Credentialing in the CSET Education Change Process

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Abstract— Efforts have been made to improve technical and professional skills in engineering graduates, but little widespread change in pedagogy has occurred within U.S. engineering education institutions. Our group studied the genesis and implementation of an innovative engineering curriculum (Iron Range Engineering) through a series of interviews with a wide range of stakeholders. Using a grounded theory approach, we found that to "shoehorn" an innovative curriculum into a traditional university setting required ad hoc solutions – almost akin to hacking a system. The findings in the study of this process also showed that the most common barriers to widespread educational innovation can be framed as credentialing issues, whether as excuses for not implementing change or as legitimate obstacles. At the root of the credentialing issue is the ubiquitous standard unit of effort—the credit hour, which was originally designed simply to measure faculty workload rather than student learning. This paper seeks to describe the breadth of credentialing in terms of scope and groups involved. Finally, we propose conversations that change agents in CSET education can use to turn credentialing into a lever for systemic curricular transformation.

Keywords—credentialing; change; innovative curriculum

I. Introduction

"We can't change our curriculum like that, it doesn't fit with ABET."

"Our system doesn't allow half-credit courses, so we can't submit that idea to curriculum committee."

While many efforts have been made to improve technical and professional skills in engineering graduates, there has been little comprehensive change in the pedagogy of most engineering education institutions in the U.S. Many of these efforts involve changing only one or two aspects of the curriculum, and therefore are less likely to make significant changes in the student learning outcomes. For better success, engineering curricular changes will need to address the entire education system. By studying the origin story of one successful curriculum transformation that did address the entire system, we have identified multiple process and infrastructure barriers that we can intentionally overcome to improve computer science, engineering, and technology education (CSET). This paper specifically considers credentialing, one of the most frequently discussed obstacles. Of the 32 types of perceived barriers found in the study, 10 were determined to be rooted in the issue of credentialing. A total of 145 units of text, or 48% of all text coded as perceived barriers, were coded with these 10 credentialing-related codes.

Credentialing at its various levels of scope can be used to derail innovative curricular transformation. This paper illustrates the breadth of credentialing in terms of scope (course creation, course/curricula transcripting, and program/institution accreditation) and groups involved (including faculty, academic administration, the registrar, financial aid, veteran's affairs, and athletic eligibility). Interview data from the study of a real curriculum transformation is used to demonstrate how credentialing was invoked as a barrier and the mechanisms used to overcome this concern. Finally, we propose a series of conversations CSET education change agents can use to turn credentialing into a lever for curricular transformation.

II. Why Study Credentialing?

A. Credentialing Defined

"[kri-**den**-sh*uh* l], noun, evidence of authority, status, rights, entitlement to privileges, or the like; anything that provides the basis for confidence, belief, credit, etc." [1]

Even among those in the engineering education ecosystem who understand the importance of informed practice, one of the barriers to substantive change is the need to work within the current system of credentialing. This system works at multiple levels, including, but not limited to institutional, governmental, and accreditation bodies.

At the institutional level, the primary educational credential is the degree, minor, or certificate. In practice, however, this breaks down to the course and the system we use to count courses, namely the credit hour. The credit hour is a time-based metric roughly equivalent to 15 hours of faculty-student contact time [2]. Often called a "Carnegie hour" after its creator, the key events that precipitated the credit hour system were the shift to the elective system of course compilation toward degrees, the influence of business models in higher education, and a desire to better align the K12 and higher

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education systems [3, 4]. Andrew Carnegie defined this time unit as the basis for inclusion in a pension system [2]; it was stated distinctly from the beginning that it was not to be considered a measure of student learning [5]. Heedless of this caveat, the credit hour, and its various compilations into courses and degrees, has become the standard measure of educational attainment and the source of the standard credential. Since then, other groups have built their own systems based on the credit hour, both in academic and student affairs.

The current interest in how to assign credit for prior experience in (or related to) the field of the degree [6], alternate course mechanisms such as MOOCs and badges [7], and the potential of the "stackable" degree [8] are challenging the linkages between the institutional and federal systems as well as the accreditation bodies on which the processes depend. In the next section, we describe key players in this ecosystem.

B. The Credentialing Ecosystem

As we've seen in our research and describe more below, credentialing is one of the most cited barriers to systemic curricular change. While many faculty will point to the curriculum committee as the core, if not only, institution level barrier to innovative non-traditional curricular initiatives, other offices, such as the registrar and financial aid, have real questions and concerns as to implementations that do not exactly fit, or even break away, from the Carnegie unit. Add to this mix the concerns of the athletics department (such as NCAA expectations, and differing requirements and/or recommendations regarding the number of courses athletes should take in a given term), financial aid requirements and reporting, and the credit hour needs for veterans and some corporate-reimbursed students to receive their educational benefits. Adjunct faculty and faculty union representation may also have concerns about the way contact hours are described and compensated.

Beyond the already lengthy list of those either directly involved in the credit hour or indirectly using systems built upon the credit hour, there are additional players at the government (both federal and state) and outside accreditation body levels. In the U.S., the Department of Education requires colleges and universities to track and report certain data, which may not map automatically to the form of the innovative non-traditional curricular initiative; the Departments of Defense and Veterans Affairs have valid concerns that our service members and veterans are receiving an appropriate education, particularly if these departments are paying for some or all of it. The U.S. Department of Education just put out an 11 page letter re-stating their expectations of regional accreditation bodies for those groups to remain valid sources of evaluation [9]. Thus, demonstrations of the validity of the innovative non-traditional curricular initiative may be required by governmental bodies as well. ABET and regional accreditors have accredited programs based on innovative non-traditional curricular initiatives. However, there continue to be areas of concern that bubble up in this process, including what level of proof is likely to be required of the programs.

III. METHODS

This study explores the development and implementation of an innovative engineering program, Iron Range Engineering or IRE. This program takes a unique approach to engineering education, including a project-based, team-focused curriculum, and a unique partnership between a community college and a state university separated geographically by several hundred miles. The program takes place at the community college, targeting students in that part of the state and responding to the needs of local industries. The program was also chosen because of the long (and often difficult) journey from its conception through its approval and implementation.

Specifically, the study addressed the following questions: 1) How did the program come about? 2) What helped or hindered the process of developing and implementing the program? 3) What lessons learned from this process can inform and improve future transformational efforts in engineering education?

In order to address these questions, semi-structured interviews were conducted with 16 individuals who are or were involved in the process of developing and implementing the program. Three of these participants were founders of the program. The additional 13 interviews were intended to add depth and alternate perspectives to the story by gaining insights from a wide range of participants in the process. All interviews were conducted by one researcher during Fall 2014, and were audio recorded and transcribed. The interview protocol consisted of the following guiding questions and prompts:

1. What was/is your role in the development of the Iron Range Engineering program?
2. How did you get involved?
3. When you first got involved, what did you think of the idea? Why?
4. Did your thinking about the program change during the process? How? Why? What influenced your thinking?
5. What do you feel was the biggest challenge in getting the program started? How was that overcome?
6. What challenges is the program still facing?
7. What do you think of the current program? What are its strengths? What could be done differently?
8. What do you anticipate in the future for the program?
9. What advice would you give others who are involved in similar projects? Lessons learned?

The analysis presented in this paper draws primarily on data from responses to questions 5, 6, 7 and 9; however, the entire transcripts were coded in order to capture all data relevant to the research questions.

Qualitative analysis was conducted with all 16 of the interview transcripts, using an electronic qualitative data analysis program (Atlas.ti). An initial coding scheme was developed based on the research questions, was piloted with five transcripts, and was revised in order to fully capture relevant data. Full coding and content analysis of all transcripts were then completed by a single researcher (with regular check-ins and discussions with the full research team) in order to identify relevant concepts within the data, as well as emerging trends and themes. Thematic coding was then done

to better understand the identified themes [10, 11, 12]. Further details on the methods used in this study are available in Allendoerfer et al, 2015 [13].

IV. Barriers Framed as Credentialing Issues

Preliminary analysis of the interview transcripts resulted in the identification of 32 categories and subcategories of perceived barriers to the development and implementation of the Iron Range Engineering program, which were used to code a total of 299 units of text across the 16 interviews. Of the 32 types of perceived barriers, the most frequently cited were determined to be rooted in the issue of credentialing. A total of 145 units of text, or 48% of all text coded as perceived barriers, were coded with 10 credentialing-related codes. This suggests that credentialing is a significant hurdle to implementing a program such as Iron Range Engineering. Although the term "credentialing" was not always used by our participants, the concerns that they raised were rooted in various ways in the challenge of meshing student work and learning with existing mechanisms for granting credits, majors, and/or degrees.

For example, one co-director's comment specifically referenced credentialing:

"It's a credentialing battle, which is a university battle…. It's an industry thing, but universities are in the line of credentialing. And so if they can't credential, if it's not the universities that say who is an engineer, then who does?"

University administrators conveyed a university-level perspective, often focusing on getting degrees granted:

"They needed to get a degree and it needed to be on the books. And what could we do in terms of curriculum that would let it get on the books? Then once I got on board, a bunch of my work was negotiating the curriculum and saying how much of the content do we actually have to specify?"

"We were sort of using our existing curriculum and trying to adjust it to meet the needs of the IRE program, but we did not yet have curriculum approval for a distinct IRE program. We were using existing mechanical and civil engineering courses, allowing the students in the IRE program to enroll in them and then trying to make them, you know, do project-based learning and use the kinds of pedagogy and teach the kind of content that we wanted for the IRE program. But it was not an approved degree program at that point on the [university] campus."

"It was a problem because there was no department of integrated engineering in [university], and we had the classical civil, electrical, mechanical and computer engineering, and where did it go?"

A higher education consultant spoke to the curriculum-level challenges of the new program, as well as the challenge of meshing with the existing institutional culture:

"Well, project-based learning approach as opposed to a standard, you know, a thermo class and a dynamics class and all that kind of stuff. So it wasn't a good cultural fit in that sense with [the university], but they could grant the degree. So it had to be structured in such a way that they could retain control of what was going on and still be accreditable."

Finally, University faculty represented a department-level position, including concerns regarding curriculum, accreditation or departmental territory:

"I think a large hurdle was just, how do we measure it. … It's the accreditation piece.

How do we show that the students have met the outcomes that we want them to reach, and it's difficult in a traditional curriculum to show that they're getting what they need. It's all the more difficult when you have a little bit less, I guess, rigidity and the traditional box curriculum as to how things are measured and how the outcomes are met."

"There was a need for where would these courses plug into our department."

"I think that just the general curriculum process…is set up for the traditional boxed curriculum, where you're saying, you take these classes, you have these outcomes associated with those classes, and you end up with a degree when you've completed those classes successfully. … They [the program] have to specifically say to approve this class in the curriculum process, this is the concept, this is the topic, this is the sample syllabus associated with it. When it really doesn't fit. It's not a boxed type thing."

"The mechanical engineering department, they finally took a vote and they didn't want it listed in their courses. My department took a vote and they said the same thing. They didn't want it listed and they did not want the graduates to be called electrical engineers or mechanical engineers because we didn't feel that they were."

Whether or not the word "credentialing" was invoked, we argue that the types of barriers cited most frequently by those involved in the development and implementation process fall under the larger issue of credentialing, namely the challenge of fitting something new and non-traditional into existing boxes. In addition, our participants represented multiple levels or pieces of the larger system within which credentialing issues operate, highlighting the systemic nature of the barriers and the necessity of understanding how the various pieces are intertwined before real solutions can be found.

V. Circumventing Barriers

Participants were also asked about their perceptions of what strategies, decisions, or key events helped the program move past the various barriers. The qualitative analysis found that 18 types of strategies were discussed, in a total of 107 coded units of text. Of these coded comments, 28 (26% of all text coded as strategies) emphasized creating new boxes into which the new program could be placed as a strategy for overcoming barriers, directly addressing the credentialing challenges discussed above. For example:

"We came up with the idea to…rather than using existing programs that [university] already had, we would create a new engineering program, a general engineering degree. And I think that was less threatening to the [university] faculty

because…I don't think they worried as much that it would jeopardize their accreditation. And there were enough faculty at [university] who were kind of interested in this idea and were kind of willing to participate that if it was this separate program, they were willing to be involved. And then we agreed we would hire faculty to be focused in that program. … At some point we just started building this thing that people could at least live with.… It felt like all of that was necessary to finally get to the place where people could move forward." State University Interim Provost

"Going to general engineering, I think, saved it. That was not in the original agreement. It was supposed to be a mechanical engineering base. That was what was signed…and I made an argument, and people bought it, that, and I think it's right, that we would be more effective for the region if we were general engineering. And so it really got the heat off our back at [university]." Former Program Director

"I think having its own separate entity helped in that way that we didn't-- weren't as concerned about any impacts that might potentially be there. But also, it was easier to go through the curriculum process where they had to still get some support from the other engineering programs, but it wasn't all reliant on us, you know, approving or not approving. It was just part of the general curriculum process at that point." State University Faculty

"We had department chairs that thought that the program had potential. But one of their biggest concerns was jeopardizing their own ABET accreditation. …. And they were quite concerned about that. That if this program was a failure it would reflect poorly upon their individual [program], whether it's mechanical or electrical or civil or whatever kind of engineering it would happen to be. And so we saw that right away and we knew we wouldn't get past that barrier. And so we said, 'All right. Would you oppose our offering the program as a separate program, separate from any department?' And they'd ask, 'How would that work?' And we explained, 'We'll create a brand-new department, and it'll be independent from all of you. But on the other hand, you'll all have an opportunity to participate and provide guidance and direction.' So we didn't leave them out. Although they wouldn't be managing the department, we'd have a new department chair. So just like they were department chairs. And the dean of the college would be supportive of it. The provost and the president are all supportive of it, and so they went along with that. They agreed to that. That was the icebreaker right there, when they realized that their accreditation wouldn't be jeopardized, that they wouldn't be losing faculty lines, which was the other major concern, you know, everybody's starving for more faculty." State University President

"At some point when you're trying to do innovation and change and you bend over backwards to try to work with the structures you have, with the faculty you have and give them all the opportunity to innovate, and you put the resources out there and say, 'Here's the money, here's the opportunity. You'll get new faculty lines; you're going to get new resources.' And if at some point they just sort of say, 'You know, no thank you,' that's when you realize the only way to do it is to create a new structure. And so at some point at [university] we just realized we're going to have to create a new department here, that these departments aren't going to be capable of doing this, it'll always be this unloved stepchild." State University Provost

"We helped…dodge some of the issues by having a general engineering program, so we could have more control and less influence from outside, as opposed to being put into a mechanical engineering program that would have the influence from [university]. That would have made it really difficult. … It's a different degree, and ABET goes by programs. … So this is a different program, and then you look at the faculty for the program, and since it was its own program, it's easier to have the local faculty in control." Higher Education Consultant

"Change initiatives in higher ed[ucation] are challenging. … The moral of the story really is sometimes in higher ed[ucation], after one has exhausted the possibilities of using your existing structure -- so you don't jump immediately to an alternative structure, but if you've really tried to get the existing structure to do it and they can't, then a new structure is what you do. And then actually that works even better because you've founded something that is committed to the foundational idea." State University Provost

As seen in these comments, our participants repeatedly asserted the value of creating a new structure or "box" when the existing ones do not accommodate innovation. This type of strategy for addressing perceived barriers is not so much a solution to the barrier as it is a means of temporarily circumventing the barrier. The [name] program is currently running successfully, and is able to grant students credits and degrees; however, this is not because the credentialing battle has been won, but rather because those involved were able to "hack" the system. As will be discussed below, achieving real, systemic solutions remains a challenge. However, until ecosystems change, we can still learn some lessons from the [name] program. In particular, our findings [13] suggest that the following things can be helpful if considered or put in place in the early stages of program development:

1. *Create a new "box" at the beginning of the process*. As the comments above illustrate, many participants saw the creation of a new program as the turning point for the realization of the IRE program. These participants went on to recommend creating a new "box" earlier in the process, to avoid some of the struggles they experienced.
2. *Ensure that there are champions at all levels.* Because credentialing issues reach across many institutional levels, it appears to be critical to have someone at each of these levels who can advocate for the new program, negotiate with relevant stakeholders, and ultimately secure support.
3. *Pay attention to the "bridgers."* Given the multiple levels and pieces involved with credentialing, it is important to identify and work with those individuals positioned at key bridging points between those elements. The translation work done by these bridgers can be critical in facilitating communication among stakeholders.

VI. Moving to Solutions

The methods for overcoming barriers to implementing new pedagogies in the unique case discussed thus far do not present solutions that remove the barriers, but rather approaches that shift or go around the barriers in order to address them. While there is success, both on an institutional level for awarding degrees and on a national level for engineering accreditation, the on-going "hacks" related to addressing registration and transcripting require regular maintenance. The systemic issues have not been addressed. However, this work presents progress in identifying what is happening at the system level so that the wide range of systemic barriers can be identified.

Next steps include addressing the credentialing ecosystem so that barriers to positive change in CSET education can be identified and removed. A key issue continues to be the credit hour and the difficulty of using a single metric to both define faculty workload and measuring student learning. As a research community, we need to address these issues separately and not put an invalid equal sign between credit hours and student learning. As many faculty members have experienced, the time it takes to ensure learning for one student may be very different for another.

One pragmatic approach that puts student learning first is a competency based system. However, the current ecosystem, based on the credit hour, makes this difficult to implement. While mapping the ecosystem is an ongoing research process, moving this research to practice would require a first step of defining a mapping function from a competency-based program to credit hours met, much like an articulation agreement that maps courses from one programmatic context to another. Rather than simply mapping topics covered in one course to another, and assuming time is constant, this transfer function moves from a domain where expected learning is constant (based on uniform minimum competency) but learning speed is variable, to a domain where time is constant (as defined by a credit hour) and learning is variable (as shown with a variety of acceptable grades). The development of a transfer function is a research issue; however, the implementation of such a system and associated mapping to the existing ecosystem would benefit from our research-based recommendations that 1) there be space for the solution, 2) there be multiple champions and 3) bridge points are found and leveraged. The innovative approach of a competency-based system is more likely to thrive in this system if a mapping exists, which would reduce barriers by translating the new approach into the dominant thought system. This work done at the onset would reduce the barriers that appear after initial implementation.

Any transfer function would have to take into account appropriate stakeholders, and could not simply be a credit-based articulation agreement. Until the credentialing ecosystem is ready for a change in the base unit of the holy credit hour, this may be the best path forward for sustainable change in engineering education.

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