A Long & Leaky Pipeline:

Improving Transfer Pathways for Engineering Students

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the Research & Planning Group
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The RP Group is a nonprofit organization working to build a community college culture that views planning, evidence-based decision-making and institutional effectiveness as key strategies for student success.

Introduction

Engineering drives innovation critical for California's economic growth and productivity. Yet recent labor market projections indicate a shortfall of 40,000 engineers in the state by 2014.[1] One way to address the demand for engineers is to increase the number of community college students who successfully transfer into and complete baccalaureate programs in engineering.

The RP Group's *Student Transfer in Professional Pathways Project (STP3)* is funded by the James Irvine Foundation and the California Community College's State Chancellor's Office.

Engineering is one of five disciplines researched by the RP Group's *Student Transfer in Professional Pathways Project (STP3)*. The RP Group designed this study to better understand: (1) how students use the state's community colleges to prepare for transfer in engineering, accounting, nursing, teacher education and administration of justice; (2) what factors impact their journey; and (3) what opportunities exist for improving transfer to these professional majors.

This research brief is part of a series presenting discipline-specific findings from this multi-year investigation. The RP Group's examination of this discipline suggests that the current engineering transfer pipeline is long and leaky—requiring several years to achieve transfer and degree and exhibiting points of inefficiency along the way. Key highlights from the *Student Transfer in Professional Pathways Project* include:

- **The large majority of successful engineering transfer students were Asian and white males**
- **Most students took few engineering courses prior to transfer, signaling that there are opportunities to improve students' use of the community college system to prepare for transfer in this discipline**

Cal-PASS
California Partnership for Achieving Student Success

The RP Group completed this work in collaboration with the California Partnership for Achieving Student Success (Cal-PASS).

- **Students indicated they were challenged to meet the variability of transfer requirements across receiving universities and sometimes even between engineering programs at the same institution**
- **More than one in five students who successfully transferred to and completed baccalaureate-level engineering programs started their community college coursework in below college level math**

The RP Group designed this document for those engaged in building the engineering workforce in California, including community college and university educators and employers. We intend for this document to:

- **Share information discovered about engineering transfer through this study**
- **Promote a dialog about what the findings mean and how they can be used to improve engineering transfer paths**

In turn, this brief starts with a short overview of the RP Group's current research on transfer in engineering. We then provide a summary of findings on ways community college transfer students work toward a bachelor's degree in this discipline as well as factors that challenge and/or support their journey. We conclude with a series of discussion questions to stimulate reflection on and dialog about how educators and employers might respond to the research.

How did we conduct this research?

The RP Group studied students post-transfer, including those currently enrolled in engineering programs and those who successfully achieved a baccalaureate in this discipline. RP Group researchers also conducted preliminary investigations into the experience of community college students pre-transfer, particularly those enrolled in introductory engineering courses.

The study was driven by six primary research questions:

Question 1: Who are the transfer students?

Question 2: How do students get on the engineering transfer path?

Question 3: How do they use the community college system to prepare for transfer?

Question 4: What challenges them along the way?

Question 5: What supports them toward transfer and degree?

Question 6: What happens to students post-transfer?

We explored these questions through the research activities described below.

Examining the experience of students pre-transfer *(pre-transfer student survey and interviews)*. The RP Group documented the experience of students beginning their transfer journey by surveying those enrolled in introductory engineering courses in California community colleges. The project piloted this component of our work with a Bay Area college in fall 2010 and expanded it to include 14 colleges in spring 2011. The RP Group also conducted ongoing interviews with 15 learners attending one Bay Area community college pursuing transfer in engineering.

Backward mapping the journey of baccalaureate achievers *(quantitative data analysis)*. The RP Group collaborated with the California Partnership for Achieving Student Success (Cal-PASS) to examine the educational paths taken by 4,219 transfers who ultimately achieved a baccalaureate in engineering between fall 1996 and spring 2009. Seventeen universities were part of this analysis including undergraduate programs at nine California State Universities (CSUs), six Universities of California and two private institutions in the state. Readers should be advised that the analysis was limited to institutions participating in Cal-PASS.[2]

The RP Group's study includes:

- Analysis of the transfer path taken by more than 4,200 students who ultimately completed a bachelor's degree in engineering
- Surveys and focus groups with over 225 post-transfer students currently enrolled in engineering degree programs
- Survey of 245 pre-transfer students in introductory engineering courses at 14 colleges across the state and ongoing interviews with 15 students at one Bay Area college intent on transferring in engineering

This research included students who completed at least 12 transferable units at a California community college prior to enrolling at a university and who had at least two years of university course data available prior to degree completion. The cohort does not include students who only used the community college system during or after completion of their baccalaureate program. We performed analyses of completers' demographics, time and units to transfer and degree, pre-transfer coursework including their first English and math class, number of community colleges attended, use of support services like financial aid and the impact of these and other factors on time to transfer and degree.

Documenting the experience of students post-transfer *(post-transfer student surveys and focus groups)*. To expand on and complement these quantitative findings, the RP Group used two different methods to gather the perspectives of recent transfer students. We targeted students now pursuing their baccalaureate degree in engineering at one UC and one CSU; these universities were selected because they were among the largest recipients of engineering transfer students found in the Cal-PASS and California Postsecondary Education Commission (CPEC) databases. Approximately 178 students completed surveys. In addition, we performed follow-up focus groups to dig deeper into survey findings at the two universities and one additional private non-profit institution; 48 transfer students took part. Both the surveys and focus groups collectively centered on how participants used community colleges to prepare for transfer; the factors that impacted their transfer experience; and their advice to peers, community colleges and four-year institutions about how to strengthen the preparation and transition of future engineering transfer students.

The qualitative findings should not be used on their own to draw conclusions or make generalizations about engineering transfer paths beyond the students interviewed. Rather, the perspectives harvested through these activities highlight themes, illustrate complex experiences and augment the quantitative evidence.

How do students experience the engineering transfer pathway?

The following section presents key findings related to the six research questions (*see p. 2*). Where possible, we respond to the questions by presenting findings from all three research components (quantitative data analysis, pre- and post-transfer student surveys, interviews and focus groups). However, some questions are only informed by findings from one or two research activities.

Question 1: Who are the transfer students?

Quantitative data analysis on the demographics of transfer students who achieved a baccalaureate degree in engineering found the largest percentage of completers were male (83%), Asian (40%) and white (31%). Post-transfer student survey findings reflected these demographics and also showed that 80% of respondents were less than 29 years of age with most between 20 and 24 years old.

Question 2: How do students get on the engineering transfer path?

Surveys and focus groups with both pre- and post-transfer students revealed that many learners were motivated to begin the journey to transfer and degree by personal curiosity in engineering including a "a love of tinkering with household appliances" or an "interest in how machines work." Of pre-transfer survey respondents, 83% indicated they were driven toward this educational pursuit by a personal interest in the subject. Other top motivations cited by respondents included job/career advancement and the expectations of family and friends.

When asked about their goals, both pre- and post-transfer students appeared intentional in their use of the community college system to work toward a baccalaureate. For example, 70% of pre-transfer students indicated in their survey responses that they were "absolutely certain" they wanted to become an engineer and 89% reported they plan to transfer and earn an engineering degree.

> I knew I wanted to transfer when I started at [a community college]. It allowed me to complete a degree cheaper than starting at a four-year [university] and test the water to see if I could handle it.
>
> *– UC Transfer Student*

Question 3:
How do students use community colleges to prepare for transfer in engineering?

Quantitative data analysis on the educational paths taken by transfer students who ultimately completed an engineering baccalaureate revealed that these learners achieved the greatest number of units in science, technology, engineering and math (STEM) prior to transfer. Students earning more transferable units had a greater proportion of their units in STEM. Of note, a majority of these STEM units occurred in math with only 9% of units in engineering related courses. Further, just 5% of students' units were completed in transfer-level engineering courses. Remarkably, this percentage did not increase for students completing more units prior to transfer.

As part of this analysis, the STP3 research team also examined the level of students' first English and math enrollment by transfer students who later achieved their bachelor's in engineering. Many started below transfer level, including 33% in English and 23% in math. This analysis aligned well with post-transfer student survey results where one third of respondents reported starting in developmental English and/or math. These findings on students' placement are particularly relevant given that engineering degree seekers must pass calculus-level work not only to transfer in this discipline but also to access other lower-division major courses. It could conceivably take a student who places in below transfer level math several years to reach the entry point for the engineering pipeline. At the same time, 89% of these students also completed calculus or higher prior to transfer, indicating that it is in fact possible for students who start with a pre-collegiate math placement to make it through to transfer and a degree.

Of all five disciplines studied through this research, engineering baccalaureate completers were least likely to achieve an associate's degree before transferring. Quantitative analysis showed that nearly three quarters of those who transferred and completed a bachelor's in engineering did not complete any associate's degree pre-transfer. Of the 21% of students in the study group who did complete an associate's degree, only 5% were in a major related to engineering. Post-transfer students participating in focus groups indicated that an associate's degree did not appear to hold value for this pathway. A few respondents who did complete this credential said they did so almost "by accident" as a result of completing the numerous units needed to transfer rather than as an intentional goal.

Not surprising, the road to transfer can be long for many engineering students despite the sense of direction and focus with which many appear to approach this goal. The quantitative analysis showed that 46% of these students took two to four years to transfer while 38% took four or more years. Reflective of the requirements for this major, approximately 45% of engineering transfer students finished 70 units or more while 24% completed 86 plus units prior to transfer.

Question 4:
What challenges do engineering students encounter along the way?

Surveys and focus group results revealed that multiple issues impact students' preparation for and time to transfer. In their survey responses, both pre-transfer and post-transfer students ranked financial factors as the most difficult obstacles to their goal of pursuing a degree, including the cost of attending a four-year university, lack of financial aid and balancing work, school and

family responsibilities. At the same time, the quantitative data analysis revealed that engineering transfers who completed baccalaureate degrees were least likely to utilize financial aid among the five disciplines studied. Just over 10% received financial aid services while enrolled at a community college.

> Engineering requirements are different. Not all majors are the same. But it wasn't until I got directed to an engineering counselor that I realized I didn't need to take all of the courses I was enrolled in…by that time, I'd taken an extra year of courses I didn't need.
>
> *– CSU Transfer Student*

Students participating in surveys, interviews and focus groups also indicated that efficiently completing prerequisite and lower-division coursework at a community college can be challenging. With cuts to courses and sections due to the budget crisis and excess demand for those classes that remain, students reported problems accessing required coursework. The high number of units and the type of preparation required for transfer in this discipline make this issue particularly acute. As mentioned, students must complete calculus not only to transfer in this discipline but also to meet requirements for enrolling in other prerequisite courses; in turn, a delay in completing calculus can elongate a student's road to transfer significantly. These participants commented on the limited engineering course offerings available at their colleges as problematic to their preparation. A related finding from our quantitative analysis showed that less than half of degree achievers completed their community college coursework at one institution; 29% attended two colleges, 14% attended three and 9% attended four or more.

Pre- and post-transfer students noted that they struggled to fulfill transfer requirements that differ among baccalaureate institutions. To illustrate, a community college counselor participating on the research team reviewed the transfer requirements in mechanical engineering for a sample of CSUs and UCs. One comparison of a UC and a CSU showed significant variation in requirements. While both institutions called for 13 units of math prerequisites, the CSU required 47 units of major preparation while the UC asked for 63 units.

This investigation also indicated that financial concerns can delay students' transfer progress and factor into their decision-making. An analysis of enrollments indicated that students who transfer with fewer units spend more time at a baccalaureate-level institution completing their engineering degree. At the same time, students who transfer with many units (86 or more) are just as likely as those who transfer with fewer units to take two to three years to complete their baccalaureate and almost as likely to take three to four years to do so.

One explanation for this finding relates to students' course selection as many post-transfer survey and focus group participants stated that they took courses that did not transfer or articulate to their major while enrolled in a community college. Both pre- and post-transfer focus group participants reported mistakenly following the Intersegmental General Education Transfer Curriculum (IGETC), thinking it was required for transfer in engineering (which it is not). Taking this path resulted in unnecessary delays in their time to transfer. Post-transfer student surveys also showed that 40% of students who transferred to the UC and 50% who transitioned to the CSU had to take three or more lower-division major preparation courses once at the university—clearly delaying their time to degree completion. Similarly, interviews with representatives from a UC engineering program revealed that despite

receiving an average of over 1,000 applications each year, the department is unable to fill the 150 slots it annually reserves for community college transfers because applicants do not completed the appropriate coursework.

Question 5: What supports engineering students towards transfer and degree?

Pre- and post-transfer survey and focus group participants emphasized that an education plan was key to ensuring their efficient and effective use of the community college system for transfer preparation. The survey of pre-transfer engineering students revealed that 88% developed an education plan mapping out the specific courses required each semester to transfer and a significant majority (82%) used ASSIST.org to develop their plan. Of those with a plan, 60% indicated their plan was "very effective" in helping them identify all the courses required for transfer to the institutions they were interested in attending.

Post-transfer survey and focus group participants also underscored that meeting regularly with a counselor helped them to establish and update comprehensive plans that directed them to fulfill as many required courses as possible prior to transfer. In the case of one university involved in the research, students indicated that a dedicated counselor assigned specifically to support community college students in their transfer planning and transition to the university significantly facilitated their process.

> Everyone who wants to transfer to [this UC] knows [this counselor]. She sits down with you, she tells you about the system, what your GPA needs to be…she starts as a guide.
>
> *– UC Transfer Student*

Post-transfer students suggested taking advantage of articulation agreements and transfer admission guarantees with receiving institutions to ensure that credits accumulated at the community college level counted toward degree completion. Respondents from the participating UC had taken particular advantage of that university's transfer agreement.

Pre- and post-transfer survey and focus group participants additionally noted that special supports can help learners stay on track toward their transfer goal. Most (80%) pre-transfer students indicated in surveys that they tapped math labs and tutors at their school for assistance, often using the physical space as a place to convene with peers, study and get help with homework. Over 45% of pre-transfer survey respondents reported engaging with the Math, Engineering, Science Achievement (MESA) program which is designed to improve the success of educationally disadvantaged students in these disciplines. MESA participants spoke positively in focus groups about the targeted advising, tutoring and peer mentoring as well as the personal strong encouragement they received through this initiative.

> One semester, I didn't have money to continue and I went to the MESA program and the director convinced me to stay motivated. I wanted to make money and work full-time instead of going to school…after that, I was too embarrassed to quit. I had to stay with it.
>
> *– UC Transfer Student*

This research showed that introductory courses offering a survey of engineering careers as well as information about transfer planning and degree requirements helped students effectively navigate the path to transfer. Over 70% of pre-transfer students indicated that these courses increased their understanding of the different kinds of career opportunities available to them in engineering and 65% said these courses increased their knowledge of the type of engineering program they would like to pursue. Further, when comparing findings across disciplines included in the STP3 study, community college engineering faculty played a uniquely important role in supporting students toward their transfer goal. Accordingly, focus group participants indicated that faculty guidance on major-specific educational planning and transfer destination selection was critically important to their transfer success.

Question 6: What happens to students post-transfer?

Mapping transfer students' educational paths also generated useful findings about their post-transfer experience. When compared to other disciplines studied, engineering and nursing students took the most time to achieve their degree after transferring with a median of 2.7 years. Engineering students who transferred fewer units from the community college spent more time at the university completing their degrees; however, the reverse was not true in that students transferring 70 units or more were no more likely than those transferring with fewer units to complete their degrees in less than two years. Overall, engineering students took 6.5 years from their first postsecondary enrollment to earn their bachelor's degree and, on average, time to degree increased as the number of units earned increased. More than a quarter of students took a total of eight or more years to complete their engineering baccalaureate.

One factor that may contribute to increases in the time between degree and transfer is the need for students to take additional lower-division major

Pipeline Improvements: Accelerating and Diversifying the Engineering Transfer Path

The RP Group conducted additional research on three colleges that have designed programs to increase the diversity of STEM students and to accelerate their path through the lower levels of math to calculus. Many students, especially African American and Latino learners, enter the community college system with math skills well below college level. In turn, even those who demonstrate an interest in and aptitude for math can literally have years of remedial work to complete before they reach calculus—the real gateway to the engineering transfer path.

Featured initiatives include:

- Cabrillo College – Science, Technology and Energy: Expanding Potential (STEEP)
- Cañada College – Student On-ramp Leading to Engineering and Sciences (SOLES)
- East Los Angeles College – Engineering Transfer Pathway Program (ETP)

These programs particularly focus on serving students who have traditionally been underrepresented in the science, technology, engineering and math (STEM) disciplines. They employ two main strategies for addressing the transfer problem: (1) math acceleration and preparation programs for community college learners and (2) outreach programs targeting high school and community college students.

Each initiative promotes different approaches to math acceleration, college success and student engagement. At the same time, these colleges all benefit from strong MESA programs that provide participants with extra resources and support.

For more information, visit: http://www.rpgroup.org/resources/engineering-effective-practices

coursework at the university level. Survey findings revealed that on average, UC students took two lower-division courses in their major post-transfer, but 25% reported having to take four or more. The distribution of responses to this question for the CSU engineering students appeared similar to the UC students, except that 34% of the CSU students had to complete more than four courses. Another issue may relate to the academic intensity students encounter after transferring. A majority of post-transfer survey respondents indicated they felt "equally" or "better" prepared when compared to their peers who started at the university. Yet, some focus group participants reported feeling challenged by the increased pace and rigor of their university courses, despite feeling positively about their community college preparation.

How can we make this research work for you and for students?

The RP Group's research on engineering is intended to support the work of educators and employer partners interested in increasing students' ability to transfer and successful complete a bachelor's degree. To this end, the following section offers two sets of discussion questions to promote dialog among engineering stakeholders. One set focuses on how the research reflects your own experience and the other explores how the RP Group's findings can promote action that will help increase the effectiveness of transfer for the benefit of students and our state's ability to innovate, produce and compete.

How does this research reflect your own experience?

The following questions are designed to help engineering educators facilitate discussions on your campuses and across institutions and segments about your own experience promoting transfer.

Discussion Questions:

- How do the findings presented in this document align with your experience supporting students in choosing this major, preparing for and successfully transitioning to baccalaureate-level programs and ultimately completing their bachelor's degree?
- What findings are particularly useful? How might you use them?
- What issues seem unresolved? What additional research would be of value to your work?

How can we use this research to improve the engineering pathway?

This research suggests several possible opportunities for enhancing the efficiency and effectiveness of the engineering transfer pathway, many of them coming from the "experts"—successful transfer students themselves. Educators at two- and four-year institutions and employers might consider ways to work independently and together to explore these ideas for improvement.

Discussion Questions:

Increasing Access

- How can colleges effectively collaborate with the K-12 system to increase students' awareness of and preparedness to enter an engineering pathway and to increase the diversity of students entering the community college system interested in engineering and other STEM disciplines?
- What can the community colleges do to accelerate students' progress and persistence along the path to (pre) calculus? What can the community colleges do to increase the diversity of successful engineering and other STEM students?
- What other effective practices exist to raise students' awareness of engineering careers, the education necessary for this field and the opportunity to begin their pursuit of a degree in a community college?

Improving Success

- In an environment where budget cuts increase the ratio of students to counselors, how can we ensure that students pursuing transfer in engineering receive effective guidance in developing education plans?
- How can colleges work with industry partners to sponsor and scale programs like MESA that support students' movement through the transfer pipeline?
- How might student supports and guidance be built into introductory engineering coursework?

Enhancing Pipeline Efficiency

- What can educators do to encourage students to complete more lower-division major coursework—particularly in engineering—while enrolled at a community college?
- How can community colleges increase students' access to the courses necessary for transfer?

- How can educators and employers collaborate to mitigate students' financial concerns? What can industry do to offer paid opportunities for students that relate to students' studies and help toward transfer and a degree?
- What can four-year educators do to ensure community college transfer students and counselors are aware of their transfer requirements?

For more information…

Additional engineering transfer research produced by the *Student Transfer in Professional Pathway Project* includes:

- *Pipeline Improvements: Diversifying and Accelerating the Engineering Transfer Path*
- *Engineering Transfers Speak: Real Students, Real Stories*

For more information on the *Student Transfer in Professional Pathways Project*, visit http://www.rpgroup.org/stp3.html or contact Eva Schiorring, Project Director, eschiorring@rpgroup.org.

Notes

[1] Office of the Governor of California. (December 26, 2007). *Governor Schwarzenegger Announces 2008 Proposal to Bring 20,000 New Engineers to California's Workforce.* Press Release. Retrieved on June 29, 2009.

[2] Cal-PASS is a voluntary statewide data sharing system to track students transitioning among institutions and segments such as high school to college and community college to university.