Work In Progress: Development of a Taxonomy of Undergraduate Engineering Admissions Practices and Protocols

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Introduction

Undergraduate engineering admissions has a profound influence on engineering participation as the entry point to higher education programs but has been largely unstudied and unquestioned. This is particularly concerning because engineering has been plagued by an imbalance in participation across demographics at every stage from higher education to industry [1]. Significant research has examined this issue in the context of engineering classrooms [2], majors [3], and other institutional policies, procedures, and support [4], [5], but less frequently focuses on undergraduate admissions. This gap is troublesome given the known inequity in pre-college access to experiences valued in admissions and practices of admissions offices that run counter to the goal of increasing enrollment in engineering [6]–[8].

Existing undergraduate engineering admissions research has predominantly coalesced around evaluating the correlation between standardized testing (e.g., SAT and ACT) or grade point average (GPA) and college academic performance [9]. A weak correlation between standardized testing and future performance is well-documented and important to the growing test-optional movement [10]–[12]. Nascent work focuses on non-cognitive and affective factors (NCA) that are more reliably correlated to postsecondary academic success [13]–[15]. However, these factors are studied in students post-matriculation, and manipulation of admissions procedures to prioritize such factors has predominantly been applied to graduate admissions [16], [17]. Alignment between post-matriculation success metrics and undergraduate admissions protocols would benefit from additional research into the latter. Undergraduate engineering admissions representatives use private methods to assess the qualifications of high school applicants [18]. This secretive enterprise has resulted in a lack of scholarship in engineering education to understand how undergraduate admissions occurs and how it shapes who becomes an engineer.

As legal judgments like the recent Supreme Court ruling in *Students for Fair Admissions, Inc. v President & Fellows of Harvard College* restrict admissions protocols, there is a burgeoning importance to understand the new processes that emerge as a result. Undergraduate admissions processes vary across institutions; however, there is no current coherent framing of admissions practices in the engineering education research community. Conceptual, qualitative classifications in social sciences, like taxonomies, enable researchers to understand and analyze complex systems [19]. A taxonomy of undergraduate engineering admissions will enable a shared classification to accelerate research and triangulate findings across studies.

In this work in progress, the initial steps towards developing a taxonomy of engineering admissions (TEA) are detailed. First, literature on bias in undergraduate engineering admissions is briefly surveyed as motivation for research that could be supported by the TEA. Then, the method of data collection to develop the taxonomy is elucidated. Initial exploratory data analysis then precedes a discussion of ongoing and future development of the final taxonomy. Altogether, this work seeks to answer the following research questions: What student data are required for admission and how are these data assessed by U.S. ABET-accredited engineering programs?

How do such requirements and assessments vary by institution type? How widespread are requirements and assessments that are biased against prospective engineers?

Addressing Bias in Engineering Admissions

Bias within engineering admissions reviews can exist in both institutional and personal/implicit forms. Personal bias of admissions reviewers has been illustrated by studies that identify more favorable assessments or ratings of applications by reviewers who shared an identity (i.e., race/ethnicity, socioeconomic status [SES]) with the applicant [20], [21]. Institutional bias arises in admission processes and systems. For example, standardized tests are known to be biased based on gender, race/ethnicity, and socioeconomic status, and the prioritization of this metric in an admissions review is a form of institutional bias [22]–[24]. Holloway et al. [8] identified gender bias in one institution's engineering admissions process, which admitted more men applicants despite higher GPAs and scores on most sections of standardized tests by women applicants.

Some studies have investigated ways to mitigate the disparate impacts of bias in admissions, mostly focusing on standardized testing [8], [25]. Carnegie Mellon University's School of Computer Science identified that removing consideration of prior hands-on computing experience increased the proportion of incoming women [26], [27]. A few examples exist that identify alternative metrics for admissions, including consideration of non-cognitive factors or a socioeconomic factor [8], [28], [29]. Efforts to adapt engineering admissions have also taken place at the graduate school level, but those admissions processes differ significantly from the ones encountered by high school students [16], [30]. One of the most widely considered components in admissions reviews beyond high school transcripts is high school extracurricular involvement, which is influenced directly by societal norms and access provided by a student's K-12 environment [31]. Decreased participation in various STEM extracurricular activities was found in low-SES students, who represent a smaller proportion of the student population as admissions selectivity increases and for whom the predictive power of standardized test scores for college performance is reduced [23], [32]–[34].

Data Collection

The comprehensive data set necessary to develop the TEA requires compiling the information detailed in Figure 1. "Admissions Experience" data include information that dictates the pathway a student must follow to enter the admissions process, along with special programs offered (e.g., engineering learning communities). Data categorized as "Student Data" include pieces of personal and educational information requested from the applicant, either through the application (e.g., demographic information and essays) or third-party submission (e.g., transcript and recommendations). Specifications regarding minimum qualifications, such as required coursework or minimum GPA, are also pertinent. These data capture the scope of information used by the admissions office to determine an admissions decision. "Admissions Review" data encompass how an admissions decision is determined based on a review of the "Student Data" through an institution-specific protocol. Finally, Institutional Characteristics, including size/enrollment, student demographics, and location are necessary to correlate the admissions data to institutional qualities. Collectively, these data represent a start-to-finish snapshot of the undergraduate admissions process that addresses the roles of all parties/individuals involved.

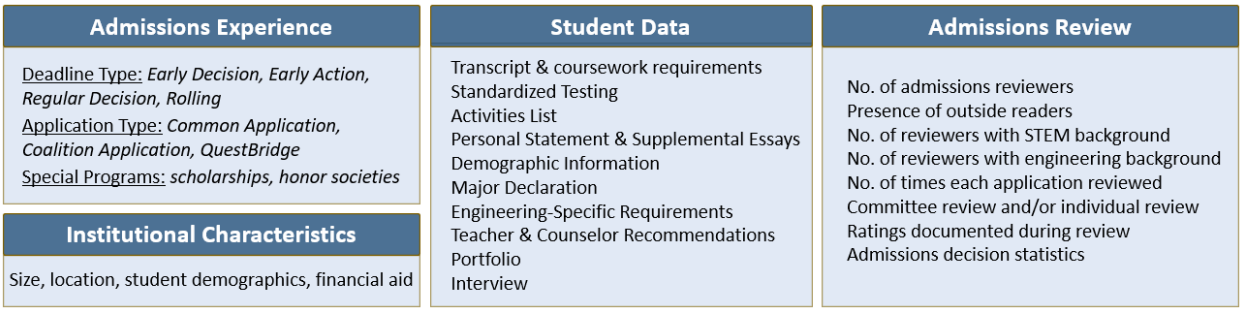

Figure 1. Categorization of comprehensive data sought for taxonomy development.

Data collection began by exporting a list of all U.S. institutions that grant bachelor's degrees accredited by the Engineering Accreditation Commission (EAC) of ABET. Individual websites of the office of undergraduate admissions at each institution were reviewed for Admissions Experience, Student Data, and Admissions Review material. These websites are the primary source of information for prospective students; thus, each contains a plethora of information from deadlines to application type to required materials. Admissions Experience and Student Data were also collected through direct study of the applications to engineering programs at each university. The applications yielded data only available on the application (e.g., demographic information, essays, major selection, etc.) and served as an opportunity to verify potentially out-of-date data on admissions websites.

Remaining data from the Admissions Review category will be sourced through direct contact with undergraduate admissions offices via email and/or phone. Contact with admissions staff will be sought to learn about the admissions review protocol, as well as verify the accuracy of the data collected from websites and applications. Admissions reviews may differ by the number of times each application is read, documentation/notes taken, rating/rubrics applied, and whether decisions are made by individuals or a collective of admissions counselors called a "committee."

Institutional Characteristics that will be used to analyze the groupings of engineering admissions pathways by institution type will be partially collected from the sources above, with the remainder sourced from the National Center for Education Statistics (NCES) and profiles held by the American Society for Engineering Education (ASEE) [35], [36]. NCES contains an array of historical data from each U.S. institution including standardized test score ranges of accepted students, institutional characteristics (e.g., public or private, average cost of attendance), enrollment information, graduation rates, and more. This rich source of data can be supplemented by profiles submitted to ASEE by participating institutions, which contain similar data to the NCES database, as well as faculty demographics.

Preliminary Findings

The list of institutions accredited by the EAC of ABET was exported to establish the scope of data collection. Following the removal of duplicate listings and institutions that are no longer accepting applications, 498 institutions comprised the list for data collection. A single institution/program may accept multiple applications (186 institutions accept one application, 265 accept two, 45 accept three, and 2 accept four) and due to some degree programs that accept the same application as another, a total of 849 applications were reviewed. All data available on public websites and applications, encompassing the Admissions Experience and Student Data

categories above, were documented and links to the data source were recorded for all individual items. Next, reports of the data collected will be sent to each institution's office of undergraduate admissions for validation/confirmation of accuracy and to learn about necessary edits. Additional items will be added to a survey that probe the Admissions Review information to finalize the data collection.

While the publicly available data that was collected awaits verification by each institution, initial exploratory analysis of the data has commenced to seek the prevalence of policies or practices across the undergraduate engineering admissions landscape. Early Decision application deadlines in which a student is required to attend (also called "binding") if accepted have been shown to decrease the diversity (e.g., racial/ethnic, geographic) of the incoming student cohort and perpetuate inequities that extend past admissions and into the undergraduate educational journey [37], [38]. Of the 498 institutions studied, 74 (14.9%) offer at least one Early Decision deadline, 166 (33.3%) offer at least one non-binding Early Action deadline, 197 (39.6%) offer at least one Regular Decision deadline, and 317 (63.7%) offer a Rolling Admissions deadline. It is important to note that each institution may offer more than one deadline type. Due to a combination of known bias and challenges associated with the COVID-19 pandemic, the number of test-optional institutions that accept but do not require standardized tests has increased in recent years [12]. Of the institutions studied for this taxonomy, 337 (67.7%) are currently test-optional in the 2023-2024 admissions cycle, while 68 (13.7%) are test-free, meaning they do not consider test scores in the admissions process.

Exploratory analyses have also focused on application components that invite students to share content by explicitly focusing on engineering or STEM experiences. For example, 15 out of the 849 reviewed applications (3.0%) invite applicants to share a portfolio that includes creative STEM content (sometimes referred to as "maker" content). Prior studies have hypothesized that the inclusion of portfolios in admissions can reduce the bias of standardized tests, but portfolios remain most-commonly requested of applicants to preforming or visual arts programs [39]. Written essays that invite applicants to share a personal perspective or insight are more commonly requested in applications than portfolios. The application review revealed that 57 applications (6.7%) contained essay questions that explicitly invited applicants to comment on engineering or STEM experiences, 44 (5.2%) of which contained an essay asking the students to explain their interest in the major selected on the application.

Proposed Future Work

To instigate the formation of the taxonomy, data from publicly available sources, including institutional websites and applications, were collected. That data will be shared with each individual institution to verify accuracy. Though the collected data represents the admissions policies as expressed on a website or application, the verification step may reveal differences in praxis that supersede the publicly-described policy. For example, an institution may use the term "Regular Decision" for their deadline yet make decisions on a rolling basis, such that Rolling Admissions would be a more accurate characterization of the experience of a student applicant. Along with verification of data gathered from public sources, additional data related to decision-making policies/practices (categorized above as "Admissions Review") will be collected via a survey of admissions staff at each institution.

Creation of the final TEA will begin upon receipt of the full data set described above. Development of the taxonomy will follow the 2022 method of Kundisch et al. that updated the 2013 approach of Nickerson et al. and will adapt the method to the undergraduate admissions context, rather than that of information systems [40]–[42]. The iterative method will include identification of target users, definition of objectives, iterative design, and evaluation. Following the creation of the taxonomy, exploratory data analysis of the taxonomy by classification level will be conducted. For example, correlations between institution size and the presence of a committee-based decision-making protocol may reveal patterns in admissions processes across institutions. Additional analyses will seek to discover the prevalence of biased practices in the engineering undergraduate admissions landscape. Finally, the taxonomy will be made available via a free, online resource for the benefit of those who seek to research undergraduate engineering admissions or to analyze the practices of undergraduate engineering admissions.

Implications and Conclusion

This work in progress presents the advancements towards the development of a taxonomy of undergraduate engineering admissions policies and practices. Data that was collected from publicly-available websites and admissions applications will be verified with each institution as additional data regarding application review practices is gathered. Together, the data will provide a broad snapshot of the current admissions practices as experienced by engineering applicants to undergraduate programs and as practiced by admissions professionals. The taxonomy under development aims to advance the understanding of the under-studied realm of undergraduate engineering admissions, support additional research in engineering admissions (e.g., assist researchers in identifying wide-spread practices for further investigation), and inform practices of admissions counselors who review applicants of prospective engineers.

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