Quantitative Exploration of International Female and Male Students in Undergraduate Engineering Programs in the USA

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***Abstract*—This study focuses on quantitative analyses of international and domestic students pursuing undergraduate degrees at institutions in the USA. Metrics used include representation at start of university studies, representation at graduation and six-year graduation rate. Results are disaggregated by origin (domestic or international), sex (female and male), and major (engineering or non-engineering). Results show that more international students choose engineering than other majors. There are more men than women in engineering and this is more pronounced for international students. International students graduate at higher rates in engineering than domestic students by about 5%. This may reflect a tension between their higher academic qualifications but challenges of adjusting to studying in another country. These insights can be used to support student success.**

Keywords—graduation rate; international education; study abroad

I. Introduction and Background

According to the Institute of International Education (IIE), the numbers of international students studying in the USA have increased in the last decade to over 1 million international students in 2019 with 53% being from China and India [1]. International students make up 5.5% of students in higher education in the USA [2]. About 50% of the international students studying in the USA pursue Science, Technology, Engineering, and Math (STEM) majors. Engineering is the most popular field of study with 21.3% of international students studying abroad choosing engineering [2].

Studies have been done on international students in the USA and published in various venues, but with little attention to the success of international students in completing their degree program and related outcomes. A journal devoted to the topic, the *Journal of International Students*, has 15 categories of commonly published work, none of which addresses academic outcomes. Most published work in that journal addresses outcomes specifically related to international study (intercultural engagement, global learning, transnational perspectives, career & employment), topics related to the health, safety, and well-being of students studying internationally (health & well-being, social networks, mobilities, belonging, acculturation & adjustment, geopolitics, COVID-19), and methods for conducting international studies (technology & online learning, faculty & classroom, second language). Even the category "gender" is found to include research that fits one of those other three groups that considered gender effects [3].

There have been some studies exploring the experiences of international students in undergraduate engineering with most focused on the first-year experience. Wait and Gressel studied the impact of the Test of English as a Foreign Language (TOEFL) score on international students' academic success in engineering [4]. Barnes and Loui used a survey and focus groups to compare the challenges of first-year international and domestic engineering students in adjusting to college [5]. Jimenez-Useche, Hoffmann, and Ohland considered students' academic performance in a required first-year engineering class comparing international and domestic students [6]. Jimenez-Useche, Ohland, and Hoffmann investigated the dynamics of first-year engineering teams that included international and domestic students [7]. In that work, the authors state that "non-U.S. students often outperform domestic students in math and science and they graduate at rates similar to those of domestic students" citing [8, 9] to support this claim. Beigpourian, Ohland, and Ferguson studied the impact of the percentage of international students on the psychological safety of students on first-year engineering teams [10].

Quantitative analyses of undergraduate engineering students in the USA disaggregated by race and sex including graduation rates have provided useful insights into their experiences and how to support them (see for example, [11]). Detailed quantitative enrollment data is available for international students [2]. Less information is available on outcomes such as graduation rate. For all majors at one public university in the USA, Fass-Holmes showed that international students were successful academically in terms of time to degree and graduate rate [12]. However, detailed quantitative analyses of undergraduate engineering students who leave their native countries and pursue their education in the USA have not been extensively studied. In this work, we quantitatively explore the representation of these international undergraduate engineering students at enrollment and graduation and examine the outcome of six-year graduation rate. We compare them to domestic U.S. students. Given our large dataset, we are able to disaggregate by sex to separately consider students who identify as female and male.

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II. METHODS

A. Dataset and Population

This study uses the Multi-Institution Database for Engineering Longitudinal Development (MIDFIELD) [13] that has been shown to be representative of engineering programs throughout the USA [14]. MIDFIELD includes institutional records from all undergraduate, degree-seeking students at nineteen universities in the USA with data for 1987 through 2018. The total MIDFIELD population includes 1,722,094 students.

In this work, we define "international students" as students who were not born or naturalized in the USA who matriculate in engineering programs in the USA. Domestic students are defined as students who are citizens of the USA. Thus students are classified as international students or domestic students. Engineering (Engr) students includes all students who ever enrolled in a major with Classification of Instructional Programs (CIP) codes beginning with 14 [15]. Non-engineering (Non-Engr) students includes all students who ever enrolled in a major with a CIP code that does not begin with 14. This includes business, science, liberal arts, etc. These CIP codes were developed by the National Center for Education Statistics (NCES) of the United States Department of Education. This work uses the 2010 revision of these codes. Table 1 shows the population used in this study which includes engineering students, non-engineering students, international students, domestic students, female students and male students. The sample is restricted to include only those for whom we have sufficient institutional data to determine whether they graduated within a six-year period.

TABLE I. POPULATION FOR THIS STUDY FROM MIDFIELD

Starting Major	Sex	Origin	Number at Start
Engineering	Female	Domestic	51,198
Engineering	Female	International	3,814
Engineering	Male	Domestic	199,488
Engineering	Male	International	17,490
Non-Engineering	Female	Domestic	657,917
Non-Engineering	Female	International	26,292
Non-Engineering	Male	Domestic	640,512
Non-Engineering	Male	International	34,228

B. Metrics

In this exploration, we use the metrics of *representation at start of university studies*, *representation at graduation*, and *graduation rate*. *Representation at start of university studies* considers the number of students when they begin their studies at the university. *Representation at graduation* captures who is in the room at graduation within six years of starting. Note that this includes all graduates regardless of whether they started in the major or transferred into the major or the institution. *Graduation rate* is the number of students who graduate in six-years in a group of majors divided by the number who started in that same group of majors. Group of majors is defined as having the same first two digits of the CIP code. For example, students who started in Electrical Engineering and graduated in Chemical Engineering would be included. However, students who started in English and graduated in History would not. Given our large dataset, we are able to disaggregate by sex to separately consider students who identify as female and male.

C. Limitations

There are several limitations to this work. Although international students share the experience of studying in the USA, the category of "international" represents a large aggregation of students who are diverse in terms of race, ethnicity, socioeconomic status, citizenship, and native language. There are certainly cultural differences and different levels of cultural adjustment for different countries. Some of these students went to English-speaking programs right before college and others did not. Some students come from countries where their government pays for their education. Others come from countries where their families must have sufficient financial resources to support all of their education and provide proof of this at enrollment. Tuition at public colleges in the USA is considerably higher for international students. Experiences also vary by institution. All of the data reported on here is from before the COVID-19 worldwide pandemic, which has had profound impact on travel and the ability of international students to study in the USA, although many continue to study at US universities remotely.

III. RESULTS

A. Representation at start of university studies

In MIDFIELD, as seen in Fig. 1, there are more domestic students than international students at the beginning of university studies. International students begin their studies in engineering at higher rates than in other majors. 7.8% of the engineering starters are international students compared to 4.4% of the non-engineering starters.

As reported in studies throughout the USA, there are more male students in engineering than female [16, 17, 18]. This is even more pronounced for international students as shown in Fig. 1. In Fig. 1b, domestic women are 18.8% of the engineering starters and international women are 1.4% of the engineering starters. Domestic men are 73.3% of the engineering starters and international men are 6.4% of the engineering starters.

At the start of university studies, international students in engineering have a lower percentage of women compared to domestic students. 18% of international engineering students are female and 82% are male. 20% of domestic engineering students are female and 80% are male. Of the women in engineering, 93% are domestic and 7% are international. Of the men in engineering, 92% are domestic and 8% are international.

In majors outside of engineering, there is more of a balance between women and men. This is consistent with other reports in the USA [18]. In Fig. 1a, domestic women are 48.4% of the non-engineering starters and international women are 1.9% of the engineering starters. Domestic men are 47.1% of the non-engineering starters and international men are 2.5% of the non-engineering starters.

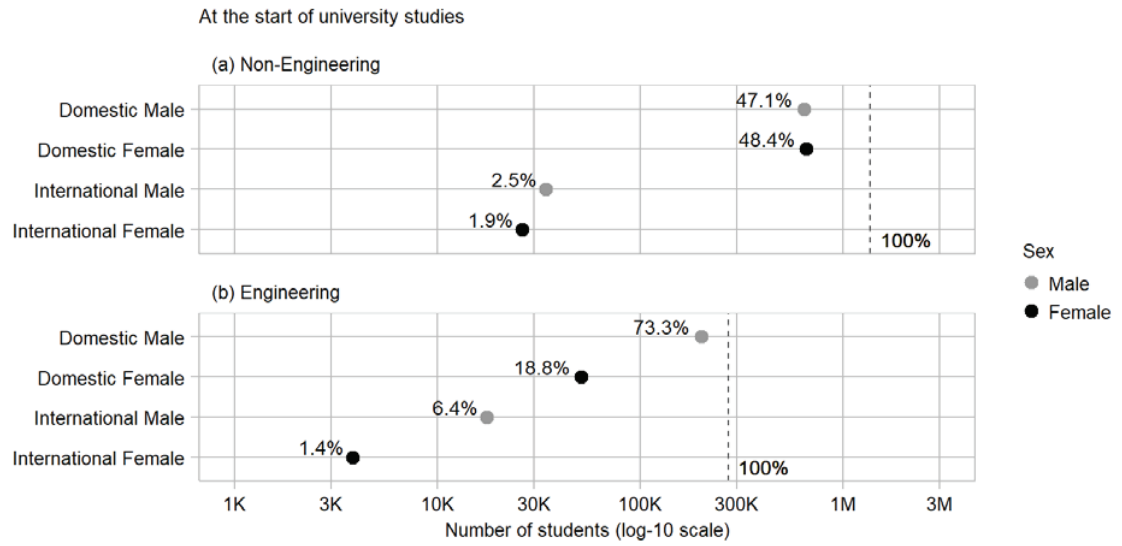

Fig. 1. Representation of international and domestic (USA) students at start of university studies disaggregated by sex and major (a) non-engineering or (b) engineering.

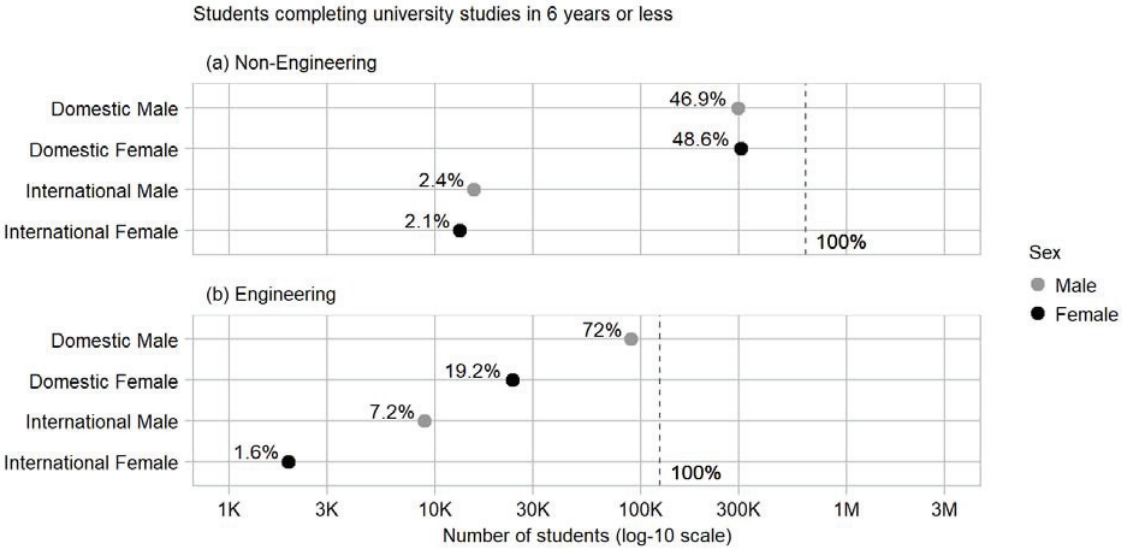

Fig. 2. Representation of international and domestic (USA) students at start of university studies disaggregated by sex and major (a) non-engineering or (b) engineering.

There is considerable variation in international representation by institution. International students represent 4.8% of the total MIDFIELD population and 8.5% of engineering students with a range from 1.6% to 19.4% for different institutions. Women comprise 44.7% of the total MIDFIELD population (ranging from 11.3% to 63.7% for different institutions) and 19.9% of engineering students (ranging from 11.0% to 32.1%). International students who are women make up 36.8% of all international students (ranging from 12.8% to 45.7%) and 17.9% of international engineering students (ranging from 10.9% to 45.5%).

B. *Representation at graduation*

By graduation in MIDFIELD, there is not much change in most metrics from when students started at the university. As shown in Fig. 2, international students are still present in engineering at six-year graduation at higher rates than in other majors. 8.8% of the engineering graduates are international students compared to 4.5% of the non-engineering graduates.

Of the women graduates in engineering, 92% are domestic and 8% are international. Of the men in engineering, 91% are domestic and 9% are international. International students in engineering have a lower percentage of women compared to domestic students: 18% of international engineering graduates are female and 82% are male. 21% of domestic engineering graduates are female and 79% are male.

There are more domestic and international men than women among engineering graduates as seen in Fig. 2. In Fig. 2b, domestic women are 19.2% of the engineering graduates and international women are 1.6% of the engineering graduates. Domestic men are 72% of the engineering graduates and international men are 7.2% of the engineering graduates.

In majors outside of engineering, there is more of a balance between women and men. In Fig. 2a, domestic women are 48.6% of the non-engineering graduates and international women are 2.1% of the engineering graduates. Domestic men are 46.9% of the non-engineering graduates and international men are 2.4% of the non-engineering graduates.

C. *Graduation Rate*

Fig. 3 shows the six-year graduation rate for students in MIDFIELD. The graduation rates for engineering students are considerably higher than for non-engineering students (more than 11 percentage points). This is consistent with prior research with MIDFIELD [19].

In engineering, the graduation rate is higher for international students than for domestic male and female students by about five percentage points. It was difficult to hypothesize this result; whereas the high academic qualifications of international students and their higher level of financial support would have predicted this, the challenges of adjusting to US language and culture as well as the possibility of encountering xenophobic tensions might have suggested the opposite result.

Domestic female students graduate at slightly higher rates in engineering than male students (38.7% vs. 38%). This is consistent with previous studies [16, 17]. International female students, however, graduate at slightly lower rates than international male students (43.2% vs. 44.1%).

IV. Discussion and Conclusions

This focused study of international students in undergraduate engineering in the USA disaggregated by sex provides insights into the representation and outcomes for these students. A higher percentage of international students choose to study engineering compared to other majors. The study reveals that the international student population in engineering has a similar distribution by sex at the start of university studies and at six-year graduation and has better academic outcomes than domestic students, revealing their resilience to the challenges of adapting to the language and culture of the USA. These insights can be used to support these students to further enhance their success.

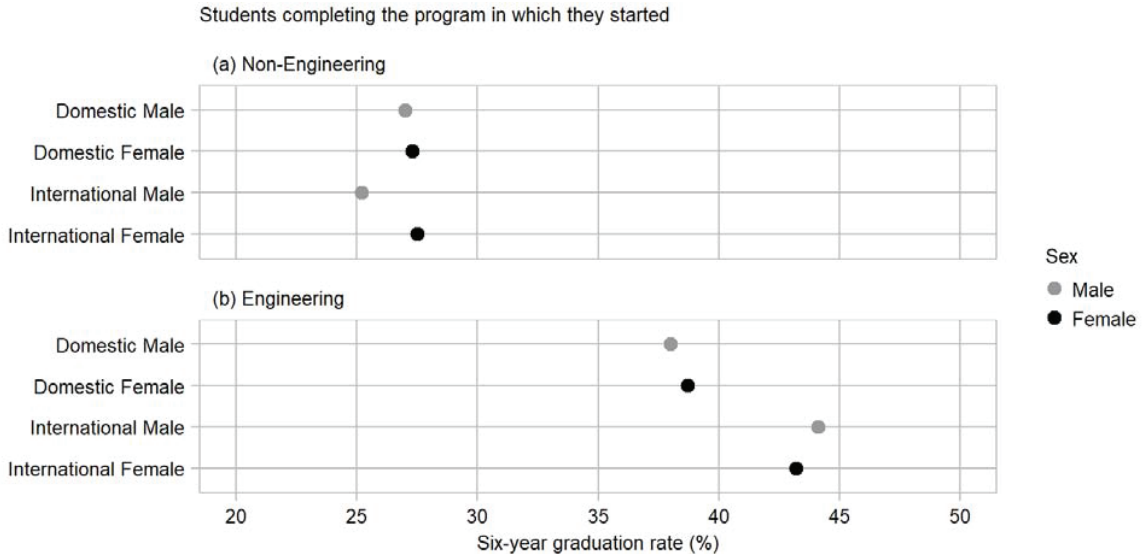

Fig. 3. Six-year graduation rate of international and domestic (USA) students disaggregated by sex and major (a) non-engineering or (b) engineering.

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