Equitable Attainment of Engineering Degrees: A Tri-University Study and Improvement Effort

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Equitable Attainment of Engineering Degrees: A Tri-University Study and Improvement Effort (Work in Progress)

Abstract

In this paper we describe a work in progress tri-university study that focuses on increasing the equitable attainment of engineering degrees and improving four-year graduation rates in five engineering disciplines; a challenge that is increasingly difficult at four-year institutions. Using Kotter's Change Model to guide this study, we (1) evaluate how various engineering disciplines differ regarding the curriculum and instruction they tend to offer, (2) measure how the differences in curriculum and instruction between disciplines impact time-to-degree and student success across student demographic groups, and (3) evaluate the systemic inequities built into the respective engineering disciplines due to curricular structure and/or instructional design. To accomplish these aims, we first collected curricular structure, student performance, and demographic data which identified equity gaps that showed the urgent need to address demographic discrepancies between state, university, and engineering discipline populations. This data identified inequities leading to delayed graduation, however, data and analytics alone is not enough to catalyze change.

Next, we describe how we built a guiding coalition by establishing learning communities to empower faculty to create impactful change in curricular structure and design to improve four-year graduation in engineering disciplines. These learning communities are made up of faculty across five engineering disciplines at the University of Arizona, the University of California San Diego, and the Georgia Institute of Technology. Faculty in the learning communities discuss data including curricular complexity, student progress and outcomes, student demographics, factors impacting time-to-degree, and institution-specific characteristics to collaboratively identify areas and mechanisms to improve equitable attainment of engineering degrees. Through these discussions faculty develop a vision and strategy for addressing equity gaps and improving four-year graduation rates in engineering disciplines.

By communicating this vision and strategy to provosts, vice chancellors, deans, and department heads from participating universities we can remove obstacles such as data and analytics support at each institution. Empowering faculty to be the catalyst for change creates short term wins and consolidates long term gains. Moving forward we will continue to institutionalize positive changes within the cultures of our universities. In this session, we will share best practices in learning community formation and training as well as results showing how demographic and complexity factors are linked to time to degree and on time graduation.

Introduction

When a student pursues higher education there is an assumption that the student will earn their bachelor's degree within four years. However, far too often, students take longer than the assumed four-year time frame. Although time-to-degree is an admittedly arbitrary measure of student success, it does provide insight into student access. Engineering degrees taking more time to complete does have an inequitable impact when you consider who is able to afford the

expenses associated with additional time in college, and the negative impact a longer time-to-degree can have on post-college earnings [1], [2], [3].

Students come from a wide variety of backgrounds, with different access to resources and academic preparation, but universities remain inflexible to their educational approach. A student's academic journey can be delayed in several ways whether that be financial burden, familial obligations, or academic challenges [4], [5], [6], [7]. With students often finding a need to juggle several responsibilities at once, their academic program's curricular complexity only diminishes a student's margin of error for on time degree completion [8], [9], [10]. In trying to address student barriers, decrease curricular complexity, and improve time-to-degree, to increase overall access, one challenge involves overcoming the tenure and promotion demands that often conflict with service and teaching work involving curricular reform and equitable attainment of degrees [11], [12], [13]. This creates a challenge in generating faculty buy-in, signaling a need for further structural change.

This study focuses on increasing the equitable attainment of engineering degrees and improving four-year graduation rates in five engineering disciplines and aims to (1) evaluate how various engineering disciplines differ regarding the curriculum and instruction they tend to offer, (2) measure how the differences in curriculum and instruction between disciplines impact time-to-degree and student success across student demographic groups, and (3) evaluate the systemic inequities built into the respective engineering disciplines due to curricular structure and/or instructional design.

To accomplish these aims we first examined each participating institutions' curriculum in Aerospace Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial Engineering, and Mechanical Engineering and identified differences in instruction. Next, in partnership with faculty learning communities, we analyzed student performance and outcome data to identify where differences in curriculum and instruction impacts time-to-degree. Lastly, using the information gathered in aims one and two, we evaluate if the curriculum structure and design at each institution creates systemic inequities impacting time-to-degree within engineering disciplines.

Two of the key components of this study are to work with faculty learning communities to analyze student performance data and curricular complexity data. Curricular complexity measures how easily a student may progress through a curriculum towards graduation. It is a function of structural complexity, how curriculum is structured, instructional complexity, and how instruction is taught and supported within a curriculum [8]. Ultimately, the more complex a curriculum pathway is, the less likely it is that a student would graduate on time [8], [9], [10]. By reducing the complexity of the structural design of the curriculum, the likeliness of on-time degree completion would increase.

Learning communities are made up of faculty from each of the five engineering disciplines listed above from each participating institution. There are both internal learning communities where faculty from the same institution can work together to analyze their own data, as well as discipline based cross-university learning communities. These groups include faculty from the same engineering discipline at each university. Through these learning communities a trained

facilitator leads discussions to analyze curricular structure and student performance data, and discussions involve developing a vision and strategy for change.

Theoretical Framework

This study calls for creating change within institutions to improve equity and access in obtaining engineering degrees. Therefore, Kotter's change model was chosen to serve as the theoretical framework for this study. Kotter's change model uses an 8-step approach to systematically implement change [14]. These 8 steps include creating a sense of urgency, creating a powerful guiding coalition, building a vision and strategy, communicating the vision, removing obstacles, creating short term wins, consolidating gains, and implementing change within culture [14]. Table 1 describes how this study uses these steps throughout its methodology.

Table 1: Using Kotter's Change Model in Study Methodology

Kotter's Change Model Steps	Study Design Methodology
Creating urgency	• Engineering disciplines remain some of the least diverse fields in STEM, featuring significant differences between engineering colleges and state and university populations [15]
Form a powerful guiding coalition	• Endorsed by top academic administrators at each institution, this study has a coalition to guide it. • Utilize learning communities that include faculty at all participating institutions in each of the engineering disciplines.
Develop a vision and strategy	• While this study has formed an overarching vision to build a framework to improve equity in engineering, this project utilizes learning communities to allow faculty to be the catalyst in developing a vision and strategy for change using the data we collect
Communicate the vision	• The overarching vision and plan were communicated to faculty by administrators from each university during faculty recruitment.
Remove obstacles	• The heavy lift of data collection was reduced by including institutional analytical support at each institution's institutional research office.
Create short-term wins	• Empowering faculty to participate and be the catalyst for change within their own programs
Consolidate gains	• By coming together regularly, faculty can share their strategies of success for other programs at participating institutions to learn from
Anchor change in culture	• Faculty buy-in is key to institutional curricular change. By gaining buy-in from faculty, they can be the catalyst for that change.

As evidenced in Table 1, learning communities are the key to using Kotter's change model successfully in this study. Through these learning communities, faculty are the catalyst for change. They can analyze data from within their own institutions, and then work with partner institutions to better understand how their students and curricular design compare and could potentially be improved. Through this experience they can lead the development and overall implementation of a vision and strategy for improving equity in engineering education outcomes.

Methodology and Data Analysis

Utilizing a pragmatic approach, this study used a sequential mixed methods design to identify best practices in improving the equitable attainment of engineering degrees. The first step was to collect curricular structure, student performance, and demographic data which identified equity gaps that showed the urgent need to address demographic discrepancies between state, university, and engineering discipline populations. A description of the specific student performance data we collected can be found in Table 2.

Before faculty were able to review the data that was collected, they participated in a one-hour workshop aimed at learning how to analyze student performance with an equity lens. Next, we brought faculty from all three institutions together for a two-day workshop to serve as the start of the learning community process. Here, faculty were able to analyze the data and begin identifying where change would be most needed, impactful, and practical.

Faculty had the chance to meet internally with a trained learning community facilitator to analyze and reflect on their own program's data. After faculty were able to analyze their own student performance and curricular complexity data, faculty had the opportunity to meet in discipline-specific groups. For example, all participating mechanical engineering faculty at each university met to share their data and how they made sense of the data.

The faculty will continue meeting internally and in discipline specific learning communities over the course of a year. During this process faculty will be able to ask more clarifying questions and request the data needed to answer those questions. With this information and throughout the learning community process faculty will be able to develop a vision and strategy to implement to improve the equitable attainment of engineering degrees.

Table 2: Student Performance Data Points Collected

- Four- and six-year graduation rate in each engineering discipline at each university
- Four- and six-year graduation rate in all other colleges at each University (Business, Science, Social and Behavioral Science etc.)
- Average grades for each engineering course. Specifically, the classes that students performed the worst measure by classes who had the most students receiving a D or E for students who already had two D's or E's
- Time to degree for each discipline at each university broken down by AP credits brought in from high school (0-9, 9-12, etc.).

*Each data set was then disaggregated by race, ethnicity, first generation status, and Pell recipient status.

Discussion

The purpose of this project is to identify areas where curricular changes in engineering programs may have significant positive impact on equitable access as well as graduation rates. Using Kotter's change model, we recognized an urgency to address access to engineering programs both because engineering has a need to increase diversity as well as address a need to increase

the number of students entering the engineering workforce. By working with and gaining buy-in from faculty, they are able to develop, own, and lead the change, resulting in a better chance of success.

Throughout this study, there were a variety of successes and challenges. First, it was critical to gain support from academic administrators from each institution. These administrators include individuals at the vice provost, vice chancellor, dean, and faculty chair levels. This support symbolized the importance of improving equity and access at the institutional level.

One of the greater challenges was getting the initial faculty buy-in and for them to give their time to the project. Faculty have busy schedules and have worked hard to build the curriculum they already use, and it can be difficult trying to incentivize analyzing how the curriculum could be changed. We found that individuals at the dean and faculty chair levels had greater success in recruiting faculty to participate. We also believe that the opportunity to collaborate with faculty from other institutions proved to be critical to this project's success and served as an incentive for faculty to participate.

Moving forward it will be important to build on the momentum of the project. While we were successful in collecting curricular structure and student performance data as well as working with faculty learning communities to analyze the data, understanding where problems exist is not sufficient. Working with faculty to be the catalyst for change will be critical to implementing the vision and strategy for change. The next steps of this project will be to work with faculty from each institution to begin implementing changes and identifying ways to evaluate these interventions.

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