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Retention and Persistence among STEM Students: A Comparison of Direct Admit and Transfer Students across Engineering and Science

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Abstract
Improving student retention in particular science, technology, engineering and mathematics majors has focused on identifying strategies, and practices that will encourage students to complete a degree in STEM major. In this paper, we present findings from a study of retention and migration among STEM students, comparing rates across both engineering and science students. We look at all students admitted between 2009-2014, both direct admits and transfer, at a large public university. Transfer students are often neglected in studies of retention and persistence especially in engineering. We found that engineering students are more persistent than science students with retention rates over 60% for engineering students compared to 40% in math. Persistence rates for first-time students are less than transfer students in the engineering enrollments. Also, as in previous studies, most migration out of discipline occurs in the first two years of enrollment. We also found that among enrolled students, a large number of engineering students (almost 20%) have not declared a major some until later in their studies.

1. Introduction

Science, Technology, Engineering, and Mathematics (STEM) professionals are needed more than ever; based on economic projections the nation may suffer from a workforce deficit in these majors if college graduation rates remain the same (Olson & Riordan, 2012). Higher education, at the same time, and STEM fields, in particular, are aware of this issue and continue to identify ways to increase the number of STEM degrees graduates. According to a NCES report, "A total of 48 percent of bachelor's degree students and 69 percent of associate's degree students who entered STEM fields between 2003 and 2009 had left these fields by spring 2009. Roughly one-half of these leavers switched their major to a non-STEM field, and the rest of them left STEM fields by exiting college before earning a degree or certificate." Starting with providing exposure to underrepresented students to STEM students in K-12, the efforts to increase STEM graduation rates include more advising and tutoring support in college, hands-on learning environments, etc.

Complicating and contributing to the lack of STEM graduates is a low retention rate. The President's Council of Advisors on Science and Technology report (2012) note that fewer than 40% of students matriculated in STEM actually receive their degree in STEM. The high exit rate has led to many researchers to examine and analyze the matriculation and retention of STEM majors at colleges across the nation and take actions to increase the retention rate and thus the production of STEM professionals (Hayes et al., 2009).

These programs often conclude that the most expedient and direct path to providing professionals in STEM fields is to increase the retention rate in STEM majors (Olson & Riordan, 2012). Importantly, retention rates, availability of STEM programs, and student demographics vary across institutions of higher education making it essential to focus not just on national numbers but individuals' institutions to derive those contextual differences that may drive STEM student success.

In this paper, we analyze the date from a large public university to examine the retention rate in engineering and science colleges. We also conducted an analysis of when students switched or dropped out of the major. Providing current information will help administrators and faculty develop strategies and programs that can increase retention rates. It is important to note that retention rate in this paper is the percentage rate of students who remain in the major they enrolled in the previous year.

2. Background and Definitions

Persistence, in a broader scope, has been an issue in higher education for many years, and if has not resolved over the next decade, a national workforce deficit may occur (Olson & Riordan, 2012). Persistence is particularly important in the STEM fields, where individuals with specific skills and knowledge are needed to fill the largest growing workforce sectors, often in technology related areas. One promising intervention is built on the assumption of a pipeline where there are not enough interested and qualified K-12 students who are eligible to enter STEM major in college thus reducing the availability of these graduates. A few interventions, such as the "Hour of Code", have been developed over the last few decades to address the pipeline issues to make STEM majors appealing to students. This has been inferred from (Hurtado et al., 2010): the number of students enrolling in STEM majors has increased; however, the number of graduates within five years declined, which correspondingly suggests that some work need to be done in post-secondary education to retain students who show an interest in STEM by enrolling in the program at the first place (Watkins, Mazur, 2013).

Retention rate is typically measured on a year-to-year basis. Those students who re-enrolled in the same institution the previous year are considered retained (Arnold, 1999). However, in this report, we use the retention rate in a narrower scope to refer to the percentage of students who re-enroll in the same major they enrolled in the previous year. It has been known the retention rate is perceived as an indicator to the program quality and student success (Arnold, 1999). Some other terminology that will be used in the paper and as defined in (Arnold, 1999): persistence rate which generally means the percentage of students who continue studying until they graduate, and attrition rate is the percentage of school's loss of students. Persistence rate is used in this paper to refer to the percentage of students who remain enrolled in the same major they matriculated in up to the semester under study.

3. Related Work

There are many studies that report the large percentage of student loss from STEM majors. Although more than half of engineering students either switch or dropout (Wilson et al., 2012, Hurtado et al., 2010, Oslon & Riordan, 2012), it is also demonstrated that a certain amount of switching is expected from students in all majors (Ohland et al., 2008). In (Ohland et al., 2008) study, they compared engineering with other majors in terms of persistence, engagement, and migration. They found that engineering has the highest persistence rate compared to other majors and the lowest inward migration rate. Students generally remain within engineering colleges once they are admitted and rarely switch to different engineering majors. In terms of engagement, they found that engineering students are as engaged in their majors as their peers are in their majors. This study, however, excluded transfer students from the study, which we consider in the paper.

Other researches focused on identifying the factors the impact STEM students' attrition at the undergraduate level. The poor quality of teaching and the lack of student-faculty interaction are among the major factors that affect students to leave the program (Watkins & Mazur, 2013, Seymour et al., 1997). In (Marra et al., 2012), an exploratory analysis conducted to determine the factors that influence students to leave engineering. The results show that there are both academic factors such as poor teaching and advising, and non-academic factors such as lack of belonging. They also found some differences between the majority group and underrepresented groups. In (Chang et al., 2014), they studied the retention for underrepresented minority groups. They found the minority races are less likely to persist in STEM; however, institutions can improve their persistence rate by increase the likelihood that these students will engage in academic experiences.

Studies show that most of the major switching and dropouts from STEM majors occur in the first or second year of college (Seymour et al., 1997). Thus a large amount of researches such as in (King, 2005) focus on enhancing the first year persistence rate. It is widely believed that if students are able to make it through the first year, their likelihood to persist will improve significantly. Recent research though shows that the middle years can also be equally critical, especially for engineering students. These studies propose polices that can help increase the retention rate such as improve the campus environment, and provide academic advising. For transfer students, their first and second years are completed at a community college or other four-year university thus complicating these data and identifying a gap in the literature. Moreover, students' involvement in research shows a strong correlation to students' retention in STEM (Lopatto, 2004).

This study provides a primary analysis conducted using undergraduate student enrollment data. We report the persistence rate per major, identify the point in time when the most migration out of college occurs, and to which major. Similarly, we also present the point in time and identify the major of students migrate within the college. In addition, we also identify the major with most students migrating in.

The report is organized as the following: first we describe the data and give an overview of the persistence rate in the science and engineering schools. Then, we analyze the engineering school and college of science separately. After that, we looked at the persistent rate for the transferred students who enrolled in engineering.

4. Data

The data used for the analysis comes from a large public university during the timeframe of Fall 2009-2014. We utilized the data of students who started in Fall 2009 and Spring 2010 to project the retention rate in every major at each semester for 8 semesters. The data includes 328 students matriculated in Engineering and 299 students matriculated in Science for that year. In addition, we analyzed the transfer data for students accepted in engineering school, which is composed of 573 students. We had IRB approval to acquire and analyze the data for research purposes.

5. Analysis

A. Persistence in Science and Engineering

The number of students who persist to the eighth semester in their majors is 229 in engineering and 131 students in science. The difference is obvious in the persistence rate between the Engineering and Science schools; it is approximately 70% in engineering and 44% in science.

B. Engineering Students

In this section we take a closer look into the persistence and migration in the engineering school. Although the school has several new departments, in this analysis we focused on the departments that have at least 5 students. By this constraint, we concentrate on 7 majors. The analysis reveals several findings:

a. The persistence rate for all majors is over 60%. Information Technology (INFT) is the highest with approximately 85%. Computer Science (CS), Systems Engineering (SYST), and, interestingly, students with undefined major (UNDE) follow with around a rate of 70%. On the other end on the spectrum, Civil Engineering (CEIE) and Electrical Engineering (ELEN) appear with the lowest rate 62%. The table below shows the persistence rate for each major, and the figure shows the decline in the persistence rate over eight semesters.

Table 1: persistence rate for engineering majors

Major	Persistence Rate
ACS	66.67%
CEIE	62.22%
CPE	70.00%
CS	72.22%
ELEN	62.50%
INFT	84.62%
SYST	71.43%
UNDE	71.19%

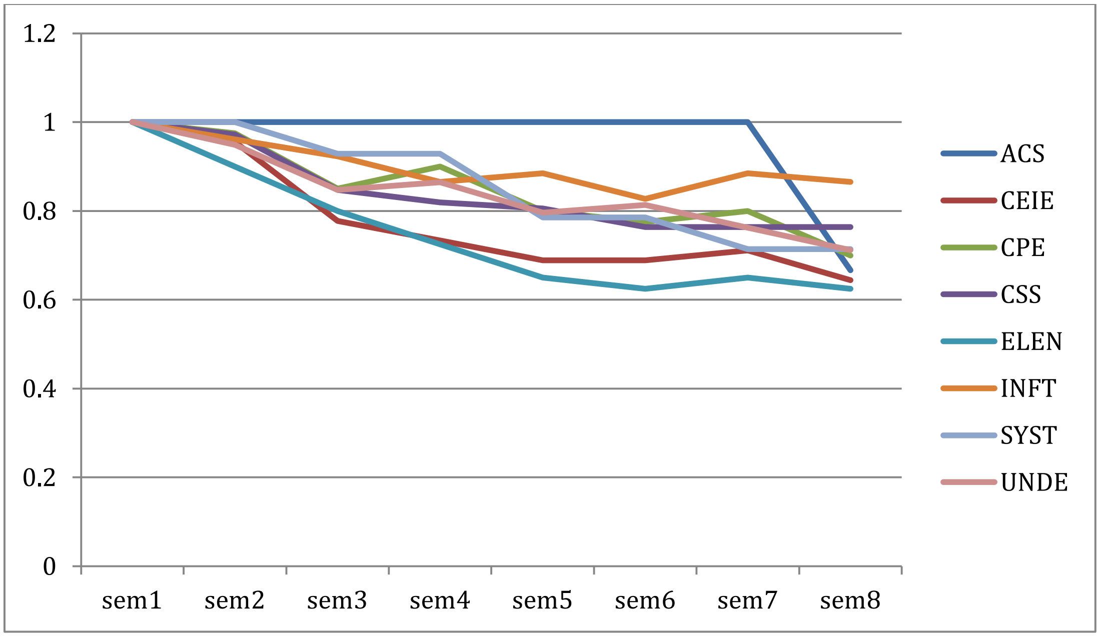

Figure 1: persistence rate for main majors in engineering over eight semesters

b. Although migration to other majors can take place at any semester, the greater part of migration typically occurs in the first or second year, which confirm to other studies that has been reviewed. Interestingly, changing major within the school appears more frequent. Furthermore, it is common to witness students migrating within the school in the later years of their studies. Figure 2, shows the distribution of migration over the semesters for both migrations outside the school and within the school.

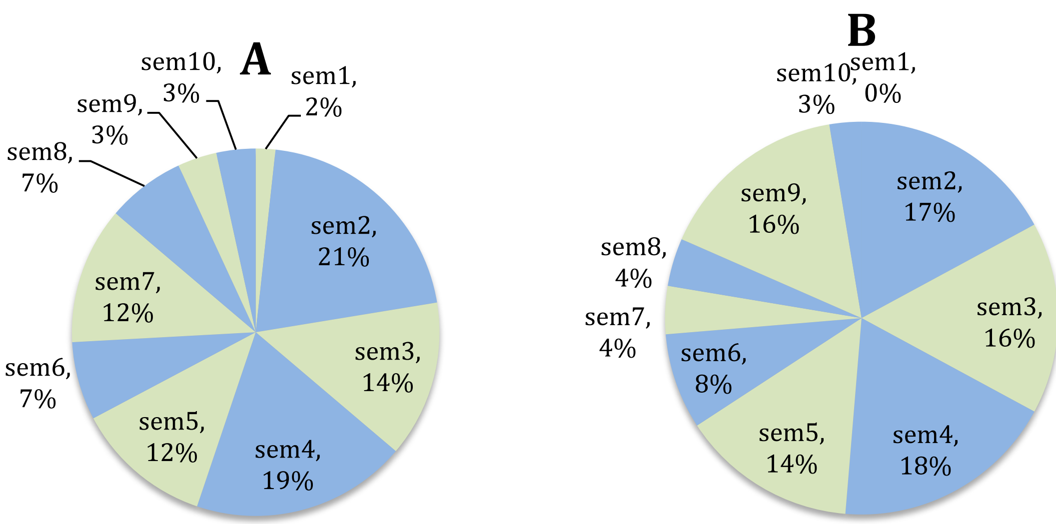

Figure 2: It shows the distribution of migration by semester. (A) Migration outside the engineering. (B) Migration within the engineering school.

c. The majority of students transferring within the engineering school are transferring to Information Technology. The second largest group of students transferring to UNDE, followed by CEIE, AIT, ELEN and CS.

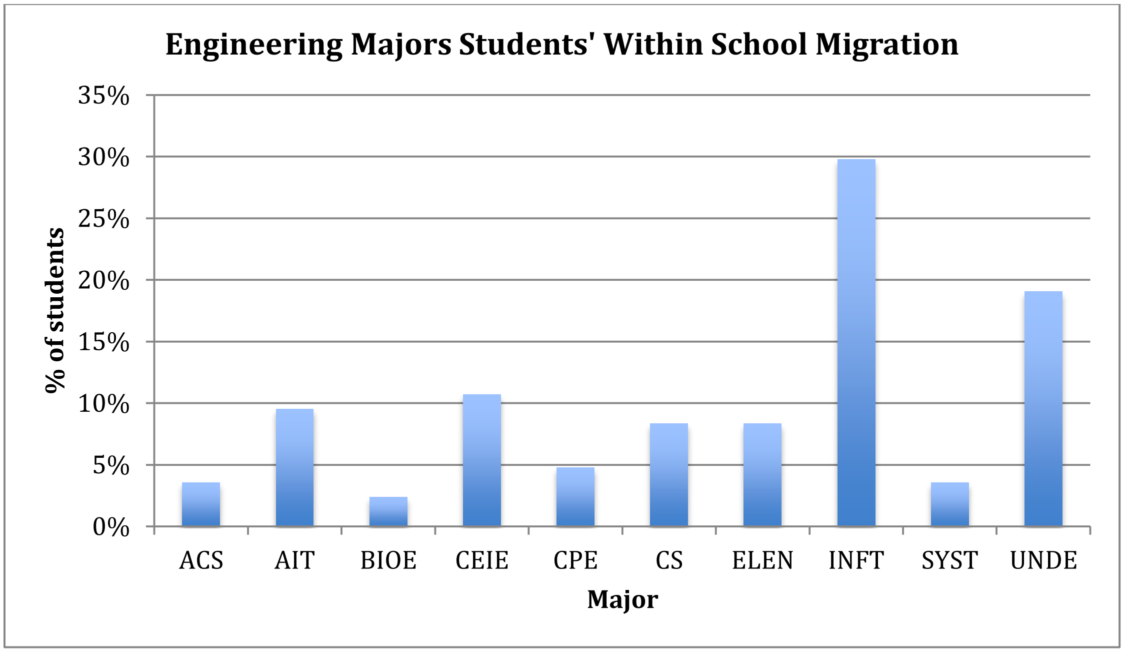

Figure 3: the percentage of students migrating to another engineering major within the school. It shows how the departments are doing in attracting students within the same school.

C. Science Students

We applied the same analysis on student data from the College of Science (CoS). Since the college has 13 majors, we focused on the majors that have at least 5 first-time students enrolled. The findings can be summarized as the following:

a) Biology (BIOL) has the largest enrollment number with approximately 42% persistence rate. Figure 5 demonstrates the persistence rate per semester. For example, in the eighth semester, we can see that Chemistry (CHEM) has the highest persistence rate (61%) and Global and Environmental Change (GLEC) has the lowest (10%). Figure 5 illustrates the persistence rate for all science majors.

b) All students enrolled in science have declared a major. The number of UNDE students is zero. Every student in the college has to be enrolled in a major.

c) Out of the science majors, CHEM and BIOL are the highest in accepting transfer students from within the college. In fact, a high number of BIOL students, who change their major within the college, major in CHEM, and vice versa.

The methodology used to compute the persistence rate is that for each major in each semester, the number of students who are enrolled in that major at that semester are counted and divided by the total number of students in that major at the first semester. As a result, we can see that the persistence rate at the first semester is 100% no one has moved out of his/her major yet. In the following semesters we monitor a decline in the persistence rate with the lowest in the last presented semester. Only PHYS exhibit an increase at the fourth semester, which means some students have migrated to it.

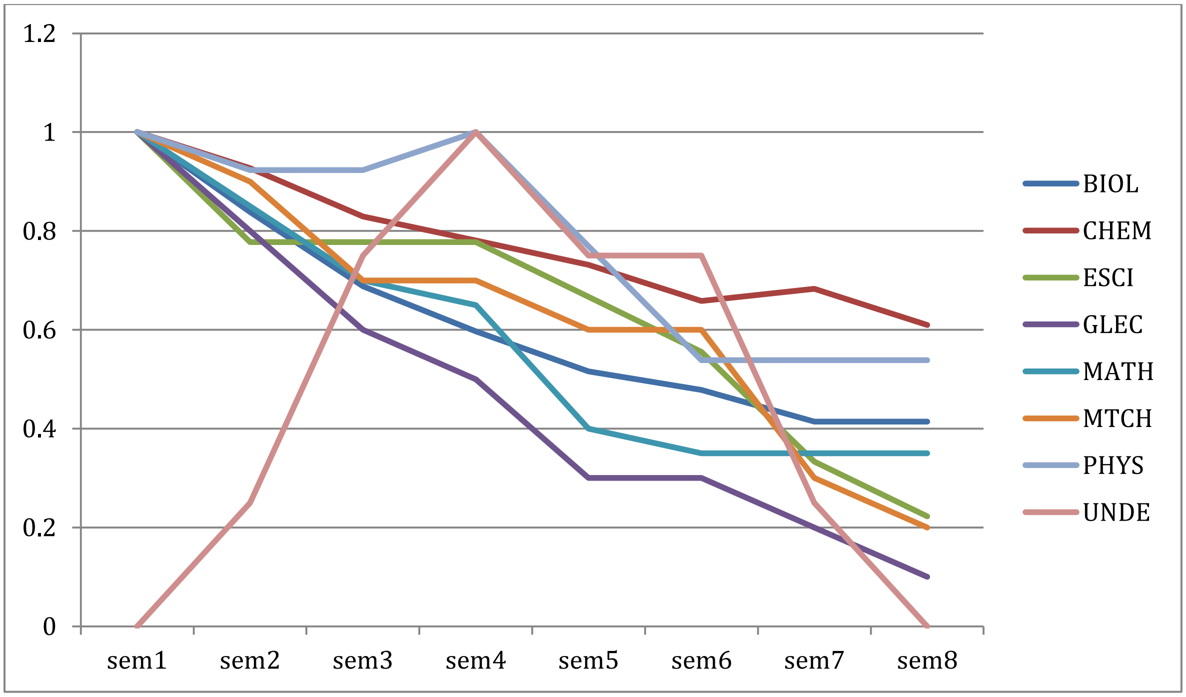

Figure 4: persistence rate for science majors over eight semesters

D. Transfer Students

This section provides a descriptive analysis of transfer students who transferred from another institution to the engineering school. Engineering receives a lot of transfer students at this university and given the paucity of research on transfer students within the engineering education literature, we focus on this student population here.

The total number of students that have been transferred to Engineering is 573. Among all majors in Engineering, Information Technology (INFT) has the highest transfer enrollment rate in the school. Almost 50% of the transferring students choose INFT as their major. Computer Science (CS) and Civil Engineering (CEIE) followed INFT in their enrollment rate with 14% and 11% respectively.

We have computed the persistent rate for all Engineering majors in the transferred data. The results demonstrate a high persistence rate for all majors; it is over 80% in general. Some majors such as CPE, ACS and Electrical Engineering ELEN have no migration recorded. Figure 5 illustrates the persistent rate for majors where there is some migration to other majors either in the same engineering school or outside.

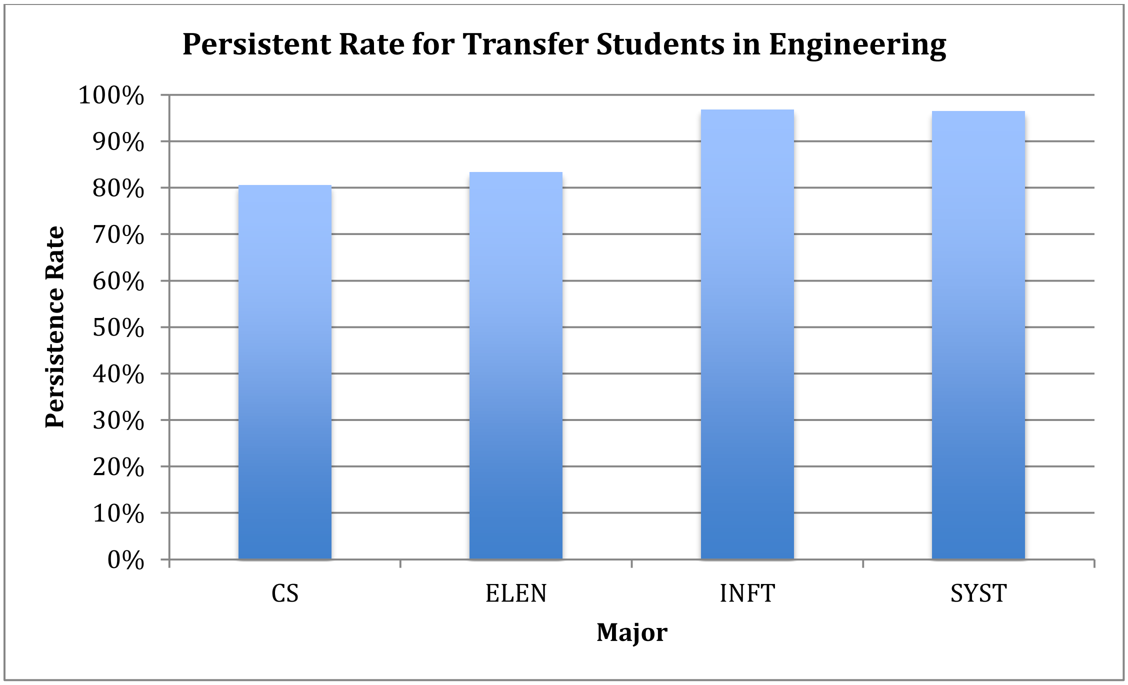

Figure 5: Persistence rate for engineering majors for transferred students

6. Discussion

Engineering majors have a better retention rate compared to science majors; yet, in both schools there is still a room for improvement. A potential future work is to investigate and evaluate the practices and strategies used by the majors. In addition interest researchers can dig deeper to include the demographic difference in the analysis.

More than 50% of major switching in engineering school occurs in the first two years, which confirm to general findings (Ohland et al. 2008). A noticeable percentage of switching majors within the same school happens in the 9^{th} semester, which suggests that either the undeclared students chose a major or the students already have the engineering required courses and can easily switch to another major in the school. A lot of students do not have the requisite GPA to declare a major and stay in the undeclared status until they have taken enough classes to receive a high enough GPA.

As expected, transfer students are more persistent than first-time students; however, it is important to note that their previous transfer history is not visible. One piece of information was missed in the data, the transferred-credits of the transfer students, could help us better compare direct admitted and transfer students at the same curricula point. Future research could compare the two groups at the same curricula point and use the result of the persistence to evaluate the academic preparation adequacy.

The engineering school, unlike the college of science, does not require declaring a major when students are first admitted to the school. Thus, the number of undeclared major students remains high up-to the fourth year. Undeclared students on the other hand typically do not satisfy their intended major requirement, so they attempt to improve their academic performance throughout the years to fulfill the major requirements.

Our study has some limitations as it is looking at only one institution and at a limited dataset. Future work can expand on this to include more institutions, provided they have similar numbers of transfer students. Our analytical techniques are also limited and in future work we plan to include more data mining techniques to better understand if migration and retention patterns can be predicted and if so, what students experiences and outcomes they can be related to (e.g. their grades) (Almatrafi et al., 2016; Sweeney et al. 2016).

7. Conclusion

In this paper, we analyzed the retention and migration rates in engineering and science schools in a large university, which is an essential step to improve students' retention, and we compare the persistence rate for direct and transfer students. We found that engineering school majors have higher persistence rates compared to the college of science. Additionally, more than half of migrations occur in the first two years. Due to the flexible major declaration policy in the engineering school, there is a large number of students enrolled in engineering but do not declare a major; and some remain until late stages of their studies. In contrast, in college of science, all of the enrolled students have declared a major and by the eighth semester no one has undeclared major. As expected, retention rate for first-time students is less than transferred students in the engineering enrollments. This up-to-date information is of help for educational leaders to investigate the practices used in majors, which lead to high retention rate and high inward migration.

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