Continuous Improvement for Equity in Engineering- Addressing Departmental Change with Theory-Informed Case Study Research (EBR)

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Abstract

Institutional change in higher education is known to be a slow process. Like most systems, higher education was designed by and for the elite, and built to maintain the status quo. As issues of equity in the United States become more and more salient, it is vital to understand change agency at multiple levels within organizations. The IUSE Revolutionizing Engineering Departments (RED) grant was designed to ignite and measure change in an engineering department to support inclusivity, diversity, and excellence. Literature indicates that organizational change hinges upon multiple factors. In particular, the ways in which incentives and reward structures are used to support the change sought, the ways in which financial priorities shape practices in an organization, human resource allocation and training, and policies that shape practice are critical components in change.

Using a continuous improvement mindset to consider change, which assumes integral change rather than drastic shifts to practice, we frame a mixed methods case study of the University of Texas at El Paso computer science department, a recipient of a 2016 RED grant, among four main themes. We contend that a department's financial priorities, departmental policies, human resource allocation and training, and incentive and rewards structures are vital to achieving equity, particularly when these elements align with departmental values. We posit that the department can create a student support structure (Kezar, 2016) for equitable student outcomes, and theorize that this student support structure can be enhanced when the practices match the departmental values, and when the University of Texas at El Pasoal and departmental values align. We provide recommendations regarding social science research in department level change and recommendations for departmental practices that promote equity.

Introduction

Despite the importance of the department as a locus for undergraduate STEM improvement (AAAS, 2019), scant research has examined organizational change at the department level (Kezar, 2018; Kezar & Bernstein-Serra, 2020). We posit that the department can create a *student support structure* for equitable student outcomes and theorize that this student support structure can be enhanced when the departmental practices align with the departmental values, as well as broader University of Texas at El Pasoal values and practices. We use the context of a RED grant to study change in a computer science department that emphasizes student engagement for success.

The Revolutionalizing Engineering Departments (RED) grants were developed by the National Science Foundation to create widespread, large-scale change to improve equity and support cultures of inclusion in engineering. This is a case study of a 5-year organizational change effort

within a Hispanic Serving Institution. The computer science department emphasized the use of continuous improvement as a strategy for engaging faculty in change processes and departmental policy. We offer the theoretical framing of Kezar's model for developing student support structures using four mechanisms for change, and provide recommendations based on the experience of one University of Texas at El Paso.

Theoretical Framework

Drawing from the current state of the research on higher education organizational change in undergraduate STEM reform efforts, an underlying premise of the theory of change guiding this case study is that organizational change toward sustainability of student success practices must: (1) be centered in the department; (2) focus on four departmental practices (incentives and rewards, financial resources, policies, and human resources); and (3) also engage the University of Texas at El Paso and discipline. Throughout the case study, we draw out the theme of continuous improvement as an approach to organizational change.

Scholars of STEM organizational change found that multiple and sometimes competing forces influence how faculty respond to and implement proposed initiatives. In their empirical work studying multi-University of Texas at El Pasoal STEM reform initiatives, Kezar, Gehrke, and Elrod (2015) and Kezar and Bernstein-Serra (2020) emphasize the importance of the multiple and conflicting perspectives faculty bring to bear on their everyday work. presupposes that *understanding departmental stakeholders' assumptions, beliefs and behaviors* underlies the conceptual and practical foundation for adapting and sustaining effective teaching and learning practices. Locating student support strategies in the discipline of computing, rather than more vague STEM disciplines in general, strengthens the specificity of sustained organizational practices to support Hispanic and URM students in computing (Chapman, 2019; Kezar & Bernstein-Serra, 2020; Mack et al., 2019). Based on the literature on higher education organizational change in undergraduate STEM reform efforts, we focused our analysis on understanding four ***mechanisms*** that influence equitable outcomes— a) *allocating financial priorities toward equity*, b) *setting inclusive incentive and reward structures*, c) *implementing equity-oriented policies and programs*, and d) *supporting diverse human resources*

Allocating financial priorities toward equity. MSIs in general and HSIs in particular operate on less funding, on average, than other higher education institutions (NASEM, 2019; Núñez et al., 2015). In a department context, funding priorities can be a mechanism for promoting equitable student outcomes. Research indicates that a lack of financial resources slows organizational change in higher education (Osei-Kofi et al, 2010). Hispanic students more likely than others to report concerns about finances and jobs affecting their education. In addition to the availability of actual funding dollars, the extent to which personnel in a department perceive that there is an adequate amount of funding can influence how these personnel carry out initiatives and efforts toward organizational change; even the perception of fewer funds for departmental operations can inhibit organizational change and responsiveness efforts (Kezar, et al 2008).

Setting inclusive incentive and reward structures. Part of the reason that it is critical to attend to departmental, institutional, and disciplinary factors in promoting equity in undergraduate STEM is that all of these levels affect evaluation of faculty. Therefore, faculty vary in whether they act in accordance to expectations of their institution and department (often a more local focus) or

expectations of their discipline (a more national and international focus)(Chapman, 2019). An institution's mission and the extent to which it focuses on research or teaching can also shape incentive and reward structures, and in turn influence departmental mechanisms for promoting equitable student outcomes. One critique of HSIs is that although the term implies that these institutions "serve" Hispanic students, they are not held accountable in their incentive and reward structures to do so, because HSIs are based on enrollment and not mission definition (NASEM, 2019; Núñez et at., 2015). Decisionmakers should consider the alignment between faculty and staff role expectations and the additional workload that develops with a strong student support infrastructure (Argryis & Schon, 1978; Kezar 2008; O'Day, 2002) and can maximize the likelihood of organizational improvement by emphasizing multiple types of rewards, e.g., monetary, emotional/ psychological, and recognition-oriented (Doten-Snitker et al 2020).

Implementing equity-oriented policies and programs. Departmental policies about curriculum, instruction, and co-curricular engagement can serve as mechanisms for promoting equitable student outcomes and have a particularly powerful effect on URM success in STEM and computing (Hrabowski, 2019). A central premise of the overall RED initiative is that institutional practices and policies, rather than perceived student deficiencies, are central to student success (Kezar 2008). If stakeholders are to develop student support structures to promote equity in computing, they must see value in the change and feel like they had a part in decision-making in processes concerning implementation of policies and programs (Gerber 2001 Jones 2011 in Doten-Snitker et al 2020). In addition, faculty need to buy into departmental policy efforts as aligning with, rather than contradicting or ignoring, the values of the department. Implementing more equity-oriented policies and programs can involve challenging academia's status quo of individualistic and competitive values (Page, 2007; Santamaria 2013).

Supporting diverse human resources. Departments have opportunities to create equitable student outcomes through the training, hiring, and professional guidance of staff and faculty who reflect the student body ethnically, racially, and culturally (Garcia, Nunez, and Sansone, 2019). These personnel can serve as institutional agents who understand students' cultural backgrounds and apply that understanding to serve as sponsors, mentors, or advocates for URM students to navigate what can be challenging and exclusionary cultures in STEM. Because faculty and staff diversity in STEM is so limited, especially in disciplines like computer science, it is important that all departmental personnel, regardless of their background, have opportunities to cultivate understanding of how to promote URM student success in STEM (Mack et al., 2019).

Method

This participatory case study used iterative analytic practices. Author 1 has fourteen years of experience with the case at hand through multiple project evaluations and social science research efforts, including 5 years evaluating the RED grant. Author 2 is a faculty member at University of Texas at El Paso in a social science department and led social science efforts with a team of graduate students locally, including course observations, interviews and focus groups with students, and participant observation in RED grant meetings. We employed Merriam and Tisdell's practice of intertwining data collection and analysis (Meriam and Tisdel 2015), utilizing constant comparative methods of meaning-making (Charmaz, 2006). First, author 1 reviewed documents, assignments, faculty and student surveys, faculty student and staff

interviews, early reports of RED activity, and transcripts of meetings with grant leadership within the department. Author 1 outlined the themes over the first 3.5 years of the study, and found the mechanisms addressed by Kezar aligned with the findings to date. At this point, case data was collected in semi-structured focus groups with RED personnel, and IRB processes were adjusted to focus on the mechanisms of change observed. Authors 1-3 began discussions related to how experiences resonated (or did not resonate) with the themes introduced and began more targeted data collection with the described emphasis, as well as an emphasis on lessons learned in the grant. The team met to document their reflections on their experiences. Large group discussions were audio taped and transcribed.

Results

The results sections are structured around the themes addressed in the theoretical framework. We emphasize three in this Experience Based Research, specifically *continuous improvement* as a messaging and process strategy for departmental change towards equitable student success, *human resources practices* that support equitable student success, and *departmental policies* that support equitable student success.

Continuous improvement

Continuous Improvement became an integral part of the *messaging of change* and the *process of change* in the RED grant implementation at University of Texas at El Paso. Initial communications between faculty and change agents brought in to facilitate department improvement were met with resistance. This was evident in the first summer of the grant, and is documented in an early focus group report:

> Faculty had the sense there was a plan developed by the RED team to move forward, and that faculty who were not PIs or co-PIs did not have access to the details of that plan. Some co-PIs of the RED grant clarified during the focus groups that the plan is emergent, and that the goals were to develop a plan together.
> ***Some faculty perceived an assumption by the external consultant that the department was in need of a drastic change in culture/climate.**
> *Some faculty perceived a lack of willingness on the external consultant's part to discuss the approach to address climate/culture in the department.

In year 2, a shift in practice occurred with regard to the RED approach to change. Evaluation workshops were developed with faculty each semester with three main purposes: a) share the data collected from the department in the previous semester, b) engage in data interpretation as a faculty team, and c) discuss and plan the next round of data collection and analysis. These meetings were held as faculty meetings, with attendance and engagement as expectations. According to faculty engaged in the grant, this shift created a sense of ownership of the data, and began a shift in the work of the department. In 2021, faculty leaders reflected on the shift in this way:

> "I feel like one of the things that I always talk about is the work of the climate survey and sharing that. The process of (evaluation) sharing that with the faculty and having them

think through, do some self-reflection. If I learned something from all of this, is the importance of self-reflection and having faculty look at data and coming to their own conclusions. …While it seems like it was kind of incremental and didn't move at a fast pace, I think that there's definitely change in the department compared with when we started."

The shift in emphasis from outside-driven change through consultancy to faculty- driven change through analysis and interpretation of climate data honored faculty perspectives and may have increased buy-in. Evaluation provided opportunity to discuss data, reflect and interpret data, and consider what could come next in service of students. The evaluation team curated datasets, in some cases subsets of data, to draw attention to certain areas of interest to the RED PI team (e.g., women in the department) or specific research questions posed by faculty collectively in the previous workshop. This shift towards continuous improvement messaging and processes for incremental change such as with the development of data analysis cycles may have led to a slower, sustained effort to support students in the department. This narrative description of the overall shift in strategy describes how messaging and approach moved towards continuous improvement. Throughout the next results sections, we highlight this theme of continuous improvement as a mindset that permeates the RED process at University of Texas at El Paso.

Human Resources Practices

From our perspective, the ways in which staff and faculty are hired, trained, and supported in their work towards equity in student outcomes are integral to departmental success. Over the past decade, the number and diversity of staff roles, in many cases undergraduate staff, have shifted to emphasize support in early courses from peers, near peers, and graduate students. As enrollment has increased in the department, the number of support staff have increased as well. The department has hired TAs, Peer Leaders, and Instructional Assistants for all the lower level computer science courses. In addition, extra resources were put in place to bolster departmental advising in the early years of the major.

This bulking up of support staff early in the computer science degree is meant to keep students retained in the major, and is a strategy that research indicates can work to retain undergraduate staff as well as students enrolled in the course. Undergraduate course support staff become recognized as competent, and have additional opportunities to consider key concepts in the major as they guide their students in their learning. Both opportunities to develop competency and recognition are key elements of developing strong computing identities (Carlone & Johnson, 2007). Particularly during the pandemic, this support for students in courses that abruptly moved online was described as vital to student success—a survey of 100 University of Texas at El Paso computer science students in April of 2020 revealed they connected with faculty and their peers to a great extent following the move to online learning. The University of Texas at El Paso data compared favorably against other H.S.I. computing departments in a multi-institutional study, which reported similarly high faculty engagement but much less peer interaction once learning moved online. Specifically, three quarters of students received academic support from T.A.s/I.A.s/peer leaders (75%, 11% were contacted by the TA/IA/peer leaders regarding

participation) and nearly two thirds interacted with advisors during the COVID-19 crisis as of April 2020 (62%, 10% were contacted by the advisor directly).

At University of Texas at El Paso, there is a historical practice of hiring from within the department for advising, staff support, training, and instruction. Often, the individuals hired have shown great initiative and great understanding of the departmental and institutional values of "student access and excellence." Departmental leadership describe the process of developing positions and hiring from within to fulfill urgent departmental needs with individuals from the community who can serve as mentors as they fulfill their responsibilities to the department. Individuals who serve in these roles have been observed in multiple settings drawing on their similar backgrounds to motivate students in the major. A professor of practice recently hired from within responded in an interview regarding the value of the position to the department:

> "I think I am very valued in the department, I do because I do a lot. … I think I'm valued. And I think I'm the right person in my position because I understand the process of how it is to be a student and how it is to be a member of the faculty. And what the students think, what the faculty think and how to maybe mesh those things up a little bit together. I'm still young, so I think that I still have that relatability to some certain things such as advising or understanding how to say, 'Okay, well, maybe students want to take classes later, so we put courses at a different time.' So I think I'm valued, I really do, I'm appreciated. I know I've been told a lot and I appreciate it."

Faculty also describe their roles in training the undergraduate staff who interface with students in the department through course support. A junior faculty member describes the process of training and mentoring in this way:

> "We're doing training. I'm working with one of the lead TAs that's trying to show that to other TAs. So we're trying ... My TAs, and my IAs and my PLs are my eyes. So I tell them, I cannot see everything, but if you tell me there is a problem, then we can fix it together. But that requires empowering them, too. So I empower them a lot. A lot. And I give them constructive feedback. 'This is how you have to do it. This is how you have to change this. But I'm very happy.' I had amazing TAs. Now I've been training. I have two in training, but that's okay. There is a lot of regular communication. I meet with them every week before class."

At the course level, instructional staff may receive additional mentoring and training from faculty that relates to how to engage with students in the course, and how to communicate issues students are having with the team. The faculty member describes empowering instructional staff who are also undergraduate students to engage students in the course, and the tone connotes a need to continuously look to improve. The quote also hints at the cyclical nature of training undergraduate students—there are always new students who need to learn the ways of the team.

Training and targeted hiring across all departmental positions have become an emphasis of departmental leadership during the RED grant. The training practices ranged from technical training to job shadowing, to educating new staff about the culture of the department and the institution, which emphasize H.S.I. servingness (Nunez, et al, 2015), asset-based pedagogies, and

collegiality. New training efforts during RED have developed mentoring practices through the hiring of a "Lead TA" and supervision of TAs and other instructional staff through professors of practice. A departmental leader described staff hiring in this way:

> "The way we hire, the questions that we use when we hire are really directed at student success, your role as a staff member, what our expectations are. An example is with tech support for the department… We hired additional tech support. It wasn't guaranteed, but it really paid off for us because our tech support, the people we hired...they're very student oriented."

The emphasis on front-loading student support in coursework and in the major, hiring staff at all positions who communicate values that relate to emphasizing student assets, and the use of multiple training and supervision mechanisms indicate how University of Texas at El Paso worked towards incremental change that embodies the values of student access and student excellence through its human resources practices.

Departmental Policies

Departmental policies can cover a broad swath of rules, norms, practices, supports and barriers from the rules of engagement for students, course assessment, grading, acceptance in the major, academic roles and responsibilities, and faculty incentive and reward structures. In this paper, we focus our analysis of departmental policies on the processes faculty undergo to assess growth and make change, as the norms of these processes may have paved the way for collaborative improvement efforts during the RED grant. University of Texas at El Paso's department of computer science had a history of deliberate collaborative processes that it brought to the change process. Two specific processes, CQI and faculty review, appear to be constants in the department and have norms of communication, collaboration and faculty ownership that are hallmarks of the improvement efforts in the department.

Continuous Quality Improvement, an ABET accreditation practice, is a collaborative effort in the department under study. As new faculty members join the team, they shadow more senior faculty, to get a better sense of the process before taking on the responsibility more fully. It is described in this way by faculty leads at the department:

> "As part of our undergraduate curriculum, if you can think about it, it's broken down into different components, different areas of computer science, fundamentals, systems and so on. The assessment is broken into subcommittees. Each subcommittee, certain set of faculty will teach courses in these areas, will do research in these areas and they're the ones that assess these course. There's, are they doing what they're supposed to do, basically. Every faculty member belongs to at least one, some belong to two because their area is just overlapping. Junior faculty are also a part of these committees, but again, for the first year or so, they're just there as observers as shadow... they shadow people and so on. That's another thing. I guess if we're talking about CQI also in terms of advising, our newcomers, our junior faculty, they don't advise for the first year, but they're still involved in advisory because they're shadowing the newest member just recorded."

Another collaborative practice that predates the RED grant and involves structured participation from faculty is performance review of faculty. While all departments have some form of accountability and review for faculty, the UTEP faculty describe the collective and collaborative nature of the process locally. This established policy and the norms surrounding its implementation may also contribute to other improvement practices established more recently. The practice is described below by one of the leads.

> "We do take annual evaluations really seriously. **Not in terms of the results, but the process.** In terms of annual evaluation, faculty are supposed to think about their plan for the upcoming year. That is reviewed by the most senior faculty and then by the Chair, so there is formal advice provided to junior faculty and I'm sure part of it is, 'this does not fit well with where we need to go, this does not fit well with the department goals,' but of course as importantly, does it fit well where we are as a unit?"

With these structured practices as backdrop for continuous improvement, the RED grant created opportunity for three new efforts, curriculum alignment, refining of mathematics policy in the department, and major "track" development. These were described as collaborative efforts to make change in the department in service of student success.

Perhaps the newest of these was a practice of course to course curricular alignment. This process was developed to clarify communication across courses early in the major. The deliverables included a new set of course outcomes, yet the process of meaning-making was viewed as an important element of collaboration for faculty. A junior faculty member described the impetus for the concern, as well as the process faculty underwent in this way:

> "Well what happened is that we saw that some students were struggling, for whatever reason, I couldn't pinpoint it at this moment. But they were struggling with that course and we wanted to kind of understand what was going on. So why are people not doing well in that course? So what we did is we kind of just took a look at the course and tried to figure out what was going on, what was the problem for students to be failing the course. And as we took a closer look, we kind of figured that, through discussion, that some instructors were interpreting certain things this way other instructors interpreted this way, some instructors were doing things that might have been more advanced or less advanced, or whatever the case may be.

> So that's kind of how we did it, and we spent last summer focused on how we can restructure the course and get it to fit the needs of the department….. And that's something we want to do for our other courses as well. Because we thought it was pretty successful. It took a long time, but it was pretty successful to kind of redo the course and see the {COURSE TITLE} people understand what was actually being taught, so that there's no gaps in knowledge as soon as you begin."

The depiction of the course alignment process brings out two elements of departmental policy regarding continuous improvement —the need to answer a question about student success, and the use of dialog to make meaning across faculty.

Another change that relates to departmental policy was the use of the newly developed 1 and 2 credit course options to offer discrete mathematics within the department. The move was developed to make sure the content was tailored to computer science, and to align the mathematics for "just in time' learning—when students take courses as designed, they learn discrete mathematics content along with application in their more traditional computer science courses. This change was first signaled in the retreat in 2016 as a need and was first implemented in spring of 2020. Unlike the processes above, the discrete math process was undertaken solely by faculty deemed qualified to teach the mathematical content, and so was less widespread than other processes described above. According to faculty engaged in the process, this had both positive and negative consequences. Faculty beyond those involved in course development had little interest and therefore little ownership of the policy change. However, students have benefited from the change according to survey results—specifically, they feel the course content is more relevant and easier to apply to their major. Three student responses below show the benefits of this policy change with a focus on student outcomes and experiences.

> "The added value is that in class we just don't learn about discrete mathematics, we also learn where we're going to use the knowledge and why it is relevant."

> "This class allows for you grasp why math is important in computer science. Acting as a bridge between the two rather than an assumption that math is just linked to computer science."

> "I think that the change (to math policy) is perfect. It covers the areas that will most benefit us. The material that we discussed is not simple. It takes more time in order to understand. When we can focus more time into the material, we do not lose time learning something not relevant to our field. It is good to learn the other info as well, but it should be briefly covered. The info we will benefit from most should be covered more thoroughly and that is what this course allows us to do."

A third change that was addressed through faculty collaborative practice was the addition of computer science "tracks" that guide course taking and allow for applied courses in the middle years of the major. A department leader described the impetus for tracks in this way:

> "I think what led to tracks is the discussion was always, students in the early years of computer science, they get these exciting project ideas about computer science and then their middle years, all they do is theory, which can push them out of the field. And then they go back in their senior year, where they start taking all of these, again, the exciting projects, final projects, the capstone project, but in the middle two years, that's where they lose excitement about the field. So part of it was retention through those tracks, to have people get a little bit more cyber security and data analytics for example in the junior year, to keep them engaged."

Track development has been collaborative as well, with faculty ownership of tracks where their expertise resides, and the overall faculty approval needed to create accountability to the group. Just as with previous faculty collaborative efforts, the processes are student-centered, have

emphasis on a problem to be solved, and include input across the majority of faculty to put the change into place.

Promising practices and recommendations for departments engaged in change efforts

In this section, we highlight departmental factors that we consider as potential mechanisms for creating incremental change in UTEP computer science and offer these factors as potential for building recommendations for departmental change. We note the limitations of qualitative case study efforts and the need to consider similarities in contexts in any effort to generalize findings to new situations, yet we hope the story of UTEP can serve as one of many models for departmental improvement. The notion of leadership and the ways in which strong leaders embody equitable values was noted as important for creating and sustaining change—the department had 2 chairs during the grant, and specific mentoring and partnering across the transition occurred to ensure succession would lead to a similar set of values and practices in the succession of chairs. The majority of faculty in the department note the collegiality that exists, even across differences and arguments over departmental strategy. Collaborative policies and practices with transparent structures may contribute to this collegiality among faculty, though this is a supposition and is not based in evidence to date. UTEP has a record of including an ethic of care in its operationalization of *servingness* in the H.S.I., and that ethos is mirrored in faculty discussions. This care for students is a value that permeates human resources hiring, teaching practices, and collaborative efforts to improve the department. Finally, the messaging of continuous improvement, in which incremental shifts in practice based on data can improve student success, was found to be more effective at creating buy-in from faculty in the department, and created common ground for motivating new policies, human resource practices, and student opportunities.

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