APPLES instrument is intended to validate the PIE survey findings, as well as to extend the results to a much more broadly representative population of students.

## II. Refinement of the PIE Survey

The PIE survey is still evolving. Over the course of the past three years, the PIE survey has been administered six times longitudinally to a cohort of 160 students studying engineering at four undergraduate institutions. During the six administrations, the constructs of the PIE survey have been continuously refined. The items that make up the constructs have been fairly stable since any significant changes in the actual survey questions would limit our ability to conduct a longitudinal analysis. However, the groupings of items under constructs, as well as the definition of those constructs, have been refined based on the outcomes of qualitative and statistical analysis of the responses. In a small number of cases, it was necessary to modify the actual survey items as well. The constructs such items were associated with were tracked back and reported only to the administration during which a significant item change has occurred; construct values of those constructs for previous administrations were not reported or included in the analysis.

Table 1 outlines the final set of PIE constructs and associated items (for a discussion on the definition and rationale of the constructs, see previous publication[1]). Internal consistency values for multi-item constructs and item total correlations for those items are also reported based on the fifth administration of the survey (fall 2005), which corresponds to the first semester or quarter, of the participants' junior year in college. The internal consistency reliability value for Construct 2d was not reported since those items were only administered during the second administration of the survey (spring 2004).

Table 1. *Fall 2005 PIE Survey Constructs, Items, Internal Consistency Reliabilities, and Item-Total Correlations.*

| Construct and Item Content | | Fall 05 Item-Total Correlation | Fall 05 Alpha |
|---|---|---|---|
| **1a.** | **Academic Persistence** | | n/a |
| | *Do you intend to complete a major in engineering?* | n/a | |
| **1b.** | **Professional Persistence** | | n/a |
| | *Do you intend to practice, conduct research in, or teach engineering for at least 3 years after graduating?* | n/a | |
| **2a:** | **Motivation (financial)** | | .76 |
| | *Engineers are well paid.[1]* | .74 | |
| | *Engineers make more money than most other professionals.[1]* | .69 | |
| | *An engineering degree will guarantee me a job when I graduate.[1]* | .40 | |
| **2b.** | **Motivation (Family Influence)** | | .85 |
| | *My parents would disapprove if I chose a major other than engineering.[2]* | .75 | |
| | *My parents want me to be an engineer.[1]* | .75 | |

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|---|---|---|---|
| **2c.** | **Motivation (Social Good)** | | .70 |
| | *Technology plays an important role in solving society's problems.[1]* | .54 | |
| | *Engineers have contributed greatly to fixing problems in the world.[1]* | .54 | |
| **2d.** | **Motivation (high School Teacher/Mentor Influence)** | | --- |
| | *A high school teacher/advisor encouraged and/or inspired me to study engineering.* | | |
| | *One or more of my favorite high school teachers were math/science teachers.* | | |
| | *I had one or more high school math/science teachers who seemed genuinely excited about math/science.* | | |
| **2e.** | **Motivation (Mentor Influence)** | | .65 |
| | *A faculty member, academic advisor, teaching assistant or other university affiliated person has encouraged and/or inspired me to study engineering.* | .48 | |
| | *A non-university affiliated mentor has encouraged and/or inspired me to study engineering.* | .48 | |
| **3a.** | **Confidence in Math and Science Skills** | | .83 |
| | *Science ability* | .74 | |
| | *Math ability* | .73 | |
| | *Ability to apply math and science principles in solving real world problems* | .61 | |
| **3b.** | **Confidence in Professional and Interpersonal Skills** | | .84 |
| | *Leadership ability[5]* | .71 | |
| | *Self confidence (social)[4]* | .67 | |
| | *Public speaking ability[5]* | .65 | |
| | *Communication skills* | .62 | |
| | *Ability to perform in teams* | .62 | |
| | *Business ability* | .50 | |
| **3c.** | **Confidence in Solving Open-ended Problems** | | .69 |
| | *I am skilled at solving problems that can have multiple solutions.* | .53 | |
| | *Confidence: Critical thinking skills* | .52 | |
| | *Creative thinking is one of my strengths.[1]* | .46 | |
| **4a.** | **Perceived Importance of Math and Science Skills** | | .79 |
| | *Math ability* | .78 | |
| | *Science ability* | .76 | |
| | *Ability to apply math and science principles in solving real world problems* | .41 | |
| **4b.** | **Perceived Importance of Professional and Interpersonal Skills** | | .79 |
| | *Leadership ability[5]* | .70 | |
| | *Public speaking ability[5]* | .65 | |
| | *Self confidence (social)[4]* | .56 | |
| | *Communication skills* | .55 | |
| | *Ability to perform in teams* | .55 | |
| | *Business ability* | .26 | |

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|---|---|---|---|
| **5.** | **Knowledge of the Engineering Profession** | | n/a |
| | *I am familiar with what a practicing engineer does.* | n/a | |
| **6a.** | **Exposure to Project-Based Learning Methods (Individual Projects)** | | n/a |
| | *Since September, what percentage of your classes used the following teaching methods? Individual Projects:* | n/a | |
| **6b.** | **Exposure to Project-Based Learning Methods (Team Projects)** | | n/a |
| | *Since September, what percentage of your classes used the following teaching methods? Team Projects:* | n/a | |
| **7.** | **Collaborative Work Style** | | .61 |
| | *I prefer working as part of a team to working alone.* | .46 | |
| | *I am a collaborative person.* | .42 | |
| | *I get along well with others in study situations.[5]* | .41 | |
| | *I prefer studying in a group to studying by myself.[2]* | .37 | |
| **8.** | **Extra-Curricular Fulfillment** | | .85 |
| | *Some people desire to be involved in non-engineering activities on or off campus, such as hobbies, civic or church organizations, campus publications, student government, social fraternity or sorority, sports, etc. How important is it for you to be involved in these kinds of activities?* | .75 | |
| | *How often are you involved in the kinds of activities described above?* | .75 | |
| **9.** | **Curriculum Overload** | | .81 |
| | *How stressed do you feel in your coursework right now?* | .74 | |
| | *Thinking about your college experience this year, please comment on the following:* | | |
| | *Course load (amount of course material being covered)* | .68 | |
| | *Course pace (the pace at which the course material is being covered)* | .63 | |
| | *Balance between social and academic life* | .53 | |
| | *How well are you meeting the workload demands of your coursework?* | .54 | |
| **10.** | **Financial Difficulties** | | n/a |
| | *Do you have any concerns about your ability to finance your college education?* | n/a | |
| **11a.** | **Academic Disengagement (Liberal Arts Courses)** | | .58 |
| | *Skipped non-engineering related class[5]* | .41 | |
| | *Turned in non-engineering related assignments late[5]* | .41 | |
| | *Came late to non-engineering related class[5]* | .38 | |
| | *Turned in non-engineering related assignments that did not reflect your best work[5]* | .29 | |
| **11b.** | **Academic Disengagement (Engineering Related)** | | .70 |
| | *Skipped engineering related class[5]* | .54 | |
| | *Turned in engineering related assignments late[5]* | .51 | |
| | *Turned in engineering related assignments that did not reflect your best work[5]* | .48 | |
| | *Came late to engineering related class[5]* | .41 | |

| | | |
|---|---|---|
| **11c . Academic Disengagement (Overall)** | | .74 |
| *Turned in non-engineering related assignments late[5]* | .51 | |
| *Turned in engineering related assignments late[5]* | .51 | |
| *Turned in engineering related assignments that did not reflect your best work[5]* | .48 | |
| *Came late to engineering related class[5]* | .43 | |
| *Came late to non-engineering related class[5]* | .43 | |
| *Skipped engineering related class[5]* | .42 | |
| *Turned in non-engineering related assignments that did not reflect your best work[5]* | .40 | |
| *Skipped non-engineering related class[5]* | .36 | |
| **12. Frequency of Interaction with Instructors** | | .69 |
| *TAs outside of class or office hours[4]* | .53 | |
| *Faculty outside of class or office hours[4]* | .42 | |
| *Faculty during class* | .41 | |
| *TAs during class* | .41 | |
| *TAs during office hours[4]* | .40 | |
| *Faculty during office hours[4]* | .39 | |
| **13a. Satisfaction with Instructors** | | .84 |
| *Availability of teaching assistants* | .74 | |
| *Quality of instruction by teaching assistants[3]* | .71 | |
| *Quality of advising by teaching assistants* | .71 | |
| *Quality of advising by faculty* | .61 | |
| *Availability of faculty* | .58 | |
| *Quality of instruction by faculty[3]* | .49 | |
| **13b. Satisfaction with Academic Facilities** | | .83 |
| *Computer facilities[4]* | .70 | |
| *Classrooms[4]* | .68 | |
| *Libraries[4]* | .66 | |
| *Laboratories* | .59 | |
| **13c. Overall Satisfaction with Collegiate Experience** | | n/a |
| *Rate the overall quality of your collegiate experience so far* | n/a | |

[1] From the Pittsburgh survey (with permission)
[2] From the Pittsburgh survey, and modified slightly (with permission)
[3] From the CIRP survey, and modified slightly (with permission)
[4] From the YFYC 2003 survey (with permission)
[5] From the YFYC 2003 survey, and modified slightly (with permission)

## III. Survey Administration

The PIE Survey has been administered longitudinally to a cohort of 160 students, 40 at each of the four CAEE campuses, beginning during their first year in college. All incoming students in Fall 2003, who had indicated an interest in studying engineering were invited to participate, and students then self-selected to be a part of the study. Six surveys have been administered since then, approximately once per semester (every other quarter). The seventh and final administration, which will be during the students' senior year, is scheduled for spring 2007.

Based on responses to demographic questions asked in the winter 2004 survey, the students in the cohort are not married (100%), the majority are U.S. citizens (83%), and have a modal age of 19. The cohort is 61% male and 39% female, and they self-identify by ethnicity as the following: 42% White/Caucasian, 23% Black/African-American, 18% Asian/Asian-American/Native Hawaiian/Pacific Islander, 3% Mexican American/Chicano/Latino, and 14% Other/Multiracial.

The raw data from the surveys required processing for analysis. As different survey items had different response scales, the score for each construct was normalized by a linear mapping to a scale of 0 to 1. The normalized score is given for each construct; full details of the included items can be found in Table 1. Data for all timepoints were pooled and t-tests were used to determine differences between the persister and nonpersister groups (reported as the 'overall' p-value). This statistical analysis is exploratory, and is most likely to overestimate the differences between the two groups as compared to a repeated-measures ANOVA (see 'V. Discussion of results'). T-tests were also performed to determine differences at individual timepoints. Levene's test was used to assess equality of variances and ensure that the appropriate t-test was used.

## IV. Preliminary Analysis Outcomes

As of December 2006, we have complete longitudinal data for 141 participants in this study, of whom 107 are majoring in engineering and 34 have decided to major in a non-engineering subject. Students who are continuing to major in engineering are referred to as *persisters*; those who have "exited" engineering are *nonpersisters*.

A preliminary analysis was performed to look for disproportionate representation by gender or school. The persistence rate, or percentage of persisters among the total, is 76% for the whole group. It should be observed that our survey respondents have a much higher rate of persistence in engineering than the national average of approximately 60%;[11] this is presumably related to the self-selection of the survey participants.

The persistence rate of women is 80% and that of men is 73%. The persistence rates by schools (referenced by pseudonyms) are as follows:

Mountain Tech: 78%
Oliver University: 74%
Coleman University: 68%
University of West State: 84%

The relatively small differences between the persistence rate for each subgroup (gender or school), coupled with preliminary information regarding differences in construct scores between these subgroups, suggest that (to a first approximation) the differences between persisters and nonpersisters do not arise from over- or underrepresentation of a particular subgroup. For our preliminary analyses we have therefore focused on the observed differences as being specifically related to persister/nonpersister status; future analyses will incorporate differences in the subgroups which make up the persisters and the nonpersisters.

As would be expected, persisters demonstrate higher levels of agreement with statements that relate to both academic persistence (**construct 1a**; completing their degree) and professional persistence (**construct 1b**; pursuing a career in engineering) for all administrations ($p < 0.0005$

for both constructs). For academic persistence, this difference is not observed in the first semester; however, differences between the two groups are significant for the second semester onwards, which presumably corresponds to the timeframe during which nonpersisters started to exit engineering for other majors. While the items comprising the professional persistence construct were not asked in the first year, differences between the two groups were apparent by the sophomore year.

Relative to persisters, nonpersisters are equally likely to be motivated by financial reasons (**construct 2a**) or by a perception of engineering as being socially beneficial (**construct 2c**). The degree of family influence in the decision to study engineering (**construct 2b**) was higher for nonpersisters than persisters overall ($p<0.0005$); there is also a statistically significant difference in response during the first year ($p<0.05$). For both groups, the reported family influence dropped sharply for both persisters and nonpersisters after the first year (Figure 1). Nonpersisters are also less likely to attribute their motivation to study engineering to an academic mentor (**construct 2d**; $p<0.01$).

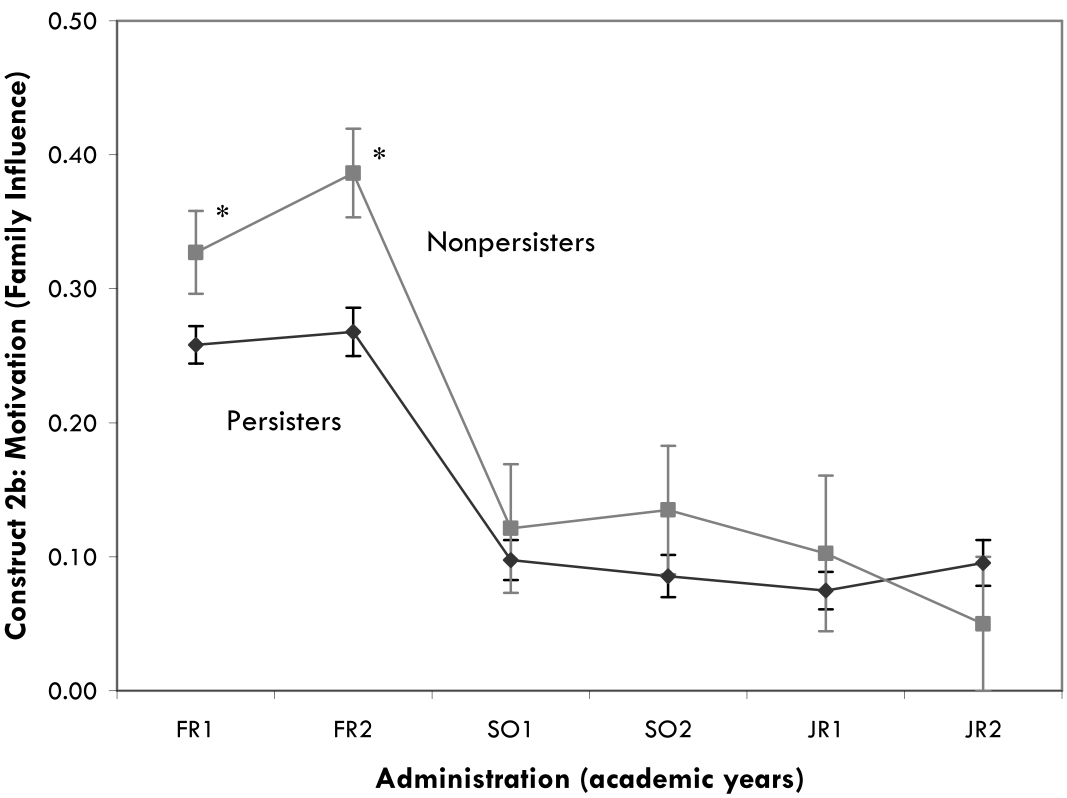


Figure 1. *Construct 2b: Motivation (Family Influence). The value for the construct is a normalized score on a scale of 0 to 1. Data are presented as mean ± standard error of the mean. Asterisks indicate significant differences between the groups for that administration (p<0.05). FRI, FR2: first year; SO1, SO2: sophomore year; JR1, JR2: junior year.*

Nonpersisters report lower levels of confidence in their math and science skills (**construct 3a**) for all time points ($p<0.0005$). However, the pattern of changes in confidence level appears different for persisters and nonpersisters (Figure 2). Nonpersisters have a lower level of confidence than persisters until the start of the junior year ($p<0.05$ for first through fourth semesters). In the junior year, there is a slight decline in the confidence of persisters and a slight increase in that of nonpersisters. This increase in confidence for the nonpersisters may reflect the fact that the nonpersisters with very low confidence in their math and science skills left engineering at an earlier stage and exited the study, or it may be that the confidence of nonpersisters in their math and science skills increases once they are out of the engineering environment. Nonpersisters and persisters rate their perception of the importance of math and science skills (**construct 4a**) as similar; in contrast, persisters rate the importance of interpersonal and professional skills (**construct 4b**) higher than nonpersisters do ($p<0.005$ overall). Nevertheless, persisters and nonpersisters report similar levels of confidence in their interpersonal and professional skills (**construct 3b**).

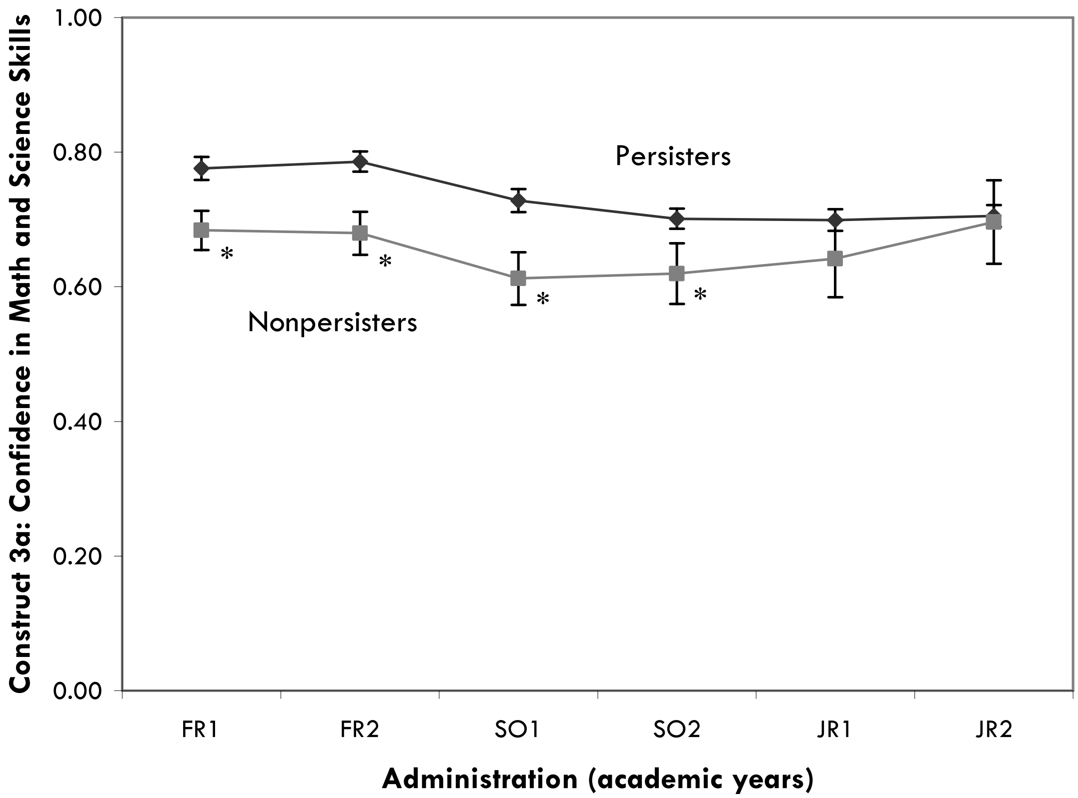


Figure 2. *Construct 3a: Confidence in Math and Science Skills. The value for the construct is a normalized score on a scale of 0 to 1. Data are presented as mean ± standard error of the mean. Asterisks indicate significant differences between the groups for that administration ($p<0.05$).*

Persisters report a similar level of familiarity with the engineering profession (**construct 5**) until the second semester of their junior year, when they diverge ($p<0.0005$ overall; $p<0.005$ for that timepoint). This is likely to reflect the continuing engineering experiences of persisters, such as internships, whereas nonpersisters are presumably no longer engaged in these experiences.

Nonpersisters also report a slightly lower level of involvement in team-based problem-based learning (**construct 6b**; overall $p<0.05$; no differences at any single timepoint).

Finally, non-persisters report higher levels of academic disengagement in liberal arts courses (**construct 11a**; $p<0.05$), in engineering-related courses (**construct 11b**; $p<0.005$), and overall (**construct 11c**; $p<0.01$) than the persisters. For engineering courses, the differences are significant in the second semester of sophomore year ($p<0.05$); overall, these differences are significant from the second half of the first year until the end of sophomore year ($p<0.05$). Both persisters and nonpersisters report similar frequency of interaction (**construct 12**) and similar degrees of satisfaction with their instructors (**construct 13a**). Oddly, nonpersisters report a higher degree of satisfaction with academic facilities and services (**construct 13b**; $p<0.05$ overall and for both junior year surveys). Perhaps unsurprisingly, persisters report a higher degree of satisfaction with their overall academic experience (**construct 13c**; $p<0.005$ overall).

## V. Discussion of results

Despite the preliminary nature of the analyses presented here, a picture of the differences between nonpersisters and persisters is starting to emerge. In general, nonpersisters are more likely to be motivated to study engineering by external (family) influences, are less confident in their math and science skills, and less likely to be engaged in their studies than persisters. It is interesting that these differences are apparent in the freshman and sophomore years; academic engagement has been positively correlated with increased satisfaction with the academic experience (as reported here) as well as with an increased retention rate.[10]

The results presented here are preliminary analyses of data from an ongoing exploratory survey. A comprehensive set of analyses will be performed after the final administration. These will include repeated-measures ANOVAs to isolate effects of time (e.g. how construct scores change as students progress through their education) as well as differences between persisters and nonpersisters. In addition, the representation of different subgroups (gender, schools) within the persisters and nonpersisters will be explored. The nonpersisters may be further subdivided into ‘early’ and ‘late’ groups to determine if differences can be observed between students who leave relatively early in their academic training (such as early sophomore year) compared to those who leave later. In addition, these survey data will enable us to investigate differences in these constructs between genders, ethnicities, and schools. Ultimately, logistic regression models will be explored for the purpose of early identification of non-persisters. Throughout this next phase of analysis, PIE Survey findings will also be interpreted against and compared with those in the literature, other national survey instruments, and the aforementioned APPLES instrument which will be administered nationally as well as to larger and more representative populations at Mountain Tech, Oliver University, Coleman University, and University of West State.A knowledge of the differences between persisters and nonpersisters may aid in the design of engineering curricula as well as strategies for academic advising.

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