

## **Analysis of barriers to graduation for transfer students in Aerospace Engineering**

### **Dr. Radha Aravamudhan, San Jose State University**

Radha Aravamudhan's research interests include Culturally Responsive Pedagogy, Community cultural wealth and their application to curriculum specifically with respect to undergraduate engineering education as well as creative Arts-Based Research and Documentary film making. She supports faculty research in the area of undergraduate STEAM teaching and learning with a focus on increasing retention and graduation rates of under-represented student populations in engineering.

### **Dr. Maria Chierichetti, San Jose State University**

Maria Chierichetti joined the department of Aerospace Engineering as a full-time assistant professor in Fall 2019. Her interests lie in the field of aerospace structural design and vibrations, with particular emphasis on developing methodologies for combining finite element analysis and machine/deep learning for structural health monitoring and unmanned Structural inspections in the context of urban air mobility. Maria is also interested in investigating how students learning is affected by external factors, such as COVID-19 pandemic and community service. Before joining SJSU, she worked as a faculty member at Worcester Polytechnic Institute and at the University of Cincinnati. She earned her PhD at Georgia Tech in 2012 working on the monitoring and tracking of helicopter blade deformation. She earned a BS and MS from Politecnico di Milano (Italy) in 2004 and 2007 respectively, with majors in Aeronautical Engineering. She is an Amelia Earhart Fellow – Zonta International Foundation.

# **Analysis of barriers to graduation for transfer students in Aerospace Engineering**

## **Abstract**

The proposed study focuses on identifying the causes and implications of extended time to graduate for many transfer students in Aerospace Engineering at San Jose State University. Community colleges where many students begin their higher education are a critical part of the engineering supply pipeline to four-year universities such as San Jose State University. In Fall 2021, approximately 35% of the students admitted to the College of Engineering and 21% in the Aerospace Engineering department were transfer students. Analysis of data for the 2015 cohort of transfer students shows that the 2-year graduation rate for transfer students in Aerospace Engineering is 20% and gradually climbs to 63% for 3 years and 83% for four years. Graduation rates of underrepresented minorities (URM) for the same cohort of transfer students is 15% in comparison to the non-URM students at 23%; in addition, 91% of the non-URM students in Aerospace Engineering graduate in 5 years in comparison to only 77% of the URM students. While there are many factors that can contribute to the time to degree, a preliminary analysis of the data suggests that it is impacted by the number of courses that students transfer from their community colleges. For the Fall 2015 cohort, students who graduated within 2 years or 2 years and an extra term had 2.6- 6 lower division courses while a junior or senior at San Jose State University. For cohorts in 2016 and 2017 the lower division courses taken ranged from 2.3-4.3. The courses in the junior year of the Aerospace Engineering program require the completion of math, science and engineering core courses and the lack of these prerequisites sets back many of the transfer students from graduating in 2-3 years. The most recent data from Fall 2021 Aerospace Engineering transfer students' data reveals that though transfer students (from approximately 25 different community colleges) admitted to the program are typically expected to have earned enough units to reach junior standing, only 10% of the students have completed the Math and science requirements and 3% have all the required engineering core courses even though many of the community colleges offer these courses. In order to support the transfer students and URM students in particular, it is important to understand the underlying causes for challenges that students face in their transfer pathway. In this study, the researchers will use surveys, interviews and student transcripts to understand the academic experience of transfer students, identify their points of struggle and examine advising and other support structures for transfer students.

## **Introduction and Background**

The increase of the STEM workforce is an area of national importance, due to shortages in the current and future workforce. STEM pathways between 2-year and 4-year institutions are a key element in achieving a larger and more diverse engineering workforce. Community colleges where many students begin their higher education are a critical part of the engineering supply pipeline to four-year universities, such as San Jose State University (SJSU).

Students attending more than one institution on their route to their bachelor's degree are defined as transfer students, and represent a growing student population in the United States [1]. Transfer students are generally considered to be more motivated to study engineering than first year students, but they usually face many academic, social, and/or psychological challenges during the transfer process [2]. As a result, many transfer students obtain a lower GPA in their first year

after the transfer process is complete. This phenomenon is often referred to as “transfer shock”. As a result, transfer students generally have lower graduation rates with respect to their peers. A study of existing literature reveals that the most common barriers to degree attainment of transfer students are:

- (1) financial reasons [3], including the cost of attending a four-year university, lack of financial aid and balancing work, school and family responsibilities [4];
- (2) the ability to transfer credits toward major coursework and the efficient completion of required transfer classes [3], [4];
- (3) insufficient advising of possible STEM pathways to optimize time and resources to transfer [3];
- (4) transfer pathways that are difficult to navigate [3].

Some of the challenges that students face in the transfer process such as inadequate advising, lack of knowledge regarding transfer criteria, selection of coursework to be completed prior to transfer also translate to barriers to graduating and extend the time to graduate for transfer students.

To support transfer students, 2- and 4- year universities need to establish articulation agreements that guarantee credits will transfer toward required coursework within the major. For example, the state of California has well-defined agreements between community colleges and the California State University system (CSU) as well as the University of California system (UC) [5]. Students can build their transfer plan of study on the ASSIST.org platform based on the existing agreements by defining their 2-year college and the major they would like to transfer to in the 4 year university[5].

Other aspects that facilitate the transfer process are the possibility of regular meetings with counselors [3], and opportunities to engage with high impact practices, such as undergraduate research [3]. In addition, it has been shown that offering introductory engineering courses at the 2-year institution helped students effectively navigate the path to transfer when such courses included a survey of engineering careers as well as information about transfer planning and degree [3]. Additionally, faculty guidance on major-specific educational planning and transfer destination selection was critically important to transfer success [3], as well as outreach and recruitment activities in which faculties from 4-year institutions visit the community college to present the major and their scholarly interests [2].

The existing literature that analyzes the performance of transfer students is mostly limited to the analysis of the first post-transfer term. This study analyzes the graduation rates of transfer students with respect to first time students at a large minority serving public institution, as well as the students’ experience in their transfer process.

## **Analysis of graduation data**

Community colleges where many students begin their higher education are a critical part of the engineering supply pipeline to four-year universities such as San Jose State University. In Fall 2021, approximately 35% of the students admitted to the College of Engineering and 21% to the Aerospace Engineering (AE) department were transfer students [7]. Transfer students make up at least a quarter of the engineering students admitted every year but their graduation rate is low. A granular analysis of the data further reveals that the rates are lower for URM transfer students when compared to their non-URM peers.

Table 1 below compares the graduation rates of URM and non-URM transfer students in AE for the cohorts from 2015. Table 2 shows a comparison of the graduation rates of first-time students in AE. For transfer students, the 2-year graduation rate (Grad 2 year in tables) can be considered equivalent to the 4-year graduation rate for first time students, and the 4-year graduation rate (Grad 4 year) equivalent to the 6-year graduation rate for first time students. The comparison of Tables 1 and 2 shows that the 6-year graduation rate equivalent to the 4-year rate for transfers is the same for the Fall 2015 cohort of URM students (transfer; 69%; first-time: 68%) but more non-URM transfer students graduate in 4 years when compared to the non-URM first-time students who graduate in the equivalent 6 years (transfer: 91%; first time: 68%). For the Fall 2016 cohort of students, a larger percentage of the URM transfer students graduate in 2 years (60%) when compared to the URM first-time students who graduate in 4 years from the same cohort (11%), while the trend is reversed for the non-URM students (transfer: 38%; first-time: 50%).

Table 1. Cumulative Graduation Rates of URM and non-URM AE Transfer Students [6].

	Cohort Size		Grad 2 year		Grad 4 Year	
	URM	Non URM	URM	Non URM	URM	Non URM
<b>Fall 2015</b>	22 (63%)	13 (37%)	15%	23%	69%	91%
<b>Fall 2016</b>	10 (32%)	21 (68%)	60%	38%	80%	86%
<b>Fall 2017</b>	18 (38%)	29 (62%)	28%	45%	78%	83%
<b>Fall 2018</b>	6 (24%)	19 (76%)	67%	11%		
<b>Fall 2019</b>	5 (42%)	7 (58%)	29%	40%		

Table 2. Graduation Rates of URM and non-URM AE First-time Students [6].

	Cohort Size		Grad 4 year		Grad 6 Year	
	URM	Non URM	URM	Non URM	URM	Non URM
<b>Fall 2015</b>	28 (41%)	41 (59%)	14%	24%	68%	68%

	Cohort Size		Grad 4 year		Grad 6 Year	
	URM	Non URM	URM	Non URM	URM	Non URM
<b>Fall 2016</b>	18 (35%)	34 (65%)	11%	50%		
<b>Fall 2017</b>	11 (18%)	51 (82%)	0%	25%		

The graduation rates also vary widely by demographics. As can be seen in Table 3, 100% of Asians and Whites in the 2015 cohort of transfer students graduate in 4 years in comparison to 67% of Hispanic students. Though the gap narrows for 4-year graduation rates for the subsequent cohorts, the 2- and 3-year graduation rates of Hispanic and African American students is comparatively lower. For the 2016 cohort of students, the 4-year graduation rate of Hispanic students was comparatively higher than Asian and White students in the same cohort.

Table 3. Graduation Rates of AE Transfer Students by Demographics [6]

Transfer Cohort	Graduating Within	Graduating Asians	Graduating African American	Graduating Hispanic	Graduating White	Total (Including Two or more races, Non-resident aliens)
<b>2015</b>	2 years	43%		17%	18%	20%
	3 years	86%		58%	64%	63%
	4 years	100%		67%	100%	83%
	6 years	100%		75%	100%	86%
<b>2016</b>	2 years	22%		67%	43%	45%
	3 years	67%		89%	71%	71%
	4 years	78%		89%	86%	84%
	6 years	78%		89%	86%	87%
<b>2017</b>	2 years	38%	0%	29%	54%	38%

	3 years	75%	0%	65%	77%	68%
	4 years	88%	0%	82%	85%	81%
<b>2018</b>	2 years	0%	100%	60%	25%	24%
	3 years	56%	100%	60%	100%	72%
<b>2019</b>	2 years	67%		40%	0%	12%

Existing literature indicates multiple factors contributing to time to degree, an important factor being the number of courses and credits transferred from the community college.

AE students are required to complete 120 units to graduate, 70 of which are lower division General Education (GE), math and science, and engineering core courses that are completed in the first two years of college. Ideally, a transfer student will enter the AE program with all the lower division courses completed at their community college. But in reality, transfer students enter the program with a varying degree of courses completed at their community college.

The AE program is designed such that students complete 33 units of math and science and 13 units of core engineering lower division courses in the first two years of the program. Students in their junior year of the program begin core AE courses with these lower division math, science and core engineering courses as prerequisites. The program offers a sequence of core courses over the fall and spring semesters with each of the core courses being offered only once a year. A delay in completing a core course in the Fall semester usually leads to a year's delay in completing graduation requirements as there are multiple interdependencies among the core courses in the fall and spring semester.

Table 4. Structure of AE program

<b>Courses</b>	<b># Units</b>	<b># Courses</b>	<b>Average # Units Transferred – Fall 2021 Cohort</b>
Lower division GE	24	8	17 (71%)
Lower division math and science	33	9	15 (45%)
Lower division engineering core courses	13	5	5 (38%)

<b>Courses</b>	<b># Units</b>	<b># Courses</b>	<b>Average # Units Transferred – Fall 2021 Cohort</b>
Upper division major courses	50	17	-

For the most recently admitted Fall 2021 cohort of transfer students, an average of 15 units of math and science courses and 5 units of core engineering course credits were transferred. Many of the students thus have a need to complete the required math and science courses in their junior year before enrolling in the AE core courses leading to a year's delay in graduating at the minimum.

San Jose State University student success dashboard data also shows that the 2015 cohort of transfer students who graduated within 2 years or 2 years and an extra term had 2.6- 6 lower division courses while a junior or senior at San Jose State University [8]. For cohorts in 2016 and 2017 the average lower division courses taken ranged from 2 -4 courses [8].

### **Methodology and Research Questions**

This section describes the methods our team used to recruit participants and to survey them. The research questions that we wanted to answer are:

- (1) What are the barriers to successful transfer of students from community colleges into the aerospace engineering program at San Jose State University?
- (2) What is the academic experience of transfer students after they transfer into San Jose State University?
- (3) How do existing support structures at San Jose State University and transfer institutions support transfer students?

The survey was designed by our team to analyze the students' transfer pathways. The team submitted an IRB application and it was approved on 01/10/22. There were 93 students who were enrolled as AE majors in Spring 2022 that had transferred from community colleges; each of these 93 students was sent the survey through Qualtrics. The first email with the survey was sent on 01/31/22 with follow-up emails on 02/2/22 and 02/08/22. The survey was closed on 02/15/22.

The survey was composed of 15 questions that explored students' academic path, their motivation for transferring into San Jose State University, and their general experience before, during and after their transfer into San Jose State University.

## Results

A total of 22 students completed the survey, which represents about 24% of the surveyed population. About a third of the students spent between 1 and 2 years at their previous institution, a third between 2 and 3 years, and a third higher than 3 years (Table 5).

Table 5. Number of years attended at a previous institution

<b>Years at College</b>	<b>Respondents</b>	
Years at previous institution	Count	Percentage
Between 1 and 2 years	6	27%
Between 2-3 years	8	36%
Greater than 3 years	8	36%

The top three reasons for which students decided to transfer to San Jose State University from a community college include (Figure 1):

- (1) Availability of desired major (17/22 students)
- (2) Location (14/22 students)
- (3) Future career perspective (9/22 students)

The community colleges allow students to complete many of their lower division requirements at an affordable cost and the ability to transfer into a 4-year university to obtain their engineering degree. The survey responses indicated that the majority of transfer students currently enrolled in the aerospace engineering program chose SJSU over other universities to continue their engineering path since their desired aerospace engineering major is offered in the college of engineering at SJSU.

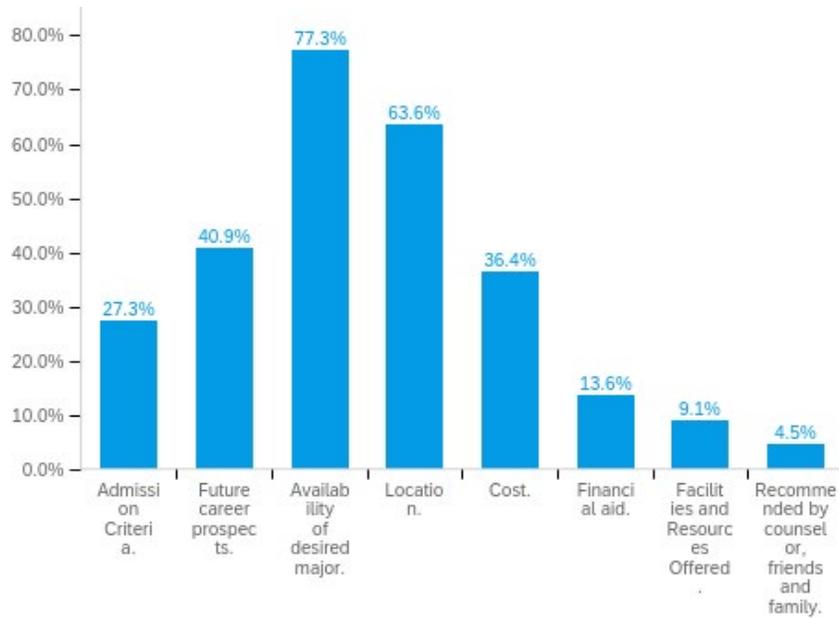


Figure 1. Response to “What influenced your decision to transfer to San Jose State University?”

As seen in Figure 2, about half of the students (50%) decided on their major before they started at their 2-year institution. This result shows that students had planned to transfer to San Jose State University before starting at a 2-year institution, since AE is not offered at 2-year institutions. About 18% of the students decided their major during their first or second year at the community college. Upon transferring, 20 out of 22 students (91%) selected AE as their first choice of major.

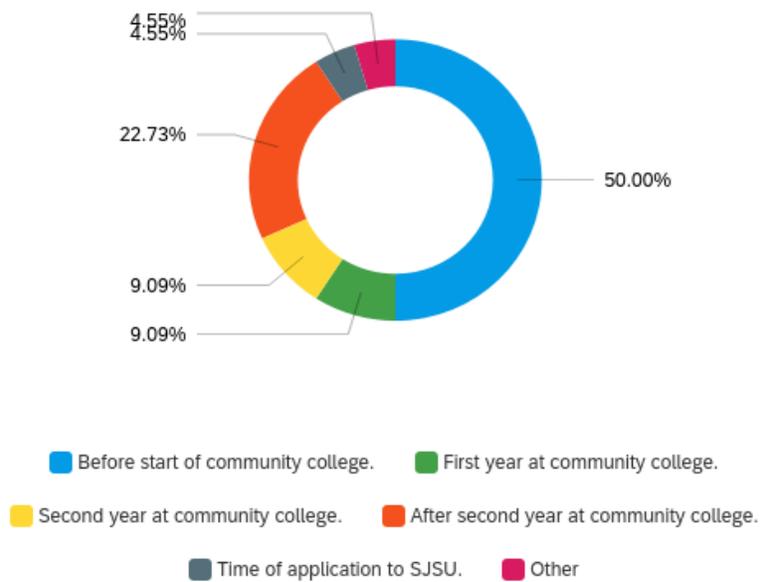


Figure 2. Response to question "When did you decide on your major?"

In response to the question on their enrolment period at SJSU, 41% of the students (9/22) stated that they have been enrolled at SJSU for a year or less, 41% of the students (9/22) are in their second year at SJSU, and 4 students (18%) have been enrolled at SJSU for 3 years or more. Among all the respondents, one student expects to be able to graduate in less than a year after enrolling at SJSU, 10/22 students expect to graduate after completion of 1-2 years at SJSU, 8/22 students expect to graduate after completion of 2-3 years at SJSU, and 3/22 students expect to graduate after spending 3-4 years at SJSU. Most of the students expect to graduate in 2 years post transfer (14/22 students – 63%) and 7 students expect an additional one or two years (32%). Only one student (out of 22) expects that 3-4 additional years are necessary to graduate.

On analysis of results, it was observed that the question could have multiple interpretations such as total time at SJSU or time expected to graduate from SJSU and the responses could indicate any of the possibilities.

The aerospace major requires 33 units (9 courses) of lower division math and science courses in the first two years of the program. Less than half of the students (10/22: 45%) stated that they have completed more than 8 of the lower division math and science courses (requirement: 9 courses); the rest of the students (12/22: 55%) completed less than 8 courses, with 20% of these students completing less than half of the required math and science classes.

Table 6. Response to “How many of the required lower division Math and Science courses did you transfer?”

<b>Response</b>	<b># Of respondents</b>	<b>% Of Respondents</b>
More than 8 courses	10	45%
6-8 courses	8	36%
3-5 courses	3	14%
1-3 courses	1	5%

The Aerospace major requires 13 units (~5 courses) of lower division engineering courses to be completed in the first two years of the program with one of them being a prerequisite to the senior year project courses and the rest are considered as important courses to support student learning in the core courses. The responses to this question as shown in Table 7 indicated that more than half of the survey respondents (12/22) had taken more than 3 lower division engineering courses required by the program while about 45% do not have the minimum lower division engineering courses prior to transfer.

Table 7. Response to “How many of the required lower division introductory engineering courses did you transfer?”

<b>Response</b>	<b># Of respondents</b>	<b>% Of respondents</b>
More than 5 courses	9	41%

Response	# Of respondents	% Of respondents
3-5 courses	3	14%
1-3 courses	5	22.5%
None	5	22.5%

When students were asked to expand on the reasons for not completing the required lower division courses, as seen in Figure 3, a majority of the respondents indicated that advising, unavailability of courses at their community college and focus on completing the general education courses led them to not take as many engineering courses prior to transfer. Among the students that chose the “Other” response, students mentioned failing some math classes at the community college, financial reasons and limited time available.

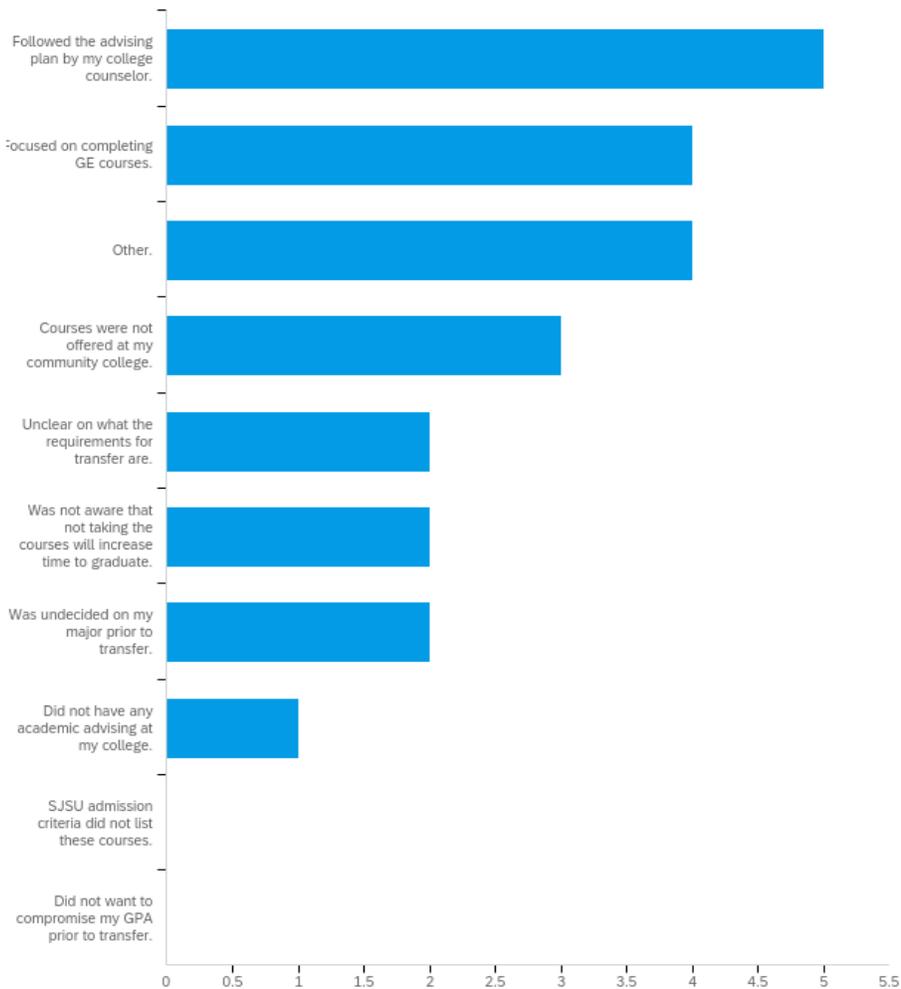


Figure 3. Response to “If you did not complete all the required lower division Math, Science and introductory engineering courses prior to transfer, please state a reason why. Choose from the list given below (can be more than one)”

In terms of resources that were available to help students with the transfer pathway, most of the students (20/22) mentioned academic advising at the community college, and some students (7/22) said that they were also able to use SJSU resources and outreach prior to application. A few students (2/22) also mentioned family and friends as a useful resource. However, 2/22 students had access to “No resources at all”.

In response to the question on challenges faced after transferring to SJSU (Figure 4), students mentioned financial reasons (47%), the need to repeat some courses (42%), being unsure about who to reach out to for advising (37%), lack of clarity about courses that are needed to graduate (32%). Among the students that selected the “other” response, students mentioned the virtual class environment due to the Covid-19 pandemic, working a full-time job, lack of mental health services at SJSU, financial difficulties, and lack of information and understanding about how the SJSU system works and who to contact to solve administrative challenges.

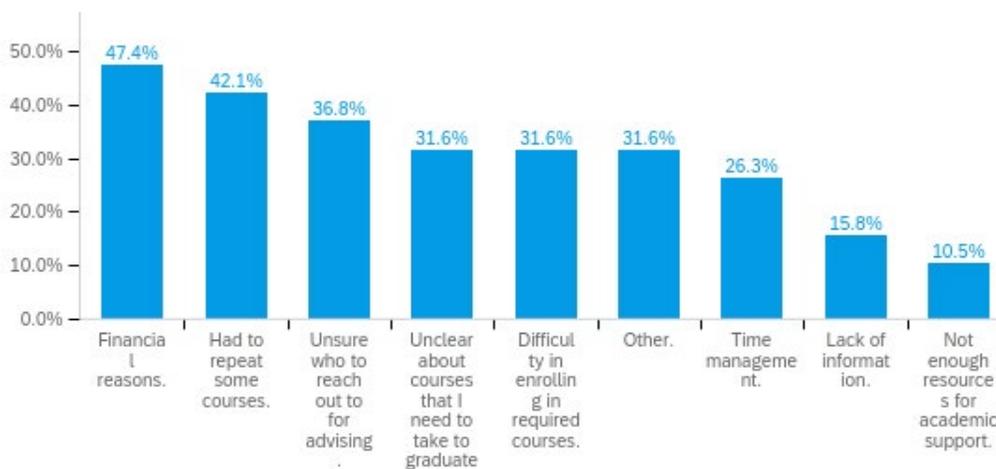


Figure 4. Response to “What are some of the challenges faced by you after transferring to San Jose State University that increases your time to graduate? (You can select more than one.)”

The survey also asked students two open ended questions: “*What were some of the challenges that you faced transferring to San Jose State University?*” and “*What do you wish you had known prior to transferring into AE major at San Jose State University?*”

The themes that emerged from the responses to the first question were personal and financial challenges, lack of guidance on resources available, online learning due to the pandemic and transfer shock. Analyzing the responses to the question on what resources would have been helpful prior to transfer, students indicated that knowledge of the admission criteria and the coursework required to transfer would have assisted them in a smooth transfer into San Jose State University.

## Discussion

The AE program requires 9 lower Math and science courses (33 units) to be completed prior to starting the upper division AE core courses in the junior year. Among the students who responded to the survey, 61% of the students had completed less than half of the courses required

to begin junior year of the program. Since the AE core courses require the completion of all the math and physics courses, there is a possibility of at least a year's delay in graduation for these students owing to the non-completion of the courses at their community college prior to transfer. In response to the question on why the students did not take the courses in their community college, there were four main reasons: Courses were not offered in their community college, students followed the recommendation of the academic advisor at their college, students completed the general education requirements at their community college and they were unsure of their major prior to transfer.

Majority of students also shared that they only used the advising resources at their community college to guide them in their transfer process. 7 out of the 23 students who responded also indicated that they utilized San Jose State University's resources and outreach to support them in the transfer process.

Students also overwhelmingly indicated that one of the key challenges after they transferred was the lack of information on advising support available. Other key challenges stated were the difficulty in enrolling in the required courses and managing finances.

Some of the limitations of the current study include the small number of collected responses due to the size of the transfer class currently enrolled at SJSU, and the inability to survey students that recently graduated from SJSU. In addition, due to low numbers, it was not possible to separate students' responses by socio-demographic factors. Additionally, upon analysis of the results, it became clear that some of the questions were not well stated and students may have misinterpreted their meaning.

Nonetheless, it is an important study to understand the experience of transfer students upon enrolling in the SJSU aerospace major, and it offers some direction for improvement purposes. The study also offers an initial instrument to analyze students' transfer pathways at a larger scale.

## **Conclusion**

The data from the survey from 22 currently enrolled AE transfer students was analyzed for the purpose of this paper. We examined factors that impact the graduation time for transfer students in order to identify critical factors that influence the graduation rates. The analysis highlighted certain areas that are potential causes for a delay in graduation for transfer students as well as important factors in their post transfer experience. While admission criteria, structure of the AE program and ability to register in the required courses are some contributing factors for the delay, the survey also revealed gaps existing in the advising structure, outreach and support for transfer students at their community college and post transfer at San Jose State University. The survey also indicated that inadequate advising structure at their community college and the lack of knowledge regarding coursework and other criteria required to transfer were key challenges to transfer into SJSU. These challenges also present as barriers to graduate once the students transfer into SJSU. The lack of prerequisite coursework extends the graduation timeline for many of the transfer students.

The CSU eligibility requirements for transfer also can be a contributory factor to the lack of emphasis on completion of all engineering lower division courses prior to transfer. CSUs list four basic skills that fall under the general requirements area and the impaction criteria for a particular major as the eligibility requirement for transfers. The admission threshold at SJSU for each major varies and is dependent on a combination of the transfer GPA and the course requirements met. All engineering majors also have supplemental course criteria that are used in

the transfer admissions ranking and decisions. The common courses that are required by all engineering majors are Calculus I, II and III and General Physics-Mechanics, Electricity and Magnetism. But each major also has other preparatory coursework that are considered for admission. Aerospace engineering for instance lists general chemistry, and introductory programming in addition to the math and physics courses as program specific preparation courses which is different from the requirement for other engineering majors. The common criteria allow for transfer students the flexibility to apply to different engineering majors. But the downside of only meeting the common minimum is that their chances for admission into a particular engineering major is compromised since the students do not have all the preparatory coursework completed prior to their transfer. Admitted students may thus be allocated an alternate choice major and would have to complete all the major specific lower division engineering coursework post transfer. Another factor that comes into play in admission decisions is the transfer GPA. Since a higher GPA allows for the flexibility for fewer preparatory courses to be completed prior to transfer, students may choose to complete the general education requirements and the common minimum engineering requirements. This allows them to maintain a high GPA as many of the lower division preparatory courses are also perceived as contributors to lowering the GPA.

To further understand these issues and provide solutions, an in-depth investigation into more granular details such as what kind of resources are needed to support student success will be helpful especially in the context of an underserved minority student population. A follow up study with interviews of these transfer students to gather more rich information on factors influencing their graduation and success in the program at San Jose State University would have to be conducted to understand these factors better and propose solutions to address any existing gaps. A similar study conducted for all engineering transfer students would also be helpful to determine gaps if any at college level and allow for collaboration of ideas and resources to best support the needs of underserved minority engineering transfer students.

## References

- [1] N. L. Smith, J. R. Grohs, and E. M. Van Aken, "Comparison of transfer shock and graduation rates across engineering transfer student populations," *J. Eng. Educ.*, Vol. 111, No. 1, pp. 65–81, Jan. 2022.
- [2] A. Miguel and S. Abraham, "Creating an Environment for Transfer Student Success," *ASEE Annu. Conf. Expo. Conf. Proc.*, Vol. 2017-June, Jun. 2017.
- [3] B. Sansing-Helton, G. Coover, and C. E. Benton, "Increasing STEM Transfer Readiness Among Underrepresented Minoritized Two-Year College Students: Examining Course-Taking Patterns, Experiences, and Interventions," *Front. Educ.*, Vol. 6, p. 196, Jun. 2021.
- [4] L. Blash *et al.*, "A Long & Leaky Pipeline: Improving Transfer Pathways for Engineering Students.," Sacramento, CA: The RP Group. 2012.
- [5] "Welcome to ASSIST." [Online]. Available: <https://assist.org/>. [Accessed: 31-Jan-2022].
- [6] Graduation and Retention Rates by Demographics, [http://www.iea.sjsu.edu/outcome/RetnGrad/grad\\_retn\\_demo.php](http://www.iea.sjsu.edu/outcome/RetnGrad/grad_retn_demo.php)
- [7] Enrollment by Department, [http://www.iea.sjsu.edu/Students/Enrollment/enroll\\_department.php](http://www.iea.sjsu.edu/Students/Enrollment/enroll_department.php)
- [8] CSU success dashboard, <https://csusuccess.dashboards.calstate.edu/public/faculty-dashboard/upper-classmen-grad-rates>.