Affordances and Barriers to Creating Educational Change: A Case Study of an Educational Innovation Implemented into a First-year Engineering Design Course

Dr. Sarah E. Zappe, Pennsylvania State University, University Park

Dr. Sarah Zappe is Research Associate and Director of Assessment and Instructional Support in the Leonhard Center for the Enhancement of Engineering Education at Penn State. She holds a doctoral degree in educational psychology emphasizing applied measurement and testing. In her position, Sarah is responsible for developing instructional support programs for faculty, providing evaluation support for educational proposals and projects, and working with faculty to publish educational research. Her research interests primarily involve creativity, innovation, and entrepreneurship education.

Megan Huffstickler, Pennsylvania State University, University Park

Megan Huffstickler in an Academic Adviser in the Biology Department at Penn State. Her undergraduate work is in Chemistry, and she will be receiving an MS in Educational Psychology from Penn State in May 2018.

Joseph C. Tise, The Pennsylvania State University, University Park

Joseph Tise is a doctoral candidate in the Educational Psychology program at Penn State University. His research interests include self-regulated learning, measurement, and connecting educational research to practice.

Dr. Thomas A. Litzinger, Pennsylvania State University, University Park

Thomas A. Litzinger is Director of the Leonhard Center for the Enhancement of Engineering Education and a Professor of Mechanical Engineering at Penn State. His work in engineering education involves curricular reform, teaching and learning innovations, assessment, and faculty development. Dr. Litzinger has more than 50 publications related to engineering education including lead authorship of an invited article in the 100th Anniversary issue of JEE and for an invited chapter on translation of research to practice for the first edition of the Cambridge Handbook of Engineering Education Research. He serves as an Associate Editor for Advances in Engineering Education and on the Advisory Board for the Journal of Engineering Education. He was selected as a Fellow of ASEE in 2008 and of ASME in 2012. He holds a B.S. in Nuclear Engineering from Penn State, an M.Eng. in Mechanical Engineering from RPI, and a Ph.D. in Mechanical and Aerospace Engineering from Princeton.

Dr. Sven G. Bilén, Pennsylvania State University, University Park

Sven G. Bilén, Ph.D., P.E. is Professor of Engineering Design, Electrical Engineering, and Aerospace Engineering at Penn State and Head of the School of Engineering Design, Technology, and Professional Programs. His educational research interests include developing techniques for enhancing engineering design education, innovation in design, teaching technological entrepreneurship, global product design, and systems design.
Affordances and Barriers to Creating Educational Change: 
A Case Study of an Educational Innovation Implemented in a First-Year Engineering Design Course

Abstract
This evidence-based instructional-practice paper describes a case study of the implementation of an educational innovation into a multi-instructor, multi-section first-year design course in the College of Engineering at Penn State University. Although literature from education and psychology fields provides many examples of how to enhance student learning, adoption rates for evidence-based instructional practices have been fairly low among engineering faculty. Even when teaching and learning centers are able to facilitate the adoption of evidence-based practices, encouraging a large fraction of engineering faculty to make substantial changes in instruction remains very challenging. This paper describes an educational innovation adopted by the engineering design program and the results of a qualitative study focusing on the affordances and barriers that emerged during the change process. The findings show that affordances that supported change were related to flexibility, fit of the instructional methods with the course, meeting a perceived need, ease of use, and financial incentives offered by the college’s teaching and learning center. A sense of community yet autonomy also encouraged faculty to participate. Barriers included implementation ambiguity, time required to implement and to prepare, and a perceived lack of expertise in some of topics involved in the innovation such as ethics. Faculty resistance to change, the logistical concerns of the course, and characteristics of the university, as well as interpersonal dynamics also impacted the likelihood of adoption. The results are discussed in terms of implications for faculty developers and teaching and learning centers.

Introduction and Literature Review
In the past several decades, engineering education has seen a significant increase in the amount of research and funding dedicated to implementing instructional change to better enhance student learning. Funding agencies such as the National Science Foundation have invested substantial monetary resources into changing engineering education to better meet global and societal challenges. Abundant research has been conducted in the STEM education context supporting the efficacy of instructional practices such as active learning (e.g., Prince, 2003; Freeman et al., 2014). However, research has also shown that many engineering faculty members still teach in a traditional manner (i.e., Bender & Weimer, 2005; Borrego, Froyd, & Hall, 2010; Dancy & Henderson, 2008). In addition, many educational initiatives, funded or unfunded, often fail to be long-lasting or transformative.

The paper examines affordances and barriers in a case study of an educational initiative implemented in a first-year design course, in order to identify elements that support instructional change as well as those elements that could be potential barriers to change. Studying this initiative, funded by a teaching and learning center, can provide insight on how various resources can best
be implemented when encouraging faculty to embrace instructional change. The study utilizes a qualitative approach, with interviews of key stakeholders in the project, including leaders who developed the instructional materials, the department head, and the instructors implementing the change.

The study of change in STEM education has been increasingly emphasized in recent years. Organizations such as the National Research Council (2011) have specified the need for engineering instructional practices to be better aligned with research in education and psychology. Research-based instructional practices can be defined as “those that have been studied in well-designed investigations that collect convincing evidence showing that the practice can be effective in promoting learning” (Litzinger & Lattuca, 2014, p. 376). Relatedly, evidence-based instructional practices include research-based practices as well as those supported by other forms of evidence, such as data collected through rigorous assessment and evaluation.

While the literature abounds with examples of research-based and evidence-based instructional practices, encouraging faculty to adopt or adapt specific instructional strategies can be challenging. Borrego and Henderson (2014) identified many variables that could potentially impact whether or not an innovation is adopted. These variables relate to the characteristics of the innovation, consequences, benefits versus costs, personal characteristics, familiarity with the innovation, position in social networks, and the environmental context, to name just a few. A qualitative study of 44 instructors at a large research institution (Merson, Schrott, Zappe, Hochstedt, & Litzinger, 2015) examined the barriers and supports that instructors perceive when choosing whether or not to use evidence-based instructional practices in their classroom. The study showed that supports such as teaching and learning centers, collaborations with other faculty, financial incentives, and support from administrators such as department heads, can help to encourage faculty members to utilize evidence-based practices. Conversely, the results shows that barriers for implementation include low awareness, lack of resources, isolation, lack of collaborators, and lack of incentives.

Litzinger and Lattuca (2004) discuss strategies that can be used to increase the likelihood that instructors will adopt different instructional practices. They state that adoption can be facilitated through a variety of strategies: “1) align the practice with important needs of intended users, 2) begin planning for transfer to widespread practice from the very start of the development process, 3) engage the intended users as early as possible…, 4) incorporate research approaches that will determine why the practice is effective, and 5) plan for the fact that many users will want to adapt the practice to match their needs and work environment.” (p. 389). Similarly, Furco and Moely (2012) state that securing faculty buy-in into a project necessitates clear communication regarding the goals of the innovation, opportunities to gain expertise with the innovation, perceptions of institutional commitment, and rewards.

Teaching and learning centers and faculty developers have the potential to help faculty and departments with the change process. Oftentimes, educational initiatives are instigated by just a few members of a department, which leads to challenges for wider adoption by other departmental faculty. Faculty developers can work with the department to identify practices that could lead to greater adoption of the innovation beyond just the project initiators. Faculty developers working in these centers can be change agents (Patrick & Fletcher, 1998), by guiding projects to align with
research on transformation. For example, if a department is interested in curricular reform, faculty developers can work with the department head and project leads to ensure the project unfolds in a manner that is more likely to lead to wider adoption among the departmental faculty.

Research on the relationship between faculty developers and change is somewhat lacking. Steinert and colleagues (2007) began to talk about how faculty developers can be change agents in their case study from the medical discipline. The authors mapped their various faculty development initiatives onto Kotter’s (1996) eight-step model. Faculty development initiatives such as leading workshops and creating communities of practice map to steps in the change process such as creating and communicating vision and empowering others. Clearly, faculty developers have the potential to act as change agents. However, it is unknown how much the literature on change informs the practices that faculty developers use when they work with faculty.

More research on faculty developers as change agents in the engineering education discipline is needed. This study begins to scratch at the surface of how teaching and learning centers could potentially help to facilitate change by identifying affordances and barriers to the adoption process of a specific educational initiative. The study builds on other research relating to affordances and barriers relating to change in engineering education, focusing on the lens of faculty development. The context for the study is further described below.

**Context of Study**

The study took place within the College of Engineering at Penn State University, a large mid-Atlantic research-focused university. In response to a call for proposals from the Leonhard Center for the Enhancement of Engineering Education (the College’s teaching and learning center), the engineering design program proposed the creation of a set of multi-disciplinary modules about the professional skill set and contemporary issues in engineering, focusing on topics such as communication, innovation, and sustainability. The modules would be implemented in a first-year design course, which is a required course for most first-year students intending to major in engineering.

Because of the large size of each year’s incoming class and the desire to keep class sizes fairly small, the number of sections offered each semester is large. Challenges associated with teaching the course include consistency across sections as well as limited teaching experience among new instructors.

As additional context, the College uses the framework of the “World-Class Engineer,” which was developed within the Leonhard Center. This framework is used as a set of guiding principles for students on what to strive for in their undergraduate path and into their careers and is often used in strategic planning by the College. The attributes of the World-Class Engineer include solidly grounded, technically broad, globally engaged, ethical, innovative, excellent collaborators, and visionary leaders. This framework is relevant to this study as it served as the foundation for some of the instructional changes made within the course.

Studying the change process with this particular project makes for an interesting case study, as the department had attempted similar initiatives in the past with mixed success. With the initial
implementation of the modules, anecdotal information suggested that the adoption process was going more smoothly than previous attempts. Therefore, a decision was made to conduct a qualitative study of the change process.

Description of course

Required of almost all engineering majors within the College of Engineering, EDSGN 100 Introduction to Engineering Design is a first-year “cornerstone” design course that occurs in a project-based learning (PBL) environment. The 3-credit residential course is offered at 20 separate campuses. Annual total enrolment in AY16–17 was around 1900 at the largest campus and 2200 total at the smaller campuses. Section sizes vary from campus to campus, but are capped at around 32 students per section.

The course exposes students to an engineering design process and an appreciation for what engineers do. Students are meaningfully engaged in design, using tools and techniques that can facilitate successful execution of the process, enabling them to identify, formulate, and solve engineering design problems. To replicate what students will experience in industry and to provide real-world context, the course includes several design projects within a PBL setting, including a culminating industry- or client-sponsored project.

History and Background—Why the Modules Were Designed and Implemented

Because of the importance of the course EDSGN 100 as a cornerstone design course within the College of Engineering, the engineering design program continually innovates the curriculum in this course. In the past, this has involved developing custom textbooks, new design projects, new methods of teaching topics, and other changes. Faculty teaching the course at the largest campus meet weekly to discuss the course as well as to share teaching innovations. Bi-annually, faculty teaching the course at all campuses meet during a larger meeting to provide updates on the course and to share innovations. A need was identified to codify many of the innovations within new teaching materials and the support provided by the Leonhard Center helped to facilitate and catalyze the faculty. Led by the course chair and director of the design program, a proposal was submitted to develop a series of modules with the following goals in mind:

- Strengthen relationship between the experience of a first-year engineering student and the vision of the college of engineering for graduating students
- To provide a framework for students for the world-class engineer early in their education
- Provide experience and vocabulary needed to make the World-Class Engineer an important part of engineering students’ identity
- World-class Engineer attributes will be reinforced through multidisciplinary modules

The proposal to the Leonhard Center provided a broad vision for the modules that was refined once the project was kicked-off by faculty involved.
Description of Modules Developed

Six self-contained modules were designed for incorporation into the course. Each was designed to require approximately one week of class time. A short description for each of the modules is given below.

1. World-Class Engineering: Introduces students to the attributes of a world-class engineer as well as the important aspects of teamwork, working across cultures, leadership, and ethics.

2. Systems and Sustainability: Introduces students to “seeing the big picture” and systems thinking through lessons on life-cycle analysis, eco footprint, and systems diagrams.

3. Innovation Process: Focuses on creativity and innovation throughout the design process by engaging students in various techniques during concept generation, concept selection, and prototyping.

4. Professional Communication: Offers a range of communication tasks, from technical presentations and reports to those that explore personality types and design critiques.

5. Making: Highlights the maker culture, traditional manufacturing, and additive manufacturing, while allowing the students to explore each element through design tasks.

6. Grand Challenges: Explores grand challenges, such as the National Academy of Engineering’s Grand Challenges for Engineering or the UN’s Sustainable Development Goals, and provides activities related to the grand challenges of access to clean water and personalized learning.

Research Questions

This study examines what characteristics of the project helped or hindered the adoption or adaption of the instructional modules by the course instructors. The following research questions were examined in the study:

1. What are the affordances that influenced adoption/adaption of the instructional modules by the course instructors?

2. What are the barriers that impacted adoption/adaption of the modules by the course instructors?

Methods

Participants: Instructors of the EDSGN 100 course, the department head, and those who had contributed to the design of the modules were asked to participate in a brief (30–60 minute) interview about the barriers and affordances of the change process. A total of 20 faculty members participated in the study. Of these 13 were male and seven were female. Nine were tenured or tenure-track faculty whereas the remaining 11 were non-tenure track instructors. Two of the instructors taught at the smaller campuses; the remaining participants taught at the university’s largest campus. All instructors who voluntarily agreed to participate were interviewed for the study. All of the instructors who agreed to participate were using the instructional modules to
some degree. For this paper, we consider the terms “faculty members” and “instructors” to be synonymous, regardless of tenure status.

Interview Protocol: The interview protocol was developed by members of the Leonhard Center. These members included individuals with backgrounds in engineering education and educational psychology. The interviews were conducted by two graduate students who worked within the Center. During the semi-structured interviews, participants were asked to talk about positive and negative experiences that they had while implementing the course modules. In addition, information was collected about specific course modules for formative assessment purposes. The interview protocol is available in the Appendix. All interviews were recorded and later transcribed. The study was approved by the university’s Institutional Review Board.

Data Analysis: One of the graduate students coded the interviews using an iterative process, which allowed for themes and codes to be added or revised as additional transcripts were analyzed (Miles & Huberman, 1994). The graduate student coded the interviews initially to identify emergent themes. The interviews were then recoded to ensure that all themes were appropriately captured and coded. The codes were checked by an educational psychologist in the Leonhard Center.

Results

General Perceptions and Use of the Instructional Modules

Understanding how instructors utilized and perceived the instructional modules is important to understand the context before discussing the affordances and barriers to the implementation of the instructional initiative. It is important to note that while the instructors had access to six total modules, none had decided to use all of them in their entirety in their course. Two of the instructors had said they used parts of all of the modules. Eleven of the instructors had selected just portions of at least one module.

Certain modules seemed to be more popular than other ones, as instructors discussed the strengths and weaknesses of each one. The Innovation-Process module was described most positively and was most often used by the participants. The World Class Engineer module was also described positively. Some of the other modules were described less positively and thus were utilized less often by the participants.

Affordances That Impacted Adoption of the Instructional Modules

The results of the coding identified seven major themes relating to the affordances to adoption/adaption. These codes are identified with definitions in Table 1. Some of the codes related to the characteristics of the instructional modules whereas others related to people and team dynamics and characteristics.
### Table 1: Codes relating to affordances of adoption of instructional modules

<table>
<thead>
<tr>
<th>Category</th>
<th>Theme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
<td>Flexibility</td>
<td>The ability to select which modules or portions of modules to utilize in the course</td>
</tr>
<tr>
<td></td>
<td>Fit with course</td>
<td>Perceptions that modules fit well with their course goals or the course structure</td>
</tr>
<tr>
<td></td>
<td>Meets a need</td>
<td>Perceptions that the modules meet a need in the course</td>
</tr>
<tr>
<td></td>
<td>Ease of use</td>
<td>Perceptions that the modules were easy to use or well-structured</td>
</tr>
<tr>
<td></td>
<td>Financial incentives</td>
<td>Perceptions that financial incentives encouraged adoption</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Community</td>
<td>Instructors perceived positive buy-in, teamwork, and communication among their colleagues</td>
</tr>
<tr>
<td></td>
<td>Autonomy</td>
<td>Instructors could make the decision whether or not to implement the modules in their course section</td>
</tr>
</tbody>
</table>

Themes related to the characteristics of the instructional modules included flexibility, perceived fit to course, meeting a need, ease of use, and financial incentives. The most commonly coded affordance theme related to the perception of **flexibility**. Elements of the modules that supported their flexibility, as mentioned in the interviews, included: 1) various options are provided in the module guidelines, 2) modules are self-contained and don’t rely on content from other modules, 3) format of the module materials was laid out in sections, 4) instructors could use any or all of the modules (as well as any or all of the material within each module), and 5) ability to use the modules in any order. The following quotes illustrate the perceived flexibility of the instructional modules:

I have liked that there’s an idea that you can go shopping, and kind of take the best things and adapt them into your course, bring them into your course.

I didn’t change much [about the modules]. There were a lot of options in the guidelines that [the module creators] made which was nice so I could kind of pick and choose what I wanted to bring in which I like.
From my understanding of it, you can decide to implement as much or as little as you want….

Another affordance related to the characteristics of the instructional modules involved the perceived **fit with the course**. Some instructors discussed how their modules fit into the course or met course objectives. As one instructor stated, “…[the module] fits in really nicely with how I run my course and it offered up some really interesting ways to do what we sort of traditionally do but maybe in a new way and the students seemed very receptive to it which was really nice.”

Related to this, some instructors discussed the modules **meeting a need**. As one individual stated, “It met the need for the first [course] project. So [the module] was really helpful to me in that sense.” Another individual said, “You know, it filled a vacuum…I rely on [other instructors] to say, ‘Okay, what are you guys doing tomorrow? Help me understand.’ Then I’d get into the modules and pick out the parts that I was comfortable with.”

An additional affordance attributed to the characteristics of the modules concerned their relative **ease of use**. Several instructors discussed the ease of implementation for certain modules. For example, one instructor stated, “It was easy to implement because it was laid out really nicely. So the way the progression was set up felt really natural for the course. And that made it very easy to use.”

The final affordance related to the project itself concerned the fact that the module creators received **financial incentives** from the College’s teaching and learning center to work on the project. The module creators received incentives in the form of supplemental summer salary to work on the creation of the instructional materials. While this affordance was not a benefit to all of the individuals using the modules, it was mentioned as one reason for the effectiveness of the modules. This affordance is reflected in the following quote:

> Yes. I mean, so first off, the ability to kind of sweeten the pot a little bit by providing some income for faculty, that’s a help, right. Because, okay, we paid you, now you got to produce, right. So as opposed to the past [initiatives], we haven’t had that….

Characteristics relating to the people and dynamics working on the project included autonomy and community. The theme of **autonomy** is related to the theme of flexibility. Many respondents liked that the modules were there if they wanted them and that the department did not force them on the instructors. The following quotes are examples that show the autonomy theme:

> I think that having the modules as suggestion and a guide is great. Having them as something that has to be done and becoming very rigid could be detrimental.

> The current project is to let people do what they do best and to create that opportunity and let people opt into using it. And previous approaches have been either legislated, “Everyone will do this.” In which case everyone says, “No, we’re not going to.”

> So instead of saying, “This is the course. This is what you must do, we’re saying, “Here are some cool materials and you can do the things that you do, and
incorporate these materials into that process.” And that improves the overall quality of instruction, but also the homogeneity across the sections, while still preserving opportunities for the faculty members to be individuals and to do the things that they do best.

Related to this is the idea of community. Some instructors described the process as being very community driven, with input from many faculty members. The fact that the project was not just driven by one individual helped to increase the buy-in by many faculty in the department. For example, one participant stated, “I think going in, we had a lot of buy-in from faculty. I mean, a lot of the faculty [were] working on [the modules]. So I think that’s helpful. That everyone’s within the process and we’re not just saying, ‘Here, go do this’ or something.”

The theme of community also incorporated perceptions relating to the sharing of ideas and expertise. The creation of specific modules was often led by individuals who were considered to be experts in those areas. As one individual stated, “the instructors and professors that wrote their modules were pretty passionate about what they were writing about, so they tried to find their best examples or they tried to provide their most interesting information.” This sharing of knowledge and expertise into a common purpose seemed to be appreciated by some of the participants. As another instructor stated, “So what I love about [the project] is, I think it’s great to just have this sharing of ideas. I learned what everyone’s doing that they see is best, and it’s great to have that communication, and to have that sharing of knowledge. And I think that even if we have the modules all designed, having just a gathering or a sharing of those practices from time to time would be very useful.”

**Barriers That Impacted Adoption of the Instructional Modules**

As mentioned above, the participants varied in terms of how many and how much of the modules that the participants had utilized in their course. When asked about the modules that they felt were most difficult to implement, participants’ comments aligned with several themes that emerged in the coding process. Table 2 identifies the primary emergent themes relating to barriers that impacted adoption of the instructional modules. As with the affordances, themes were identified as being associated with the characteristics of the modules or with the overall project as well as being associated with the team dynamics or departmental characteristics.
Table 2: Codes relating to barriers of adoption of instructional modules

<table>
<thead>
<tr>
<th>Category</th>
<th>Theme</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics of project</td>
<td>Length of modules or time required to implement</td>
<td>Perceptions that the modules were too long or required too much time to implement in the course</td>
</tr>
<tr>
<td></td>
<td>Implementation ambiguity</td>
<td>Perceptions that it was unclear how the modules were to be implemented</td>
</tr>
<tr>
<td></td>
<td>Required preparation time</td>
<td>Perceptions that modules required too much preparation time by the instructors</td>
</tr>
<tr>
<td></td>
<td>Lack of expertise</td>
<td>Perceptions of lacking expertise in areas related to the module content</td>
</tr>
<tr>
<td>Characteristics related to person/team</td>
<td>Resistance</td>
<td>Perceptions that instructors did not want to be told how to teach the course</td>
</tr>
<tr>
<td></td>
<td>Number of instructors/sections/campuses</td>
<td>Perceptions relating to the complexity of the course given the number of instructors, sections, and campuses</td>
</tr>
<tr>
<td></td>
<td>Role tensions</td>
<td>Perceptions relating to roles of the individuals (i.e. tenure-track vs. non-tenure track; main campus vs. smaller campuses)</td>
</tr>
</tbody>
</table>

Some modules were seen as overly **lengthy** or too time-consuming to implement in their course section. The modules were designed to have many options or possible implementation strategies. However, some individuals seemed to have more difficulty with figuring out how to cull the module into usable segments in their section. This theme is illustrated by the following quotes:

Some activities were just lengthier, and I just don't have class time for it. I think if we could have shortened versions or less activities involved because I feel like, sometimes, I feel like everything should be taught....

I think all the modules are quality. Just overabundant.

The flexibility and segmented nature of the modules afforded instructors much autonomy to make decisions on what they wanted to implement in the classroom. But this flexibility was also sometimes a barrier to some instructors, who had to make decisions on how to implement the modules. This **implementation ambiguity** was a concern often mentioned. Some instructors had difficulty with figuring out what activities to include and what to leave out, focusing instead on the length of the modules and the impossibility of incorporating all of the module content. As one participant stated, “In terms of the relative difficulty of implementing these modules, I think the
most difficult part was finding the right chunks and the right breakdown for what to bring in…

Breaking down 30-minute segments or hour-long segments from the modules that I could bring in was the most difficult part.” Another instructor stated the following:

I think the hardest thing overall about the modules is to know how to incorporate them into an already full schedule. Because we developed them but we haven’t figured out the overall plan or scheme or maneuver how we’re going to incorporate them.

The instructors did not receive any mandate requiring that they had to implement all or certain modules or that they had to implement certain activities. Some instructors felt that this was a challenge that impacted adoption, as illustrated by the quote below.

Because right now, [the modules] are kind of like optional. Certain ones. It’s unclear which ones are going to be required and which ones are optional. And so, I think that, that ambiguity leads people to maybe not adopt it as fast as they could or should.

The challenge with these six modules was, and something that I still don’t think that we’ve really arrived at the final answer, is which of these things should be taught by everybody and which of these things should people be able to pick and choose?

Some participants felt that some of the modules required a lot of preparation time, particularly when the instructors felt that they lacked expertise on a certain topic, for example, ethics. They felt that they had to do a lot of preparation to make sure that they were able to implement elements of the modules. The following quotes reflect these two related themes:

I had to spend a lot of time going off and researching the materials, and then putting together my storyline…. Again, I believe that the way I operate, I don’t want somebody just to give me a script. I want somebody to give me background material that has more than enough than what I need to say.

There’s some [modules] that are very well fleshed out and pretty easy to teach from. There’s one or two that—they’re outside of my wheelhouse so they felt clunky to me and I had to do more research to try and some of them I was never as comfortable with as other ones.

Some of the modules I don’t really know anything about. I mean, partially that’s my fault because I haven’t gone to explore them but I wish we could’ve had a big session where we all kind of presented on them.

Even though the modules allowed for much adaptation, resistance to being told what to do was still an issue for some participants. Some instructors had taught for a long time and were resistant to change. The following quotes illustrate this theme:
Everybody wants to do what they do, and the notion that we have to give up some of that freedom to have continuity across the sections is a difficult one for all of us.

Initially with the modules I was hopeful but a little bit wary, not just from the broader [course] perspective but also from my own as an instructor. Just like everybody else, I hate people telling me what to do. And while I appreciated that, holistically, this idea was a good one, when it came to my class, I was wary of the idea that I would have to use the results in my own course.

Relatedly, because of the high number of students at the university who take the course every semester, the number of instructors involved in teaching is very high, making the problem more complex. The number of instructors, sections, and campuses makes curricular change processes for the course more complicated. As one participant stated:

I think the fact that there’s 23 sections of the course. And at any given time, there are 15 instructors. And so, especially, you’ve got some people who have been teaching the course for 20 years and they’re really set in their ways. And then, you have new people coming in who are more open to changing things, and I think the main issue is you have so many people. And trying to get a person to buy into it and utilize it, I think is the biggest challenge.

The logistical considerations related to having instructors and sections at other campuses also complicated the adoption process. As one individual stated, “As you can imagine, getting 17 faculty here at (name of largest campus) and another more than a dozen faculty at the campuses to agree on. Everything in the course is challenge.”

Relatedly, some participants discussed prior attempts to standardize the course curriculum, describing barriers relating to what we called role tensions, or those dynamics that seem to stem from individual’s role within the overall department. Examples of the instructor role tensions that emerged from the data included more experienced versus less experienced, tenure-track versus non-tenure track, more experienced versus less experienced, or main campus versus smaller campuses. In prior efforts to change the curriculum, different instructors have prioritized different content, with different “factions” created regarding how the course should be taught. As one participant noted,

We tried probably about six or seven years ago to write our own book per se. And that ended up being kind of a disaster because some of the faculty use it. Others don’t use it. I think we had a philosophical difference in what the course should be…. We also had some very strong personalities in the department, etc. Some of whom have retired. …There’s this sort of idea that somehow you can get 25 faculty to all agree on everything. And I think that’s never going to happen.

The tenure status of the of instructors also impacted the adoption process. A tension seemed to exist, in the opinions of some participants, between the tenured/tenure-track faculty and non-tenure track instructors. This tension is illustrated in the following quote:
In the process of writing curriculum, my observation anyway, the tenure-track faculty want it to be very—I’m going to use my own jargon, high-brow and rigorous…. And the fixed-term faculty tend to want a more pragmatic sort of…workbook. So the fixed-term faculty are totally okay with that because the attitude is just what we need to know. The tenure-track faculty are more looking down the road and wanting to challenge students more and also connect more with the research work that they’re doing, too. And I think that that creates tensions when you’re trying to do anything that is course related where both kinds of faculty teach the course.

Another source of tension that related to role tensionss concerned the instructors at the university’s largest campus and those at the other campuses that offer the design course. The modules were written primarily by instructors at the largest campus, although all module design teams included a faculty member or two from the other campuses. Even so, for many of the modules, assumptions were made about the format and resource availability based on the largest campus characteristics, which were not always consistent at the campuses. The department had a difficult time integrating the instructors of the course at the other campuses. For those that did use the module, and participated in this interview, statements were often made about the lack of applicability to the campus sections. For example, one of the modules asked students to take a picture of a maker space on campus, which was feasible for students at the largest campus but generally not at the many of the other campuses. The following quotes illustrate this point:

One of the instructors that was working with us on this who is from one of the…campuses said, “Hey, you know, a lot of the [other] campuses don’t have the same facilities that you guys have, so you should really reach out to them and see what is feasible in terms of the facility standpoint and what is not.

“…[A] challenge is just a lot of the modules are built for the schedule at [the largest campus]…. I knew that our course was from very different from than [that at the largest campus], but the biggest frustration is just that I can’t use [the modules] in the setup that they’re created for because it’s not the setup that we have.

Discussion

This work studied the affordances and barriers to change in an introductory first-year engineering design course. The department created and implemented a set of modules on professional skills that instructors can use in the course, while maintaining instructor autonomy and allowing for much teaching flexibility. Aspects of the project that encouraged the instructors to utilize the modules included this flexibility, the perceived fit with the course, meeting a perceived need, and the ease of use. In addition, financial incentives in the form of supplemental summer salary offered by the College of Engineering’s teaching and learning center encouraged faculty to create the materials and use them in their course. Feelings of community as well as autonomy helped to create a large contingent of instructors who made the changes in their course sections.
In many cases, the characteristics of the modules that were seen as affordances for their implementation had an opposing barrier for other modules. For example, participants that felt that the Innovation-Process module was easy to use or fit with their class may have identified lack of clarity or lack of fit as reasons for not implementing a different module. The primary barriers that emerged included that certain modules were seen as too long or time-consuming to implement, that clear guidance for implementing modules was not provided, required preparation time, and perceived lack of expertise. In addition, the varying roles of involved individuals impacted adoption. Some participants perceived a tension between those instructors who were tenured/tenure-track and those who were fixed-term instructors. In addition, differences between how the course was offered at the university’s largest campus and the smaller campuses posed logistical concerns and created additional barriers to change.

While the project followed some of the suggestions from the literature on how to promote change, particularly focusing on flexibility and allowing instructors to adapt modules to their own instructional style, barriers still existed relating to the logistical characteristics of the course and the university. Even with the focus of the project on flexibility, some instructors were still resistant to change and did not want to be told how to teach the course. While the project has had some impact on standardizing the course, individual differences regarding buy-in of the project are apparent.

The department had embarked on similar projects in the past. From this study and through conversations with the instructors, this initiative met with greater success than those in the past, while still, of course, having barriers and challenges. The greater success of this project as compared to previous initiatives seems to stem primarily from the great flexibility available to the instructors. While all the instructors were encouraged to use the modules, instructors were not required to do so. In addition, they could choose to use portions of the modules as they deemed fit. The lack of a mandate encouraged greater participation, but also created challenges. Some instructors found it difficult to determine what aspects to use in their course. The great flexibility could also lead to lack of consistency across sections.

The study provided some insights into how teaching and learning centers can better promote the change process in a project as complex as this. Financial incentives were made available to the faculty involved, which certainly helped with the creation of the instructional materials. However, financial incentives were not enough to have all the instructors adopt the modules. Faculty developers and instructional designers should help to incorporate as much flexibility as possible in the project development phase, which will help with adoption. However, some guidance should also be available as to what elements of the instructional innovation should be implemented to meet accreditation requirements or to help with consistency. Some recommended options might also be helpful for faculty members who are newer to teaching the course. Department heads should be asked to encourage the adoption of the instructional innovation, but mandates will likely be ineffective.

Another important aspect that faculty developers need to be aware of is the context of the course, including the pain points. In this case study, understanding the complexity of the course, with many instructors of different position types at different campus locations, is critical to identifying
the barriers for adoption. Conversations with different stakeholders, including the department head and instructors from different roles would also help to identify potential challenges with implementing the instructional change.

Evaluation efforts, such as data collected from this study, could help to identify areas where the instructional changes are not meeting instructors’ needs or are posing challenges. In this study, the members of the Leonhard Center met with the project leads to provide a report of recommendations and suggestions. Suggestions from this particular study included shortening the modules, changing modules that were viewed to be problematic, providing additional guidance for newer instructors, and working more closely with campus liaisons. By providing this information from an external evaluator, the project leads and department heads could hear a fuller description of how the educational innovation is going, rather than relying on the faculty members themselves to provide feedback. Given that role tensions impacted adoption of the modules, having concerns shared confidentially with the project leaders could better help the advancement of the project.

This study has several limitations. First and foremost, not all of the course instructors participated. While all were invited to participate, several instructors either did not respond to requests or responded that they did not want to be interviewed for several reasons. Several of the non-respondents said that they were not using the modules and therefore did not want to be interviewed. While these individuals were asked to participate in the interview anyway, in order to better capture reasons why they chose not to use the modules, they declined to participate in the study. One instructor responded over e-mail that his reason for not using the modules was that he did not have a need for them. He felt his course was already full and felt like the activities he already included were sufficient. Another limitation of the study is that small number of instructors from the smaller campuses (although all instructors who expressed interest were included) meant they were not as well represented. The limited results from these instructors indicate that there are potential barriers that would need to be addressed to increase the standardization of the course content both at the university’s largest campus and at the smaller campuses.

The results of the study identified several areas for future work. As indicated in the results, perceptions may differ based on whether the interviewee was a tenured/tenure-track faculty or a fixed-term faculty. Analyzing the results with these characteristics in mind might reveal additional barriers for implementing educational innovation. Another possible area for future work is exploring differences in perceptions between novice and more expert teachers. Are expert teachers more easily able to maneuver through the modules, despite the ambiguity or lack of directions? Are novices more likely to adopt the modules in general? Additionally, future work relating to how faculty developers can help to address barriers is needed. One research question that could potentially be explored is whether or not faculty developers consider research relating to educational change when working with faculty. What best practices could help lead to greater adoption of educational innovations. Future research could explore these questions and perhaps encourage educational change in engineering education.
Acknowledgements:
The authors thank the Leonhard Center for the Enhancement of Engineering Education at Penn State for the funding to support the overall instructional revisions in the course as well as funding the data collection for this study.

References:


Appendix

1. How long have you been teaching at [the university], and what is the nature of your appointment? How long have you been teaching [the course]?

2. Describe your role in the recent revisions for [the course]

3. What were the reasons that you became involved with the [course] project?

4. What was your initial reaction to the course changes related to the modules in [the course]? Why do you think you felt that way?
   a. Did your attitude toward the changes shift? If so, please explain what led to the shift.

5. Which modules have you implemented so far in the course?
   a. Tell me about a positive experience you’ve had while implementing these modules.
      i. Can you tell me about how you implemented this module in your course?
      ii. Why do you feel that this module was most successful?
      iii. What made this module easy or hard to implement into your course? What was most challenging about implementing this module in your course?
      iv. Did you make any changes to the module in advance or “on the fly” in the classroom? Describe.
      v. Do you have any suggestions on how this module could be improved?
   b. Tell me about a less positive experience you’ve had while implementing these modules.
      i. Can you tell me about how you implemented this module in your course?
      ii. Why do you feel that this module was less successful?
      iii. What made this module easy or hard to implement into your course? What was most challenging about implementing this module in your course?
      iv. Did you make any changes to the module in advance or “on the fly” in the classroom? Describe.
      v. Do you have any suggestions on how this module could be improved?

6. Have you or anyone in the department tried to implemented similar changes in the past
   a. If yes, describe.
   b. How is the current project different from the prior experience you’re describing?
   c. What makes the current project more or less successful than past implementations?

7. What challenges do you feel there have been as the department has tried to adapt a more unified strategy for teaching [the course]?
   a. If you were in charge of the [course] redesign, what would you have done differently?

8. Do you have any other comments about the [course] revisions or any of the modules?