

International Students in Undergraduate Electrical and Information Engineering Programs in the USA

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Abstract— This research quantitatively analyzes undergraduate EEIE majors (Electrical Engineering, Computer Engineering, or Computer Science). Metrics used are major at university entrance, major at graduation, six-year graduation rate, and stickiness. We examine the data by origin (domestic or international), sex (female or male), and EEIE discipline. Analyses show that males enroll in EEIE disciplines in greater numbers than females, particularly higher for international students. International students graduate at higher rates in EEIE than domestic students by 14.5%. Both female and male international students have much higher stickiness than female and male domestic students. Graduation rates and stickiness are higher in Electrical Engineering than in Computer Engineering or Computer Science. These insights suggest that international students can be included in U.S. classrooms, enriching their educational experience and that of domestic students, while remaining confident that their experience is likely to result in positive academic outcomes.

Keywords—graduation rate, international, stickiness

I. OVERVIEW

English has become a global language and a *franca lingua* throughout Europe [1]. But only one out of four English speakers in the world are native speakers. English, as a second language, is widely taught across the world [2]. In 2019, native English-speaking countries attracted 35% of all students who studied outside of their home country. The United States is the primary destination for over one million of the 4.1 million students who studied outside of their home country in 2019 [3].

Thirteen percent of USA university undergraduate enrollment are international students (IUS) [4]. Science, Technology, Engineering, and Math (STEM) majors are the most popular majors among IUS (77%) [3]. Engineering is the most popular major of IUS who study STEM (21.3%) [5]. While females outnumber males in college enrollment and graduation, they are more likely to study arts and humanities (62% female) and health and welfare (63% female) and less

likely to study engineering (29% of international students are female) [5].

This paper is the second in a series studying international students in USA universities. Lord, Ohland, Long & Layton found that international and domestic students had similar distribution by sex at matriculation and six-year graduation in engineering overall, while IUS had better academic outcomes [6].

Few other studies on international students studying in the United States considered the academic outcomes of IUS. None of the commonly published articles in the *Journal of International Students* examine international student outcomes [7]. The experience of international students in the first year has been the primary focus of research on international students [6].

Disaggregating quantitative undergraduate engineering student data by race, sex, and graduation rates allows universities to better support international students' academic outcomes (see for example, [8]). The US Department of Education tracks international students as a race variable and provides detailed enrollment data [7], but scant is known about the academic performance of international students. Fass-Holmes examined the academic success of IUS and found that IUS are outstanding in time to degree and graduation [10]. This paper studies IUS in EEIE majors at enrolment and completion comparing international and domestic EEIE students. We also look at outcomes of six-year graduation rate and stickiness.

II. METHODS

A. Dataset and Population

The Multiple-Institution Database for Engineering Longitudinal Development (MIDFIELD) is used as the data source for this study [11]. MIDFIELD is a large longitudinal dataset that is representative of engineering programs in the USA [12]. MIDFIELD collects student record data for all undergraduate, degree-seeking students at nineteen

TABLE I. MIDFIELD STUDENTS

MIDFIELD	1,722,094
Engineering or Computer Science	268,841
EEIE	102,484

This work was supported by the USA National Science Foundation (NSF) through Grant 1545667.

TABLE II. POPULATION FOR THIS STUDY

	Electrical Engineering		Computer Engineering		Computer Science		EEIE	
	Start	Ever	Start	Ever	Start	Ever	Start	Ever
International Female	124	452	85	228	475	634	684	1,314
International Male	1,215	3,150	530	1,569	2,053	2,739	3,798	7,458
Domestic Female	2,406	4,426	918	1,872	6,450	8,856	9,774	15,154
Domestic Male	14,611	27,753	6,827	15,077	25,503	35,728	46,941	78,558
Column totals	18,356	35,781	8,360	18,746	34,481	47,957	61,197	102,484

TABLE III. POPULATION PERCENTAGES BY DISCIPLINE

	Electrical Engineering		Computer Engineering		Computer Science		EEIE	
	Start	Ever	Start	Ever	Start	Ever	Start	Ever
International Female	0.7%	1.3%	1.0%	1.2%	1.4%	1.3%	1.1%	1.3%
International Male	6.6%	8.8%	6.3%	8.4%	6.0%	5.7%	6.2%	7.3%
Domestic Female	13.1%	12.4%	11.0%	10.0%	18.7%	18.5%	16.0%	14.8%
Domestic Male	79.6%	77.6%	81.7%	80.4%	74.0%	74.5%	76.7%	76.7%

universities in the USA for 1987 through 2020. Table I shows the number of students in MIDFIELD.

International students have left their country of citizenship to study in the USA. They generally hold an F-1 or M-1 visa. Domestic students are USA citizens or permanent residents. EEIE students enrolled in a major with Classification of Instructional Programs (CIP) codes identified as Computer Engineering (14.09xx), Electrical Engineering (14.10xx), and Computer Sciences (11.01xx, 11.04xx, 11.07xx, 11.08xx). These standard codes were developed by the National Center for Education Statistics (NCES) of the United States Department of Education, 2010 revision [13]. See Table II for the count of students used in this study

B. Metrics

Many of the metrics used in this paper have definitions that were established in the first paper in this series studying undergraduate international students [6]. In this paper, we use the metrics of *major at university entrance*, *major at graduation*, *graduation rate*, and *longitudinal stickiness*. *Major at university entrance* considers the majors of students when they first enrol at the university. *Major at graduation* captures the majors of students who graduate within six years. This includes all students who started in the major and graduated in that major. *Graduation rate* is the number of students who graduate in six years in a major divided by the number who started in that “same” major. The “same” major means that the first four digits of the CIP code are the same. For example, students who started in Computer Engineering (CIP 14.09xx) and graduated in Computer Engineering (CIP 14.09xx) would be included. However, students who started in Computer Science (CIP 11.01xx) and graduated in Computer Engineering (CIP 14.09xx) would not. *Longitudinal stickiness* is the ratio of the number of students graduating in a program to the number of students ever enrolled in that [14]. Stickiness measures the extent to which a program succeeds in its basic goal of graduating the students it admits, without regard to how or when a student is admitted to a program—the metric includes students who begin college part-time, enroll mid-year, switch majors, or transfer, in addition to first-time-in-college students.

C. Limitations

This work has several limitations. “International” as defined by the US Department of Education, aggregates students from different countries of origin, ethnicity, race, socioeconomic status, and first language who will require different levels of assimilation into a new culture. Some students may have attended pre-college English language programs. Tuition at USA public universities is significantly higher for international students. USA universities require international students to provide proof of sufficient financial resources before enrollment. This requires students to prove that they have home country government financial support or sufficient personal or family financial resources. MIDFIELD data used in this study dates before the worldwide COVID-19 pandemic, which restricted international students from traveling to and studying in the USA. Sex data are collected as binary, consistent with U.S. Department of Education requirements.

III. RESULTS

A. EEIE majors at university entrance

In Table III, IUS make up 7.3% of EEIE starters and 8.6% of students who ever studied EEIE. At most USA universities, male students outnumber female students by a significant margin [15]. The same applies to the population of this study. International students in EEIE, both starters and students who ever studied EEIE, have fewer female than male domestic students. International EEIE representation varies by institution. International students represent 7.3% of EEIE starters (ranging for 1.8% to 20.0% for different institutions). International students who are female comprise 1.1% of EEIE starters (ranging from 0.0% to 3.09% for different institutions).

B. Major at graduation

Most graduates in EEIE are male and domestic (73.4%), as seen in Table IV. Graduation by sex for domestic and international students are similar (91% are male and 9% are female).

TABLE IV. MAJOR AT GRADUATION

	Electrical Engineering	Computer Engineering	Computer Science	EEIE
International Female	1,865	140	365	2,370
International Male	8,530	993	1,442	10,965
Domestic Female	23,426	702	2,923	27,051
Domestic Male	90,150	7,481	13,987	111,618
Column totals	123,971	9,316	18,717	152,004

C. Graduation Rate

Fig. 1 shows that international EEIE students graduate at much higher rates than domestic students, 19.6% higher for international females and 13.3% for international males. The higher graduation rate for international EEIE students might be explained by the higher level of academic and financial support required of international students for enrollment at USA universities. These higher graduation rates for international students are achieved despite the students having to adjust to USA language/culture and xenophobic tensions.

Previous studies [14, 15] have shown that domestic females in engineering graduate at higher rates than males. That is not true of EEIE domestic females in this study. Domestic male EEIE students graduate at higher levels than domestic females (38.5% vs. 47.3%). compared with international females who graduate in EEIE at higher levels than international males (58.1% vs. 60.6%). Fig. 1 shows EEIE six-year graduation rates by major.

IUS graduate at higher rates than domestic students in all majors. This is not true for all engineering majors [15]. Domestic females have a particularly poor graduation rate in Computer Engineering and Computer Science with graduation rates lower than 30%. Domestic males also have low graduation rates, below 40%.

D. Longitudinal Stickiness

Ohland, Orr, Layton, Lord & Long defined the concept of stickiness [14]. Stickiness is based on the idea that when

students enroll in a major, they intend to graduate in that major. In addition, allowing students to enroll in a major means that the institution and/or program is committed to supporting the students to graduate in that major. Thus, stickiness is a measure of how well a degree program is successful in supporting its students, not just a measure of attractiveness to students.

Several stories arise from Fig. 2. Once international students enroll in an EEIE major they are more likely than domestic students to graduate in that major. International females have the highest stickiness in Electrical Engineering (69%). All international students outperform domestic students. Female international students generally have higher stickiness rates than male international students, except for Computer Engineering. Because stickiness is based on whether a student ever enrolled in a major, students can be counted more than once. EEIE students generally have enrolled in one EEIE major (92%). However, 7.7% enrolled in two EEIE majors and 0.3% enrolled in all three EEIE majors at some point in their academic careers. Stickiness is higher in Electrical Engineering than in Computer Engineering or Computer Science.

IV. DISCUSSION AND CONCLUSIONS

This work provided data on the representation of IUS EEIE majors examined by major and sex at enrollment and graduation as well as academic outcomes. Graduation rates and stickiness are higher in Electrical Engineering than Computer Engineering than Computer Science suggesting cultural differences among these majors. International male and female students in EEIE graduate at higher rates and have higher stickiness in their chosen major than domestic students. This reveals the resilience that IUS demonstrate as they adapt to a new culture and language in the USA. These findings suggest that international students can be included in U.S. classrooms, enriching their educational experience and that of the domestic students, while remaining confident that their experience is likely to result in positive academic outcomes.

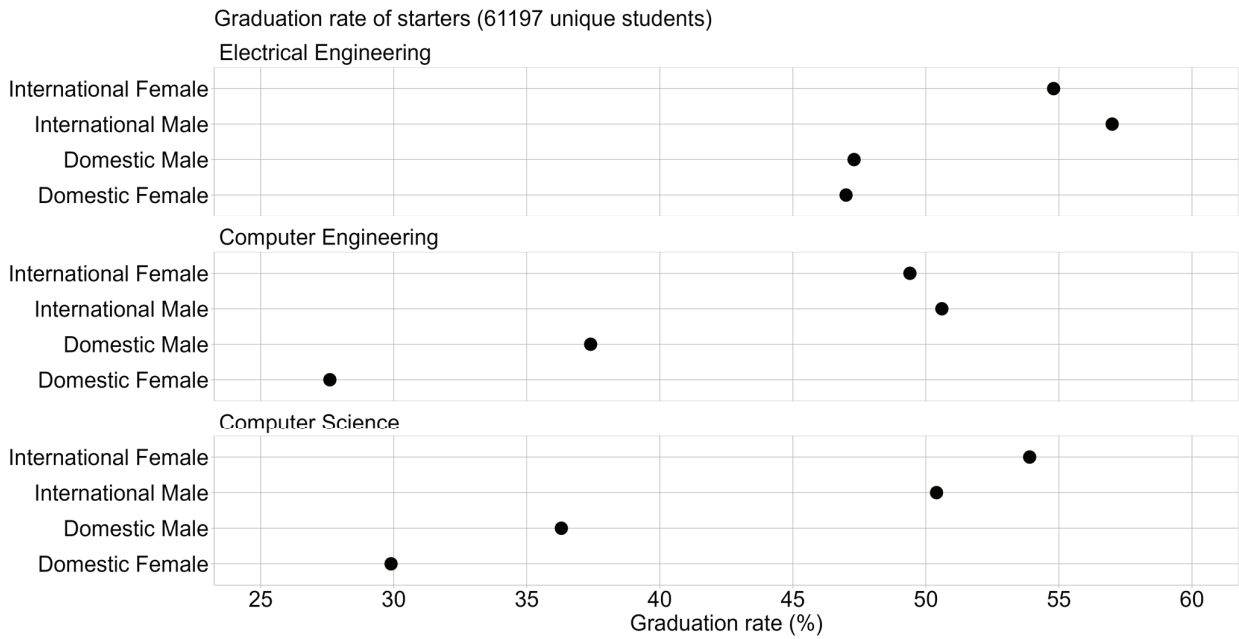


Fig. 1. Six-year graduation rate of domestic (USA) and international students disaggregated by sex and EEIE major.

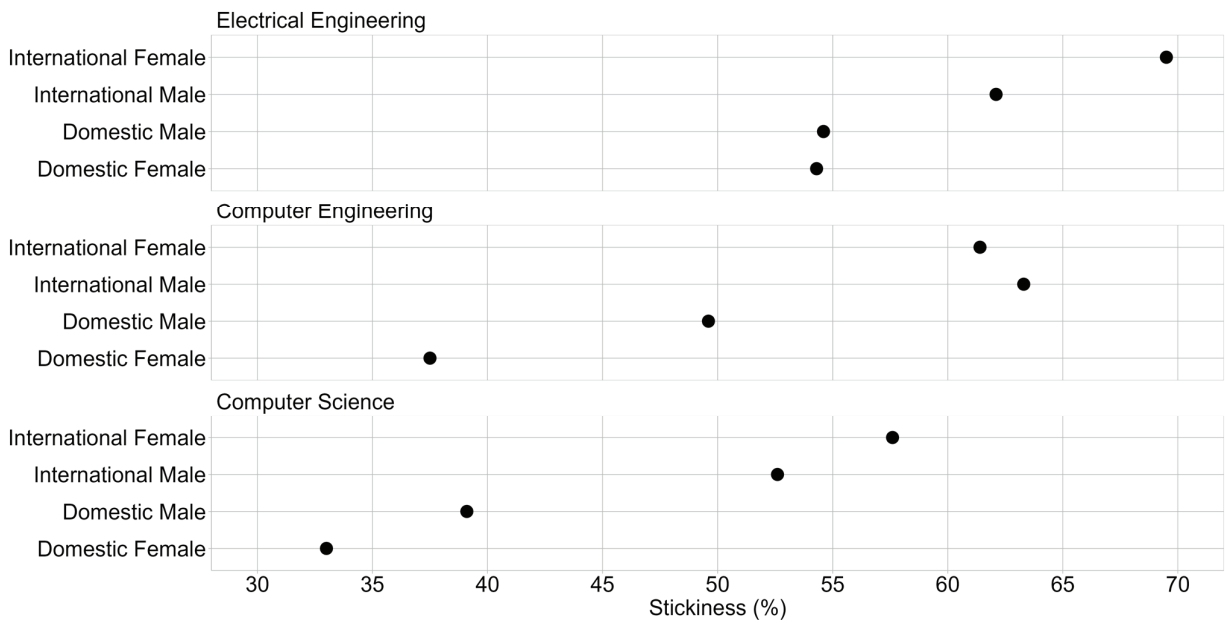


Fig. 2. Longitudinal stickiness of domestic (USA) and international students disaggregated by sex and EEIE major.

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