AC 2008-605: PERFORMANCE AND RETENTION OF TRANSFER ENGINEERING STUDENTS

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Performance and Retention of Transfer Engineering Students

Abstract

The College of Engineering at the University of Arizona (UA) and The Engineering Program at Pima Community College (PCC) have a long history of partnership. In a typical year, nearly 100 engineering students formally transfer from PCC to UA. These students have at least 24 transfer credits. Also, UA students take single classes at PCC as the schedule may be more flexible, class sizes are smaller, and instructors have a reputation for effective instruction. In a given academic year, students who originally transferred from PCC can account for 15% of the UA engineering graduate BS degrees.

This paper makes two contributions. First we describe survey results that compare key differences in PCC and UA students. Differences in age, hours working and classroom experience are clear. Also, the survey suggests key reasons why students select PCC over the UA when they actually have a choice. The second contribution is an analysis of PCC student success after transferring to the UA. We consider both graduation rates and grades in follow-on classes. This analysis is interesting since there is a UA faculty perception that students from PCC are weaker and less prepared than UA lower division students. Specifically we examine the graduation rates of the fall 1999 and fall 2000 transfer cohorts and the grades in some key junior level classes in civil and electrical engineering.

Background and Study Questions

The University of Arizona's College of Engineering has approximately 2350 undergraduate students spread over 18 majors (14 accredited). 75% of the students are Arizona residents. A typical entering class in fall has approximately 450 new 1st time students, 100 transfers from 2-year and 4-year schools, 50 international students (not counted in the previous two categories), and 10 re-admits of students who were previously in academic difficulty. In fall 2007 the 1st time students had an average SAT score of 1210, 3.6 academic GPA, and an average class rank in the top 11%. 40% of the 1st time students had credit for calculus I through either AP, dual-enrollment, or community college channels. Less than 15% of the 1st time students are not calculus ready. Students with math deficiencies or lower SAT and GPA scores are placed in a pre-engineering program and given special advisors, tutoring programs, and a 1-credit student success seminar. In fall 2007, there were 90 1st time freshman designated as pre-engineering. Typical 1st year retention in engineering can be variable, but we have held steady at the 75% level for the past 2 entering classes. These students have an 85% 1st year retention at the UA (as compared to the general UA retention of 80%) so there is some movement out of engineering to other colleges at the University.

Instructors at UA tend to be tenure track faculty with PhD's in engineering/math/science fields. They are heavily involved in research (UA is a Research I classified university) and some may have extensive industry experience. Instructors in the freshman classes tend to proven effective teachers and may be "industry adjuncts." Sophomore engineering science classes can be taught

in large sections (75 – 125 students). Graduate student TA's often lead lab/recitation/review sessions but rarely lead entire classes.

Pima Community College's Engineering program offers a strong selection of traditional 1st and 2nd year engineering classes as well as the standard math, physics, and chemistry sequences. The following engineering classes are taught in the fall and/or spring semesters:

- General Engineering – Intro to Engineering Design, "C" Computer Programming
- Civil/Mechanical Engineering – Engineering Graphics, Surveying, Statics, Mechanics of Materials, Fluid Mechanics, Thermodynamics, Dynamics
- Electrical Engineering – Introductory Circuits (non EE majors), Advanced Circuits (for EE majors), Intro to Digital Systems
- Other Engineering – Numerical Methods, Technical Writing

Instructors at Pima have advanced degrees in engineering fields (MS and PhD), generally have extensive industry experience, and focus largely on teaching. Class size for engineering classes are typically in the 10's and 20's. There are 4 campus locations, but most engineering classes are offered only at the West Campus location.

There is a formal articulation agreement that is posted on the Arizona Community College State System website. The Community Colleges submit syllabus and course materials to the system and the equivalency is approved by the State Universities (UA, NAU, ASU). These are reviewed at an annual meeting each fall and new additions and edits can be made at any time. Advisors at all institutions are aware of the agreement and there is little to no room for interpretation. If a class is in the agreement, then it will be accepted for credit.

This study is an initial attempt to organize and analyze information related to transfer engineering students and students who take one or several engineering courses in Pima Community College. There is a growing enrollment of engineering students at Pima CC and this requires recognizing student issues and understanding student attributes in order for our institutions to meet and address educational challenges. Although academic performance of transfer students is often discussed in the UA Engineering Undergraduate Studies Committee meetings, common perceptions about community college students still persist among UA engineering faculty. The typical thought is that only weak students attend the community college, classes cover less material and are generally less challenging, and students are generally unprepared for the rigorous follow-on classes at the UA. The notion is that students go to PCC to take 1 or 2 classes when they cannot pass them at the UA.

In reality, there was little substantiated understanding of why students select one program over the other and how students use both programs to their advantage. To start to understand the population and the actual issues, the following key questions were addressed in this initial study:

- What are the attributes of today's engineering students at PCC?
- What are the demographic and academic similarities and differences, between PCC engineering students and UA engineering students?
- How well do transfer engineering students actually perform at the UA?

- What should be done to improve collaboration between UA Engineering and PCC Engineering so that transfer students (in either direction) can be more successful?

To answer these questions we reviewed student data in different demographic and academic areas. Data were collected and analyzed by reviewing admission records and applications, surveys at orientation, analyzing course grades in pre-requisite and follow-on courses, and end of semester surveys. Despite the best intentions, there are several barriers to an accurate assessment. Most of our existing data collection efforts are set up to accommodate information about "linear transfers," those students who spend a year or two at the community college, earn the minimum 24 transfer credits and then enroll at a university. This is not the typical student unfortunately. The students who start their work at a four-year institution, transfer to a community college, and then return to a university are harder to track. Students that take individual classes at PCC are also harder to track.

Comparing the Student Populations at PCC and UA

A survey was developed and administered to better understand the population of PCC engineering students, and compare them with native UA engineering students in the similar courses. The survey helped to reveal the diversity of undergraduate engineering students and gave some insight in students' perception of engineering programs in UA and Pima CC. The survey included transfer students characteristics in following areas:

- demographics including age, gender, work and family commitments;
- high school location and year of graduation;
- academic plans including choice of major and expected bachelor degree completion;
- student opinions on quality of instruction at PCC;
- reasons for selecting specific courses and institutions
- past and future courses taken at PCC

The survey was given in the fall 2007 semester to all students in all PCC engineering classes and in the UA pre-engineering success seminar. The following two tables compare the age and the work commitment of undergraduate engineering students in freshman level classes.

Age and work commitment of PCC students in Introductory Engineering Classes (Percentage of Students – sample size = 84)

	Working Hours				
Age	31- 40 hrs	11- 30 hrs	1- 10 hrs	Not employed	Total
30 +	2.4 %	2.4 %	1.2 %	1.2 %	7.2 %
25-29	8.5 %	8.5 %	0.0 %	1.2 %	18.2 %
20-24	14.5 %	9.7 %	3.6 %	12 %	39.8 %
Recent HS graduates	4.8 %	12 %	6.0 %	12 %	34.8 %
Total	30.2 %	32.6 %	10.8 %	26.4 %	100 %

Age and work commitment of UA students in pre-engineering student success seminar (Percentage of Students – sample size = 87)

	Working Hours				
Age	31- 40 hrs	11- 30 hrs	1- 10 hrs	Not employed	Total
30 +	0 %	0 %	0 %	0 %	0 %
25-29	1.14 %	2.27 %	0 %	4.55 %	7.96 %
20-24	0 %	1.14 %	0 %	5.68 %	6.82 %
Recent HS graduates	1.14 %	14.77 %	3.41 %	65.90 %	85.22 %
Total	2. 28 %	18.18 %	3.41 %	76.13 %	100 %

It is clear that there are major differences in the populations. The majority of PCC engineering students (62.8%) in introductory engineering classes were worked either part-time (10-30 hours) or full-time while attending the community college and only 26.4% of the students were not employed. The same category of students of UA has different employment distribution by status: 76.13 % of them are not employed and only 20.46 % of these students had part-time or full-time work. Distributions by age also differ significantly between two groups: over 85 % of UA students are new high school graduates (17-19 years old), 17.3% were age 20 or older and only 9.3% were age 25 or older; for the same category of Pima CC students 35% were new high school graduates, 65% were age 20 and older and also more than 7.2% were age 30 or older. Only 35% of the PCC students attended the introductory engineering course directly after high compare while more than 85% attended similar course at UA directly from high school.

Having family responsibilities is an important characteristic of community college students. Of the students in the traditional 2nd year engineering science classes (129 surveys), 16% of the students are married and 28% of students are married or have dependents. 14.5% of the PCC students in the introductory engineering course are married or have dependents. These values are on the order of 1 to 2% for UA students. At PCC women make up 9% of the students in the introductory engineering class and 13.4 % in the traditional 2nd year engineering science classes. At the UA, women are approximately 19% of the total college population and ran at 20% for the fall 2007 freshman class. There is a significantly higher percentage of women in engineering at the UA.

Another point of interest was number of transferable credits earned by PCC students prior to taking the introductory engineering course.

Number of community college credits students earned prior to taking the Introductory Engineering Class

Number of credits	Percentage of students
0-15	36.1 %
16-25	16.9 %
26-35	21.7 %
36+	25.3 %

The UA students in the student success class come directly from high school and have little prior AP/community college credit. On the other hand, 15% of all 1st time freshman students in fall 07 had enough AP/community college credit to be classified as sophomores (30 or more units). The pre-engineering group is different than the Introductory Engineering Class PCC group

The data suggests that PCC serves as a starting point for non-traditional students: older, working many hours, family demands, and not ready/possible to meet demands of a full time university education straight from high school. The UA is generally a difficult option for these students.

Why Pima Community College Was Chosen

PCC Students marked all reasons for which they chose PCC. Twelve specific reasons were listed and the students were also allowed to explain in an "other" category. Here, we separated the students into two groups "Intro Engineering Course Students" and Survey data separated for two groups of undergraduate students: in introductory engineering classes and 2nd year engineering science class students. In the 2nd group, all of the students had already earned at least 24 prerequisite credits in math/chemistry/physics/intro to engineering classes.

	Percentage of Students that Chose a Particular Reason	
Reasons	Introductory Engineering Course	2nd year engineering science
Student identified themselves as PCC students	60 %	47 %
Inexpensive tuition	53 %	44 %
Smaller class size	31 %	30 %
Convenient schedule	24 %	17 %
Quality of instruction/ Reputation of instructor	18 %	33 %
UA doesn't offer course this semester	4 %	21 %
Close to home	14 %	12 %
Availability of financial aid	14 %	9 %

We can see from the table although affordability and class size are still top reasons to choose a community college, quality of instruction/reputation of instructor (especially for 2nd year courses) and convenient schedule are also among important reasons affecting students' choice. So, despite the notion that UA faculty may not consider the PCC classes as well taught, the students have a different opinion. Note that students self-identify as a PCC student early in their engineering coursework, so it should be possible to identify these students and provide services to ensure a successful transfer. Almost every student in the PCC sample indicated that they were transferring to a university and all but a few were transferring to the UA. We also noticed that even though a student did not self-identify, often it was clear from the number of classes that they had taken that they were actually a PCC student. There were significantly fewer "1-course drop-ins" than expected and these were largely due to schedule issues where the UA did not offer a class in a particular semester while PCC did have the class (21% of students of 2nd year courses have this listed as a significant reason to take course in Pima CC). In short, there is much less mixing of students between the schools than commonly thought.

Other reasons why students prefer to take engineering courses at PCC include:

- Students described PCC as a smaller, friendlier and more supportive environment than the UA.
- Students claim that Pima CC instructors more approachable and accessible than UA professors.

These two notions are extremely important for students transitioning from high school and for students that are struggling in classes. It is clear that for some students the PCC environment will help enable success more than the UA environment.

Student Success

To evaluate success of engineering students their academic performance and graduation rates were compared.

For graduation rates, we looked at entering cohorts in Fall 1999 and Fall 2000. In each we tracked all new freshman and all transfers from 2-year schools for 6 years. The transfers had at least 24 units of transfer credit (some of this may not have been applicable to an engineering degree). New freshman may have had AP/CC credit as well. Over 90% of the transfer students from 2-year schools are from PCC. The sample sizes and graduation rates are listed below:

	Fall 99 cohort	Fall 00 cohort
New freshman	442 students	497
Transfers from 2-year school	89 students	78
New Freshman % grad ENGR within 6 years	35%	42%
New Freshman % grad UA within 6 years	60%	60%
Transfers from 2-year school % grad ENGR within 6 years	55%	54%
Transfers from 2-year school % grad UA within 6 years	65%	64%

The comparison is interesting in that it seems that a transfer student is more likely to finish than a new freshman. This is due in part to the "infant mortality" that takes place in the freshman student group at the UA. The same process is taking place with transfer students but this is largely invisible since it does not take place at the UA. Another possible comparison would be to look at graduation rates of UA juniors or Sophomores and in both of these cases, the comparison result would be reversed. Students that have successfully completed the first 2 years at the UA graduate in rates over 90%. It is however encouraging that despite the difficulty of moving to a new environment that is significantly different in terms of student makeup and instructor approach (and can sometimes be less than inviting), the graduation rates in engineering are stronger than 50% and greater than 60% for some UA degree.

For our second comparison, we started with two junior level UA classes and the grades of students from the previous 2 or 3 semesters were analyzed relative to their grades in pre-requisite courses and their status when they started at the UA. As our data collection capabilities have

recently improved we were able to collect pre-requisite course grades for students that took the course at the UA and at PCC (or another transfer institution).

The first course, ECE 320 (Circuit Theory) had 230 students over 3 semesters and its required prerequisite course is ECE 220 (Basic Circuits). When a student took ECE 220 multiple times to satisfy the ECE 320 pre-requisite, we only counted the final try. Originally new UA freshman represent 126 of these students and and 51 were 2 year school transfers when they first came to the UA (the rest are international, or 4-year transfers or some other registration category). The second course, CE 333 (Structural Engineering) had 92 students and its required prerequisite course is CE 215 (Mechanics of Solids). Sixty students in this sample were new freshman when they first came to the UA students and 21 were 2-year school transfers. The following tables contain the direct grade data for the two courses:

Frequency and Percentage of Grades in CE 333 as a function of Original Registration Type

Original Registration Type	A	B	C	D	E	W	Grand Total
New Freshman	13 (22%)	24 (40%)	16 (27%)	5 (8%)	2 (3%)		60
Transfer 2-year		6 (29%)	7 (33%)	2 (10%)	2 (10%)	4 (18%)	21

Frequency and Percentage of Grades in ECE 320 as a function of Original Registration Type

Original Registration Type	A	B	C	D	E	W	Grand Total
New Freshman	17 (13%)	29 (23%)	36 (29%)	14 (11%)	23 (18%)	7 (4%)	126
Transfer 2-year	7 (14%)	8 (16%)	13 (25%)	7 (14%)	14 (27%)	2 (4%)	51

This comparison suggests that students that originally started as new freshman performed better academically than the 2-year transfer students. The comparison is over multiple sections (and potentially multiple instructors) and we checked that the grade distributions in each semester were similar. These results suggested that more investigation was needed to see where the transfer students were struggling. For example, students transferring from one institution to another often experience a temporary dip in academic performance during the first or second semester at the new institution. But after adjustment to new environment is made the differences between grades of the transfer and non-transfer students become negligible. So, an interesting

analysis is to look at grades in pre-requisite courses as well and correlate those to performance in the follow-on course. Here is an example of the analysis.

Frequency of Grades in CE 333
as a Function of Original Registration Status and Grade in the Pre-Requisite Class

Original registration status	Grade in Pre-requisite – CE 215	A	B	C	D	E	W	Total
New Freshman	A	10	9	4				23
	B	3	8	5		1		17
	C		6	2	4	1		13
	D		1	3				4
	E			1				1
	TR-TC			1	1			2
Total		13	24	16	5	2		60
Transfer from a 2-year school	A			1			1	2
	B		1	3				4
	C		2	2		1	1	6
	D		1	1	1	1	1	5
	TR-TA		2					2
	TR-TC				1		1	2
Total			6	7	2	2	2	21
Grand Total		13	30	23	7	4	2	81

The grade TR-TA and TR-TC represent students that transferred grades in for the pre-requisite course (A and C respectively). The first issue is that only 6 of the students transferred the pre-requisite course into the system (and did not take the UA equivalent). The large majority of transfer students may not be taking all of their 200 level engineering science courses at PCC. Students in this small sample that get a "C" seem to be especially at risk and this is borne out in ECE 320 as well. This is an opportunity for targeting students that may need more help when transferring (it is not possible to change the standard of transfer from the current "C or better"). For the UA and PCC pre-requisite classes, it is pretty clear that better grades in the pre-requisite lead to better grades in the follow-on courses.

Conclusions and Directions

The engineering students of PCC are more heterogeneous demographically and PCC opens doors to engineering B.S. degrees for many students who would not otherwise go to a university. This represents an opportunity and a mandate for the UA to work to improve success in individual classes and overall graduation rates. Currently, there seems to be a quality difference between UA native and PCC students when taking advanced classes and the causes of this difference require further exploration. PCC and UA will continue work together to conduct a more systematic analysis of engineering students' characteristics and academic performance.

The adjustment process of transfer students is likely to be complex--including academic, social, and psychological aspects due to the environmental differences between two- and four-year institutions. Transition challenges could cause significant impact on transfer students' performance. Our goal is to provide smooth transition, adequate support of transfer students and increase their retention in university. We believe that clear and consistent transfer agreements, effective vertical and horizontal articulation of curriculum, enhancing communication between instructors, smooth transition transfer students to university, better understanding the nature of different groups of engineering students (gender, ethnic minorities, working, low-income, first generation in college) are key directions for improving performance and retention of transfer engineering students. These current set of processes used to help transfer students and PCC and UA instructors includes a statewide articulation meeting, monthly meetings with the UA Engineering Undergraduate Studies Committee, semester meetings of instructors in common courses, and negotiation of common syllabus and learning outcome evaluation strategies. We are trying to improve our information sharing and feedback mechanisms so that perceptions match reality and transfer students can succeed in rates similar to UA students at the same level.