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Comparing the Multiple-Institution Database for Investigating Engineering Longitudinal Development with a National Dataset from the United States*

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The Multiple Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) has been used to conduct a significant amount of research on student pathways in engineering. The representativeness of the database has generally been established on the basis of its size, its completeness, and the similarity of its partner institutions to those educating the majority of engineering graduates in the USA. In this work, a richer analysis of the extent to which MIDFIELD is nationally representative has been conducted based on data available from the American Society for Engineering Education (ASEE). The MIDFIELD and non-MIDFIELD institutions are compared based on the demographic composition with respect to race/ethnicity and sex at matriculation and graduation. The similarity of the demographic composition of the five most common engineering disciplines (Chemical, Civil, Electrical, Industrial, and Mechanical) provides evidence that the MIDFIELD institutions are largely representative of the ASEE national sample to the extent that the comparison can be conducted.

Keywords: representativeness; validation; institutional data; demographic composition; undergraduate

1. Introduction

College persistence is an important measure of the student experience and informs the development of policies that promote student success. Engineering continues to suffer from a lack of diversity in the participation of women and people of color in the USA. This is problematic since diversity enhances innovation and engineering is an important discipline for shaping technology and society and thus social justice concerns spur the need for equitable representation in enrollment and graduation. Thus studying undergraduate engineering student persistence continues to be an important area of research.

Measuring persistence can be challenging and various metrics have been used. Short-term measures such as one-year [1] or two-year [2] persistence are imperfect predictors of graduation. Even eight-semester persistence [3, 4] has been shown to have a systematic majority measurement bias [5]. Cross-sectional approaches, which count students at a specific point in time, [6] estimate a graduation rate as the ratio of graduates in a particular year to students matriculating in the same year, and thus assume that incoming classes do not vary much in size and important predictive characteristics, which is a risky assumption [7]. Comparing the number of students in a cohort to the number of graduates five years [8] or six years [9] later ignores the effect of cohort growth from transfer students and students changing majors.

Longitudinal sources are particularly valuable for persistence research. Longitudinal sources are those which allow the researcher to track students over time. A variety of sources include engineering-specific data, but those sources are not longitudinal [10, 11]. Although the Integrated Postsecondary Education Data System of the National Center for Education Statistics (NCES) [12] includes graduation rates computed longitudinally, it does not include information about the paths students take in navigating their degree. A few landmark studies that include engineering education outcomes are longitudinal [13–15], but these studies aggregate engineering as a single major. There is evidence that the various disciplines of engineering attract different students [16], expose students to different climates [17, 18], and achieve different outcomes

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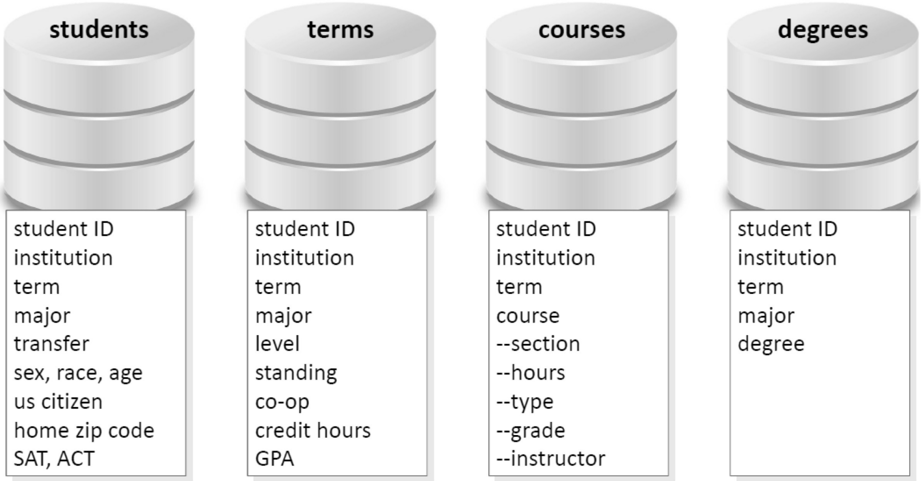

Fig. 1. MIDFIELD Data Structure.

[19–23]. There is much to be gained from a database that tracks students longitudinally through their entire academic experience.

1.1 The Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD)

The Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) comprises de-identified, whole population data of degree-seeking students at partner institutions – including students of all disciplines, transfer students, part-time students, and students who first enroll at any time of year. MIDFIELD includes four broad categories of data – students, terms, courses, and degrees (Fig. 1). The details of the creation of MIDFIELD and its data schema are described elsewhere [24].

While MIDFIELD's longitudinal student unit-record data schema is a notable improvement over cross-sectional datasets, most MIDFIELD research published to date includes data from 11 institutions, whereas there are over 400 institutions in the United States with accredited engineering programs. This raises concerns that results from MIDFIELD accurately describe what is happening at other institutions throughout the engineering education system in the USA. Multiple arguments have been made to suggest that its findings are representative of the larger system – or at least a large part of that system. These arguments are based on its size, its completeness, and the similarity of its partner institutions to those educating the majority of engineering graduates in the USA. In this work, a richer analysis of the extent to which MIDFIELD is nationally representative has been conducted based on data available from the American Society for Engineering Education (ASEE).

MIDFIELD's credibility is enhanced by its sheer size. Although MIDFIELD has been expanding to include more students and more institutions [25], the version of MIDFIELD assessed here provides longitudinal data for over 1,000,000 undergraduate students of whom over 200,000 declared engineering as a major at some point, and is the version of MIDFIELD used in various published work [6, 26–35]. Further, MIDFIELD institutions include 7 of the 50 largest U.S. engineering programs in terms of engineering bachelor's degrees awarded, resulting in a population that includes 10% of all engineering graduates of U.S. engineering programs in the period studied. The size of MIDFIELD also enables analyses that disaggregate by multiple dimensions simultaneously. The dimensions that have been disaggregated for analysis include race/ethnicity, sex, discipline, and institution. While even MIDFIELD's extraordinary size does not typically permit disaggregating all these factors simultaneously, researchers using MIDFIELD have been nationally recognized for their contribution to research recognizing the intersectionality of race/ethnicity and sex [36]. Kimberlé Crenshaw is credited with coining the term "intersectionality" to describe how multiple identities (such as Black and female) overlap in the experiences of people and should be considered rather than assuming that one identity dominates [37]. For example, the size of MIDFIELD has allowed researchers to quantitatively study the unique stories of Black females, rather than absorbing them into the stories of all "females" or "Black students".

The inclusion of whole population data in MIDFIELD also supports its generalizability. By including the academic records for all undergraduate degree-seeking students at each institutional partner during the years for which data are provided, there is no sampling bias in the data collection process within each institution.

Although MIDFIELD has already expanded to include a more diverse institutional set, the MIDFIELD institutions included in this study are all large, public, research universities with large engineering programs relative to their overall size. MIDFIELD was established in 2004 as an expansion of the Southeastern University and College Coalition for Engineering Education (the SUCCEED coalition), so the original nine institutions are all in the southeastern USA. Some geographic variability was added in 2006, when Purdue University (the current home of MIDFIELD) and the University of Colorado-Boulder were added. Thus, we expect MIDFIELD to be most representative of large public research universities with relatively large engineering programs.

Despite efforts to build confidence in the representativeness of MIDFIELD [25], predicting the behavior of the engineering education system based on a 10% sampling rate may raise concerns. The partner institutions are a non-random sample of all engineering institutions in the U.S. Since the sample is non-random, we cannot assume that it is representative of the target population (all engineering institutions in the USA). This suggests that a closer study of representativeness of MIDFIELD would be valuable.

There is no national dataset that permits a complete comparison, yet to the extent possible, in this work we will explore the congruence of MIDFIELD and data compiled by the ASEE. We will define research questions in Section 2. For the remainder of this paper, we will describe the ASEE dataset, our methods for comparing these datasets including the data sources and analysis, and results and discussion for engineering enrollment and degrees awarded by engineering overall and then for the largest five engineering disciplines. Analyses are conducted disaggregated by race-ethnicity and sex. Finally, we conclude with a summary and suggestions for future work.

1.2 The Engineering Data Management System of the ASEE

ASEE collects data on a voluntary basis from U.S. and Canadian schools offering undergraduate and graduate programs in engineering. All participating schools must have at least one four-year, ABET-accredited engineering program. Data collected through the survey is published in the online profiles and annual *Profiles of Engineering and Engineering Technology Colleges* book [38]. The stated use of these profiles by ASEE is to "allow students to compare schools using a range of characteristics from location and degrees offered to student appointments and research expenditures." The profiles are available publicly through the ASEE website, and can also be used by faculty, staff, and administrators in higher education to learn about other institutions.

The ASEE Engineering Data Management System, also known as the ASEE Data Mining Tool [39], is a query and report-writing tool that accesses the same data published in the profiles. The tool allows users to access and download data for multiple sets of schools. The Data Mining Tool is available to ASEE institutional members contributing data and on a fee basis to others.

Only a subset of the information in the ASEE's Profiles is relevant to our comparison to MIDFIELD. Specifically, we focus on engineering enrollment and degrees awarded by discipline, race/ethnicity, and sex. Though the profiles represent most institutions in the U.S., each year is an independent cross-section rather than providing longitudinal data. Thus, one can answer the question, "how many students graduated in chemical engineering in 2013?" but not "What is the graduation rate of chemical engineering students who started in 2013?" We cannot compare standardized test scores or other pre-college factors, because the ASEE dataset lacks pre-college data. We cannot directly compare graduation rates because ASEE does not have longitudinal data. A summary of both datasets is shown in Fig. 2.

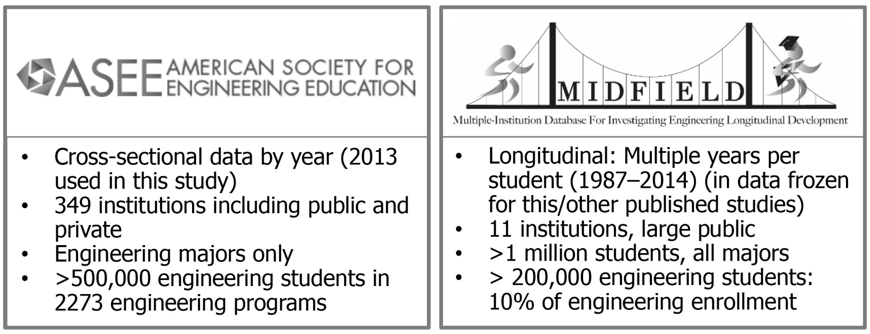

Fig. 2. Summary of ASEE and MIDFIELD Datasets.

2. Methods

As described above, both MIDFIELD and ASEE's dataset include fields not included in the other. Whereas ASEE's dataset includes information on faculty demographics, graduate students, financial aid, and other data not in MIDFIELD, MIDFIELD has a more detailed dataset than ASEE related to student pathways and outcomes. As a result, it is impossible to assess whether MIDFIELD is nationally representative on all outcomes – so we will focus on those outcomes where a reasonable comparison can be made – comparisons of fixed-frame snapshots describing student enrollment and graduation. Noting that the MIDFIELD data in this dataset spanned 1987–2014, the ASEE data from 2013 was extracted for comparison.

Since all MIDFIELD partner schools reported data to ASEE in 2013, we can evaluate these programs as a sample of all of the programs in the ASEE dataset, both in the engineering aggregate and by engineering discipline. Considering both the majors offered at the most institutions [40] and the majors with the largest student enrollments [41], we selected Mechanical Engineering, Civil Engineering, Electrical Engineering, Chemical Engineering, and Industrial/Manufacturing/Systems Engineering, as defined by ASEE, as the "top five" engineering disciplines for further study. Those five majors account for 75% of the engineering graduates in MIDFIELD and, according to the ASEE Engineering Data Management System, 61% of U.S. engineering graduates in 2013 [11]. One reason the ASEE percentage is lower is that ASEE classifications of "Electrical and Computer Engineering" and "Civil and Environmental Engineering" were not included in our calculation, for reasons discussed below.

The cross-sectional nature of the ASEE dataset imposes particular constraints on the methods used in this paper. Representativeness is measured by representation of the cohort's students disaggregated by race/ethnicity and sex in each of the disciplines at matriculation and graduation.

We have defined the following research questions:

(1) Is the demographic distribution in the ASEE data of students in MIDFIELD institutions statistically significantly different from non-MIDFIELD institutions for each of the following populations?
   (a) students enrolled in engineering programs
   (b) students graduating in engineering
   (c) students enrolled in each of the "top five" engineering disciplines
   (d) students graduating in each of the "top five" engineering disciplines

(2) Is the difference practically meaningful?

2.1 Data Source

All data in this study are from two ASEE tables: Enrollment and Degrees Awarded. One notable difference between the MIDFIELD database and the ASEE dataset is that Florida A&M University and Florida State University are reported as separate institutions in MIDFIELD, but in ASEE they are reported as one since they share a college of engineering.

In 2013, there were 414 institutions that had at least one program accredited by the Engineering Accreditation Commission [41]. Of those, 354 institutions voluntarily submitted enrollment and graduation data from 2013 to ASEE [11]. We begin with the complete ASEE dataset, which includes 587,817 students in 2273 engineering programs at 349 schools (five schools reported zero enrollment in all programs). Computer science is included as an engineering program when it is housed inside an engineering college or department. First-year engineering programs are typically counted as distinct programs that may have been classified as "Engineering (General)" or "Other Engineering Disciplines". Programs reporting zero enrollments were not included. Fifty-three programs reported enrollments but did not report race/ethnicity for any students, and these were removed from further analysis. Engineering enrollments counts are summarized in Table 1 and displayed in Fig. 3 (top).

A similar process was used for the engineering degrees awarded data (see Table 2 and Fig. 3, bottom). A total of 342 institutions were included in these calculations. Eight institutions reported race/ethnicity in their degrees awarded data, but not in their enrollment data, and three reported race/ethnicity in enrollment, but not in degrees awarded. This accounts for the difference between 337 institution used for enrollment and 342 used for degrees awarded.

In MIDFIELD, a student's specific engineering major is determined from the Department of Education's Classification of Instructional Programs (CIP) [42]. CIP codes are presented as a six-digit number representing a taxonomic scheme. The first pair of digits represent the general subject area, which for engineering is represented by 14. The second pair of digits represent various engineering disciplines, and the last pair of digits (often omitted) indicate particular specializations. For example, the code for structural engineering is 14.0803 – "14" for engineering, "08" for Civil Engineering, and "03" for structural. The top five engineering majors used in MIDFIELD analyses are Mechanical Engineering (14.19), Civil Engineering (14.08), Electrical Engineering (14.10), Chemical Engineering

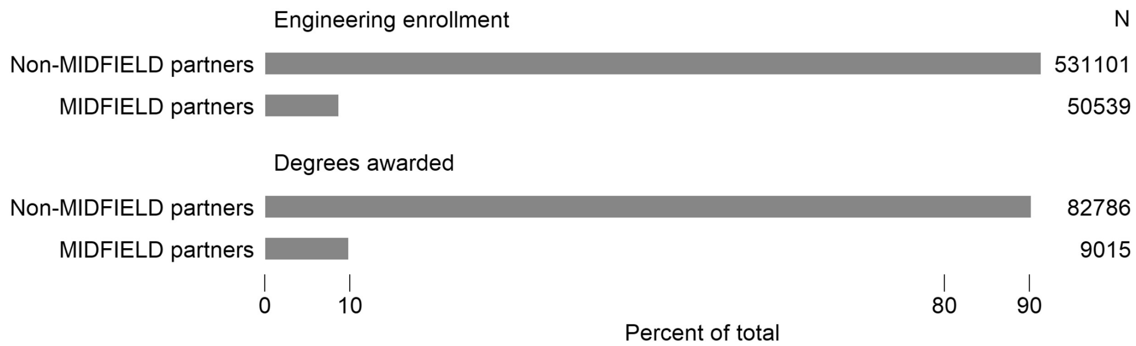

Fig. 3. ASEE 2013 Engineering Enrollment and Degrees Awarded Data for MIDFIELD and non-MIDFIELD partners.

Table 1. ASEE 2013 total engineering enrollment data used in this study

Population description	Institutions	Programs	Students
MIDFIELD partners	10	117	50539
Non-MIDFIELD partners	327	2103	531101
Total	337	2220	581640

Table 2. ASEE 2013 engineering degrees awarded data used in this study

Population description	Institutions	Programs	Students
MIDFIELD partners	10	109	9015
Non-MIDFIELD partners	332	1935	82786
Total	342	2044	91801

(14.07), and Industrial/Systems Engineering (14.35 and 14.27). ASEE does not report CIP codes, but rather broad major classifications. While the institutions reporting to ASEE would use CIP codes internally to record student degree programs, they must be reported to ASEE according to the options in ASEE's data schema.

Two of ASEE's major classifications align with those used in previous MIDFIELD studies – Chemical Engineering and Mechanical Engineering. ASEE's "Industrial/Manufacturing/Systems Engineering" classification is slightly broader than MIDFIELD's Industrial/Systems Engineering designation which includes the CIP codes for both Systems Engineering and Industrial Engineering. No MIDFIELD programs were designated as Manufacturing Engineering (CIP code 14.36). We did not include the confounded ASEE category of "Civil/Environmental Engineering" in our Civil Engineering analysis, nor "Electrical/Computer Engineering" in our Electrical Engineering analysis. Computer Engineering has been shown to have notably different outcomes from Electrical Engineering [34, 35] and conceivably, the same could be true for Civil and Environmental Engineering.

Table 3 presents number of institutions and students in the "Top 5" engineering majors in MIDFIELD and non-MIDFIELD for enrollment in 2013. Table 4 presents this information for graduates in 2013.

2.2 Analysis

To compare with previous MIDFIELD studies, students identified in ASEE data as "African American", "Asian American", "Hispanic", and "Caucasian", were selected to correspond to MIDFIELD's classifications of Black, Asian, Hispanic, and White, respectively [27]. All other students were included in the "Other" category ("Native American", "Native Hawaiian", "Foreign National", "Two or More", and "Unknown"). Foreign National students represent 9.0% of engineering enrollment at MIDFIELD institutions and 8.5% at non-MIDFIELD institutions, but no race or ethnicity information is recorded for them, so we group them with other students whose race/ethnicity is unreported or too small to disaggregate. Although we cannot meaningfully interpret these students' experiences, by including them in "Other", we can still account for their presence in the classroom and on campus. These race/ethnicity-sex categories were cross-tabulated with whether the institution was in MIDFIELD or not for both total engineering enrollment and engineering degrees awarded. Then both cross-tabulations were completed for each of the "Top 5" disciplines.

Table 3. ASEE 2013 engineering enrollment data by discipline used in this study

Discipline	Institutions			Students		
	MIDFIELD	Non-MIDFIELD	Total	MIDFIELD	Non-MIDFIELD	Total
Mechanical Engineering	10	272	282	9473	119514	128987
Civil Engineering	9	213	222	3630	53169	56799
Electrical Engineering	10	243	253	4151	52034	56185
Chemical Engineering	9	149	158	4117	40797	44914
Industrial/Manufacturing Systems Engineering	8	103	111	3996	15766	19762

Table 4. ASEE 2013 engineering degrees awarded data by discipline used in this study

Discipline	Institutions			Students		
	MIDFIELD	Non-MIDFIELD	Total	MIDFIELD	Non-MIDFIELD	Total
Mechanical Engineering	10	268	278	1934	19256	21190
Civil Engineering	9	206	215	1239	10860	12099
Electrical Engineering	10	238	248	998	9392	10390
Chemical Engineering	9	149	158	791	6814	7605
Industrial/Manufacturing/ Systems Engineering	8	102	110	871	3363	4234

For each cross-tabulation, we used the Pearson chi-square statistic to test for homogeneity. The null hypothesis is that there is no difference between MIDFIELD and non-MIDFIELD schools in the representation of each race/ethnicity-sex group. A p-value less than 0.05 indicates a statistically significant difference between the populations. The number of degrees of freedom, df, is computed by Equation (1), where R is the number of rows and C is the number of columns [43, p. 557].

$$\text{df} = (R - 1)(C - 1) \quad (1)$$

For two rows (MIDFIELD or non-MIDFIELD) and 10 columns (race/ethnicity-sex combinations), df = 9, as shown in Equation (2).

$$\text{df} = (2 - 1)(10 - 1) = 9 \quad (2)$$

A chi-square test with large sample sizes will nearly always be statistically significant, so Cramer's V is calculated as an indication of effect size. Cohen's guidelines for Cramer's V suggest that 0.1 is a small effect size, difficult to see with the naked eye; 0.3 is medium, and 0.5 is large [44, p.79]. Therefore, we consider effect sizes of 0.1 or more to be practically meaningful.

3. Results and Discussion

3.1 Engineering Enrollment

Table 5 is a cross-tabulation of total engineering enrollment by race/ethnicity-sex and whether the institution is in MIDFIELD. Columns are sorted from the largest to smallest of the total (MIDFIELD and non-MIDFIELD). A Pearson chi-square test rejects the null hypothesis that engineering enrollment in MIDFIELD and non-MIDFIELD schools is similar by race/ethnicity-sex ($\chi^2 = 2130$, df = 9, $p < 0.0005$), while the Cramer's V value of 0.061 indicates that the relationship between race/ethnicity-sex and MIDFIELD partnership is not practically meaningful. Overall, the race/ethnicity-sex demographics of engineering stu-

Table 5. Engineering enrollment by race/ethnicity-sex and MIDFIELD partnership

	Percent of Engineering Enrollment									
	White Male	Other Male	White Female	Hispanic Male	Asian Male	Black Male	Other Female	Asian Female	Hispanic Female	Black Female
MIDFIELD (n = 50,539)	50.1%	10.5%	13.5%	5.6%	6.7%	4.6%	3.1%	2.2%	1.8%	1.9%
non-MIDFIELD (n = 531,101)	46.7%	12.4%	10%	9.3%	8.6%	3.8%	3.1%	2.6%	2.4%	1.1%
Difference	*3.4%*	*–1.9%*	*3.5%*	*–3.7%*	*–1.9%*	*0.8%*	*0%*	*–0.4%*	*–1.6%*	*0.8%*

Table 6. Engineering degrees awarded by race/ethnicity-sex and MIDFIELD partnership

	Percent of Engineering Degrees Awarded									
	White Male	**Other Male**	**White Female**	**Asian Male**	**Hispanic Male**	**Black Male**	**Other Female**	**Asian Female**	**Hispanic Female**	**Black Female**
MIDFIELD (n = 9,015)	53.6%	9.6%	12.5%	8.0%	4.4%	4.6%	2.3%	2.0%	1.3%	1.6%
non-MIDFIELD (n = 82,786)	50.6%	11.0%	10.5%	9.5%	7.1%	2.8%	3.0%	2.8%	1.9%	0.9%
Difference	*3.0%*	*–1.4%*	*2.0%*	*–1.5%*	*–2.7%*	*1.8%*	*–0.7%*	*–0.8%*	*–0.6%*	*0.7%*

dents at MIDFIELD partner schools is similar to the race/ethnicity-sex demographics of engineering students at non-MIDFIELD schools.

3.2 Engineering Degrees Awarded

Degrees awarded by race/ethnicity-sex and whether the institution is in MIDFIELD are tabulated in Table 6. Columns are sorted from the largest to smallest of the total (MIDFIELD and non-MIDFIELD). Again, the differences are statistically significant (χ^2 =318, df = 9, $p < 0.0005$) but not practically meaningful (Cramer's V = 0.063). Overall, the race/ethnicity-sex demographics of engineering students receiving engineering degrees at MIDFIELD partner schools is similar to those of students at non-MIDFIELD schools.

3.3 Enrollment by Discipline

For each of the top five disciplines, the race/ethnicity-sex and whether the institution is in MIDFIELD are tabulated in Table 7. Note that the order of groups is different in each discipline because the ranking of representation varies. In all five disciplines, White males are the most prevalent group and Black females are the least prevalent. Mechanical and Electrical Engineering are particularly male-dominant. In Electrical Engineering, there are more of the least represented male group (Hispanic males for MIDFIELD and Black males for non-MIDFIELD) than the most represented female group (White females). Mechanical is not only majority White and majority male, it is majority White male in both MIDFIELD and non-MIDFIELD.

Chi-square tests showed that the MIDFIELD enrollment distribution was significantly different than non-MIDFIELD in each of the top five fields (details in Table 8). Table 8 also includes the effect size (Cramer's V), which was not practically meaningful for four of the five disciplines. For Industrial/Manufacturing/Systems Engineering, the effect size just barely reached our cutoff for practical meaningfulness. The populations with the largest differences between MIDFIELD and non-MIDFIELD for Industrial/Manufacturing/Systems Engineering are White females who have a larger percentage in MIDFIELD than non-MIDFIELD and Hispanic males who have a lower percentage in MIDFIELD (Table 7). This may be due to the inclusion of Manufacturing Engineering in non-MIDFIELD but not MIDFIELD schools. Manufacturing Engineering has been shown to be more male-dominated (85%) than Industrial Engineering (70%) or Systems Engineering (80%), according to NCES counts of Bachelor's degrees [45]. Although NCES provides a variety of tables disaggregated by race/ethnicity and sex, there are no public-access tables that disaggregate by race/ethnicity and discipline.

3.4 Degrees awarded by Discipline

Degrees awarded in each of the top five disciplines, the race/ethnicity-sex and whether the institution is in MIDFIELD are tabulated in Table 9. Groups are ordered by their representation in the complete ASEE dataset. Many of the enrollment patterns seen in Table 8 are repeated in the degrees awarded data in Table 9. Specifically, in every discipline, White males are the most prevalent group and Black females are the least prevalent. Mechanical and Electrical Engineering are particularly male-dominated. In Electrical Engineering, there are more degrees awarded to the least represented male group than the most represented female group, overall, although there are more White females than Hispanic males in Electrical Engineering at MIDFIELD schools. Mechanical and Civil Engineering are majority White male. One difference is that Hispanic males are less prevalent among graduates than enrollees.

Chi-square tests show that the MIDFIELD distribution of degrees awarded was significantly different than non-MIDFIELD distribution in each of the top five disciplines, but the difference was not practically meaningful in any discipline (Table 10).

Overall, our analysis shows that the demographic distributions of engineering matriculants and graduates in MIDFIELD institutions are similar to those distributions in non-MIDFIELD institutions in the ASEE data. When disaggregating into disciplines, the only case where a practically meaningful difference was observed was in Industrial Engineering enrollment. The effect size was small, meaning that it would be difficult to see the demo-

Table 7. Engineering enrollment in the top 5 disciplines by race/ethnicity-sex and MIDFIELD partnership

	Percent of Mechanical Engineering Enrollment									
	White Male	**Other Male**	**Hispanic Male**	**White Female**	**Asian Male**	**Black Male**	**Other Female**	**Hispanic Female**	**Asian Female**	**Black Female**
MIDFIELD (n = 9,473)	59.5%	11.8%	6.2%	8.6%	5.6%	3.8%	1.6%	1.1%	1.0%	0.8%
non-MIDFIELD (n = 119,514)	56.0%	12.2%	9.7%	7.5%	6.2%	3.4%	1.7%	1.6%	1.1%	0.7%
Difference	*3.5%*	*–0.4%*	*–3.5%*	*1.1%*	*–0.6%*	*0.4%*	*–0.1%*	*–0.5%*	*–0.1%*	*0.1%*
	Percent of Civil Engineering Enrollment									
	White Male	**White Female**	**Hispanic Male**	**Other Male**	**Asian Male**	**Hispanic Female**	**Black Male**	**Other Female**	**Asian Female**	**Black Female**
MIDFIELD (n = 3,630)	53.7%	14.5%	6.1%	9.4%	3.0%	1.9%	4.7%	2.8%	1.4%	2.5%
non-MIDFIELD (n = 53,169)	45.4%	11.4%	11.9%	10.9%	6.0%	4.1%	3.7%	3.2%	2.2%	1.2%
Difference	*8.3%*	*3.1%*	*–5.8%*	*–1.5%*	*–3.0%*	*–2.2%*	*1.0%*	*–0.4%*	*–0.8%*	*1.3%*
	Percent of Electrical Engineering Enrollment									
	White Male	**Other Male**	**Hispanic Male**	**Asian Male**	**Black Male**	**White Female**	**Other Female**	**Asian Female**	**Hispanic Female**	**Black Female**
MIDFIELD (n = 4,151)	47.0%	17.2%	6.2%	9.8%	7.3%	5.1%	3.2%	1.7%	0.9%	1.6%
non-MIDFIELD (n = 52,034)	42.9%	15.8%	12.0%	11.4%	6.3%	4.8%	2.3%	1.8%	1.5%	1.2%
Difference	*4.1%*	*1.4%*	*–5.8%*	*–1.6%*	*1.0%*	*0.3%*	*0.9%*	*–0.1%*	*–0.6%*	*0.4%*
	Percent of Chemical Engineering Enrollment									
	White Male	**White Female**	**Other Male**	**Asian Male**	**Hispanic Male**	**Other Female**	**Asian Female**	**Hispanic Female**	**Black Male**	**Black Female**
MIDFIELD (n = 4,117)	43.1%	20.4%	8.4%	6.8%	5.3%	4.3%	2.9%	2.9%	3.0%	2.8%
non-MIDFIELD (n = 40,797)	40.9%	18.1%	10.8%	7.6%	5.5%	5.3%	4.1%	3.5%	2.5%	1.8%
Difference	*2.2%*	*2.3%*	*–2.4%*	*–0.8%*	*–0.2%*	*–1.0%*	*–1.2%*	*–0.6%*	*0.5%*	*1.0%*
	Percent of Industrial/Manufacturing/Systems Engineering Enrollment									
	White Male	**White Female**	**Other Male**	**Hispanic Male**	**Asian Male**	**Other Female**	**Hispanic Female**	**Black Male**	**Asian Female**	**Black Female**
MIDFIELD (n = 3,996)	35.4%	19.0%	13.0%	5.4%	7.4%	5.3%	3.3%	4.7%	3.9%	2.7%
non-MIDFIELD (n = 15,766)	37.6%	14.6%	15.0%	9.3%	5.7%	5.1%	5.2%	3.4%	2.4%	1.7%
Difference	*–2.2%*	*4.4%*	*–2.0%*	*–3.9%*	*1.7%*	*0.2%*	*–1.9%*	*1.3%*	*1.5%*	*1.0%*

Table 8. Statistics comparing enrollment distribution of race/ethnicity-sex by MIDFIELD partnership in top five engineering disciplines

		Chi-Square Tests (df = 9)		
Discipline	**Enrollment**	**Pearson Chi-Square Value**	**Asymptotic Significance (2-sided)**	**Cramer's V**
Mechanical Engineering	128987	175.764	<0.0005	0.037
Civil Engineering	56799	344.819	<0.0005	0.078
Electrical Engineering	56185	178.807	<0.0005	0.056
Chemical Engineering	44914	83.437	<0.0005	0.043
Industrial/Manufacturing/Systems Engineering	19762	202.503	<0.0005	0.101

Table 9. Degrees awarded in the top 5 disciplines by race/ethnicity-sex and MIDFIELD partnership

	Percent of Mechanical Engineering Degrees									
	White Male	**Other Male**	**White Female**	**Asian Male**	**Hispanic Male**	**Black Male**	**Other Female**	**Asian Female**	**Hispanic Female**	**Black Female**
MIDFIELD (n = 1,934)	63.4%	8.7%	8.2%	7.1%	5.0%	3.9%	1.2%	0.7%	0.8%	0.9%
non-MIDFIELD (n = 19,256)	60.7%	9.7%	7.9%	7.3%	7.5%	2.4%	1.5%	1.2%	1.3%	0.6%
Difference	*2.7%*	*–1.0%*	*0.3%*	*–0.2%*	*–2.5%*	*1.5%*	*–0.3%*	*–0.5%*	*–0.5%*	*0.3%*
	Percent of Civil Engineering Degrees									
	White Male	**White Female**	**Hispanic Male**	**Other Male**	**Asian Male**	**Hispanic Female**	**Black Male**	**Other Female**	**Asian Female**	**Black Female**
MIDFIELD (n = 1,239)	58.4%	14.4%	5.3%	7.3%	4.9%	1.9%	4.1%	1.6%	1.5%	0.6%
non-MIDFIELD (n = 10,860)	52.0%	12.6%	9.3%	8.4%	6.9%	2.9%	2.4%	2.5%	2.3%	0.7%
Difference	*6.4%*	*1.8%*	*–4.0%*	*–1.1%*	*–2.0%*	*–1.0%*	*1.7%*	*–0.9%*	*–0.8%*	*–0.1%*
	Percent of Electrical Engineering Degrees									
	White Male	**Other Male**	**Asian Male**	**Hispanic Male**	**Black Male**	**White Female**	**Other Female**	**Asian Female**	**Hispanic Female**	**Black Female**
MIDFIELD (n = 998)	49.1%	16.9%	11.8%	3.4%	7.2%	5.4%	2.2%	1.3%	0.9%	1.7%
non-MIDFIELD (n = 9,392)	45.9%	14.7%	12.4%	9.5%	5.3%	4.7%	3.1%	2.2%	1.2%	1.0%
Difference	*3.2%*	*2.2%*	*–0.6%*	*–6.1%*	*1.9%*	*0.7%*	*–0.9%*	*–0.9%*	*–0.3%*	*0.7%*
	Percent of Chemical Engineering Degrees									
	White Male	**White Female**	**Other Male**	**Asian Male**	**Other Female**	**Asian Female**	**Hispanic Male**	**Hispanic Female**	**Black Male**	**Black Female**
MIDFIELD (n = 791)	47.7%	19.6%	7.1%	7.8%	3.8%	3.5%	4.0%	1.0%	2.9%	2.5%
non-MIDFIELD (n = 6,814)	42.9%	18.1%	9.2%	8.6%	5.2%	4.9%	4.5%	3.1%	2.4%	1.1%
Difference	*4.8%*	*1.5%*	*–2.1%*	*–0.8%*	*–1.4%*	*–1.4%*	*–0.5%*	*–2.1%*	*0.5%*	*1.4%*
	Percent of Industrial/Manufacturing/Systems Engineering Degrees									
	White Male	**White Female**	**Other Male**	**Asian Male**	**Hispanic Male**	**Other Female**	**Hispanic Female**	**Black Male**	**Asian Female**	**Black Female**
MIDFIELD (n = 871)	36.4%	14.1%	14.9%	10.1%	5.7%	5.4%	2.6%	4.2%	3.6%	2.9%
non-MIDFIELD (n = 3,363)	38.8%	15.0%	14.1%	7.4%	7.6%	5.6%	4.6%	2.9%	2.4%	1.6%
Difference	*–2.4%*	*–0.9%*	*0.8%*	*2.7%*	*–1.9%*	*–0.2%*	*–2.0%*	*1.3%*	*1.2%*	*1.3%*

Table 10. Statistics comparing distribution of degrees awarded by race/ethnicity-sex and MIDFIELD partnership in top five disciplines

		Chi-Square Tests			
Discipline	**Degrees Awarded**	**Pearson Chi-Square Value**	**df**	**Asymptotic Significance (2-sided)**	**Cramer's V**
Mechanical Engineering	21190	44.696	9	<0.0005	0.046
Civil Engineering	12099	62.805	9	<0.0005	0.072
Electrical Engineering	10390	61.235	9	<0.0005	0.077
Chemical Engineering	7605	36.499	9	<0.0005	0.069
Industrial/Manufacturing/Systems Engineering	4234	30.607	9	<0.0005	0.085

graphic differences by casual observation. An example of a small effect size is the difference in height between 15- and 16-year old girls [44, p. 26].

4. Conclusion

Overall, we conclude that the demographics of the MIDFIELD institutions at matriculation and graduation are a reasonable representation of the demographics of engineering students in the broader sample of institutions in the USA based on the more comprehensive, but not longitudinal, ASEE dataset. The size of datasets such as ASEE and MIDFIELD provides statistical power to detect small differences, even smaller than those of practical value, so we used effect size to establish the relevance of those differences. The large size of such datasets also enables disaggregation across multiple dimensions simultaneously, so our conclusion of congruence is valid in an intersectional sense. As expected, all differences were statistically significant, but the demographic differences between MIDFIELD and non-MIDFIELD institutions were not practically meaningful in students enrolled in engineering programs, students graduating in engineering, or students graduating in each of the "top five" engineering disciplines (Mechanical, Civil, Electrical, Chemical, and Industrial/Systems/ Manufacturing). Among students *enrolled* in each of the "top five" engineering disciplines, there was a small difference between MIDFIELD and non-MIDFIELD populations in Industrial/Systems/ Manufacturing Engineering. Cross-sectional data from the NCES [45] shows that Manufacturing Engineering, which is not represented in MIDFIELD, is more male-dominated than Industrial Engineering and Systems Engineering, which is consistent with our findings that most female groups (White, Asian, Black, and Other) were more prevalent in MIDFIELD while most male groups (Hispanic, White, and Other) were more prevalent in non-MIDFIELD schools. Our intersectional approach showed it is important to consider both race/ethnicity and sex since it is not true that "all females" or "all males" had the same pattern. There may be factors unique to Hispanic females, Black males, and Asian males that affect academic choices and outcomes.

To support further disaggregation and generalizability, we are working to expand MIDFIELD to include regional diversity, private institutions, and Hispanic-serving institutions (HSIs) in particular. As the dataset grows, future work can include further disaggregation of disciplines, such as Industrial/Systems/Manufacturing, and inclusion of race/ ethnicities that are currently too small to disaggregate. There is also an opportunity to study the experience of international students, who, while they are a confounded group of people from various cultures and language fluencies, still share some common experience and certainly contribute to educational experience of domestic students. In addition to broadening the representation of students in MIDFIELD, we seek to broaden the pool of researchers using MIDFIELD. To this end, we have made a version of MIDFIELD that includes a stratified sample from four institutions available as an R data package through github at https://midfieldr.github.io/midfielddata/. Computational tools for working with the database are also available in a separate R package. A wider pool of researchers using an expanded MIDFIELD would allow for more high quality intersectional investigations of student persistence, retention, and success at the course, degree program, and disciplinary level. In particular, there is an opportunity for a much deeper exploration of MIDFIELD's extensive repository of course data. The rich data available in MIDFIELD can help answer important questions for engineering education and inform future research.

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