

How KEEN Encourages the Adoption of Educational Innovations Focused on Entrepreneurial Mindset into Engineering Classrooms

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Abstract

Background

A consistent challenge in educational research is ensuring that published innovations are successfully integrated into the classrooms they aim to improve. The process of integrating new pedagogy into existing classrooms involves both a method of communication (journal articles, workshops, word of mouth, etc.) and faculty motivation to make change. This work characterizes the research-to-practice translation of the Kern Entrepreneurial Engineering Network (KEEN), a network of higher education institutions invested in the development of entrepreneurial mindset (EM) in engineering students.

Results

Through semi-structured interviews with six sustained adopters of EM, we were able to examine faculty members' approaches to adoption and how these approaches correlated with KEEN's approaches to dissemination. We analyzed KEEN's professional development offerings using the Designing for Sustained Adoption Instrument (DSAAI) and described how faculty motivation, as characterized by the Intrinsic Motivation Inventory (IMI), may affect their integration of innovations into the classroom. We found that KEEN's offerings largely aligned with the DSAAI's recommendations for sustained adoption—their consistent emphasis on faculty engagement as well as a mix of active and passive professional development strategies were effective in supporting faculty members throughout the adoption process. Faculty members at the studied institution generally expressed interest in and enjoyment of KEEN professional development offerings, saw value in EM education, and were willing to put in effort to adopt related strategies, implying they have a strong intrinsic motivation to adopt EM. However, many faculty members interviewed expressed a low level of competence related to the entrepreneurial mindset.

Conclusions

Results of this study suggest that faculty members at the studied institution who successfully adopt EM into their classrooms do so using primarily professional development offerings aligning with the DSAAI's guidelines for sustained adoption. Additionally, successful adopters rec-

ognized their own deficiencies in EM and identified KEEN professional development as an opportunity for growth, indicating their high intrinsic motivation to make changes in their classrooms.

Keywords

Professional development; innovation propagation; educational innovation; STEM faculty; instructional change; engineering education guilds

Introduction

One goal of educational research is to create and evaluate more effective teaching methods. While the fundamentals of engineering may remain the same, engineers are trained to design solutions for an ever-changing world (Duval-Couetil et al., 2015). It follows, then, that instructors should adjust their classroom approaches consistently to keep up with this pace of change. Despite numerous efforts to develop and disseminate new teaching methods, transferring them into classroom practice has proven difficult (Borrego and Henderson, 2014; Melsa et al., 2009; Supiano, 2023). Some of the challenges in fostering the adoption of pedagogical innovations lies in how well the innovation is socialized among potential adopters. Previous research has shown that simply creating a pedagogical innovation and sharing it with the education community is not enough for it to be successfully adopted (Cross et al., 2021; Cutspec, 2004; Froyd et al., 2017; Pitterson et al., 2020; Mestre et al., 2019), and that when developers use a combination of passive and active dissemination strategies, adoption is more likely (Stanford et al., 2017). Among the passive strategies are journal articles or conference presentations and among the active strategies are workshops and communities of practice. These dissemination strategies have been examined in the context of National Science Foundation-sponsored projects and internally funded projects (Ma et al., 2018; Stanford et al., 2017), but have not yet been examined in the context of philanthropic foundation-funded projects.

The Kern Entrepreneurial Engineering Network (KEEN) is a professional society, funded by the Kern Family Foundation. KEEN is dedicated to helping faculty members integrate the core principles of the entrepreneurial mindset (EM) into their engineering classrooms. Specifically, this is “a community of more than 4,000 faculty and staff

with a shared mission to graduate engineers with an entrepreneurial mindset” (Kern Entrepreneurial Engineering Network, n.d.a). The EM framework is defined by the 3 Cs—curiosity, connections, and creating value—and it is expected that leveraging these skills helps one better develop their EM. KEEN offers professional development opportunities such as national conferences, faculty development workshops, Engineering Unleashed cards, annual support packages to partner institutions, and fellowships to individual faculty to encourage faculty professional growth and collaboration (Kern Entrepreneurial Engineering Network, n.d.a). We argue that the core competencies of the entrepreneurial mindset are inherently linked to the professional responsibilities of teaching faculty, as they are expected to foster students' curiosity of relevant subject matter (Pusca and Northwood, 2018), make connections with other faculty members (Meyer et al., 2023), and create value for students in their classrooms (Hartikainen et al., 2022). Other work has shown that engaging with EM professional development opportunities helps faculty to feel more confident when integrating EM content into their classroom (Jackson et al., 2022). Prior work for this project involved social network analysis to determine the effect of KEEN-related professional development workshops on the social connections between faculty members at a single institution (Riley et al., 2022). This paper elaborates on that work and investigates how KEEN-related professional development offerings impacted faculty members' motivation to adopt and the subsequent sustained adoption of EM-related pedagogy. The study will answer the following research questions: (1) What attributes of entrepreneurial mindset professional development lead to sustained adoption of EM pedagogy amongst engineering faculty members? and (2) In what ways does faculty members' motivation affect their ability to adopt content or practices related to EM into their classrooms?

Literature Review

This section will provide an overview of existing research relating to the research-to-practice process, the role of foundation-funded projects and organizations and their impact on sustained adoption of classroom pedagogy, and motivational elements that have been noted to influence the adoption of new classroom practices.

The Research-to-Practice Process

The research-to-practice process depends on the type of change strategy employed. As noted above, passive strategies that rely solely on dissemination are less likely to result in successful adoption of innovations than active strategies (Borrego and Henderson, 2014; Froyd, 2001). Passive strategies focus on dissemination in research journals and other publication venues, or through conversation between peers. The dissemination paradigm of change strategies has the goal of “systematic adoption of the educational innovation” (Froyd et al., 2017, pg 37). Rodgers (2003) provides a 5-stage framework for the research-to-practice process using dissemination strategies, including awareness (being aware of the innovation, but not having investigated much further), interest (actively seeking out information), evaluation (deciding to adopt the innovation based on expected future situations), trial (actively implementing the innovation), and adoption (continuing to make use of the innovation). Though change strategies exist to help educators adopt pedagogical changes, change is usually slow to occur, if it occurs at all. The first three steps of this framework (awareness, interest, and evaluation) are easy for faculty to achieve on their own, however, a lack of support at the trial stage often results in faculty modifying the innovation or becoming frustrated, diminishing the innovation’s effectiveness (Borrego and Henderson, 2014; Rogers, 2010).

Unsupported steps in the dissemination process, then, are a result of a lack of communication and support from other faculty members or administrators. Additional limitations could be caused by innovations not being easily adaptable for others to “plug and play”, increasing barriers to entry (Borrego and Henderson, 2014). Further, some research publications may be rushed or not exist at all, as some researchers have pointed out that time becomes a factor in completing publications from their work (Khatri et al., 2013). Overall, efforts made in dissemination-based research-to-practice strategies have been criticized for not being capable of producing wide-spread change (Froyd et al., 2017). Active forms of change strategies can be applied to encourage larger scale instances of research-based educational change as well. Froyd et. al (2017) suggests that to combat the ineffectiveness of dissemination strategies for change in educational practice, educational change makers should instead utilize the propagation paradigm. With the same goal as the dissemination paradigm, this change strategy takes a more active approach to the research-to-practice process. Propagation encourages developers to actively engage and interact with potential adopters, providing an avenue for customization of the innovation and a better supported implementation process (Froyd, 2001; Froyd et al., 2017).

KEEN utilizes both dissemination and propagation strategies in their effort to encourage the adoption of innovations related to the entrepreneurial mindset (EM) in

engineering education. One of KEEN’s most widely utilized dissemination resources is “KEEN cards.” A KEEN card is an “online template for faculty and staff to share lesson plans, activities, modules, projects, and more” (Kern Entrepreneurial Engineering Network, n.d.b). These cards are easily accessible on KEEN’s home website, engineeringunleashed.com, and the adopter does not need to interact directly with the publishing faculty member(s), making KEEN cards a classic dissemination technique. However, KEEN also offers an annual conference that includes hands-on workshops and yearly standalone workshops that directly engage faculty and support their integration of EM into their professional practice.

Motivation for Classroom Activity Implementation

A key component of the research-to-practice process is the instructors and their motivation to make changes in their professional practice. There are many reasons an instructor may not want to make changes to their classrooms: the proposed change may be overwhelming or outside their expertise (Hargreaves, 2005), they may not see the value of the change (Cibulskas, 2002), or they may not be willing to make changes at all (Cibulskas, 2002; Schuller and Saleh, 2020). Self-determination theory provides a framework to explain why an individual may undertake a new behavior, taking into account the different factors that go into making that decision (Deci and Ryan, 1985; Ryan and Deci, 2000).

As described by Ryan and Deci (2017), self-determination theory (SDT) suggests that motivation to perform a certain action or take part in a certain activity—such as making changes to one’s classroom practice—comes from a combination of internal (intrinsic) and external (extrinsic) factors. Intrinsic motivation, and therefore an individual’s ability to grow and change, may be enhanced by meeting three psychological needs—competence, relatedness, and autonomy (Ryan and Deci, 2000). Competence refers to an individual’s perceived ability in a particular skill or activity; an individual with greater perceived competence is more likely to persist towards mastery. Relatedness refers to an individual’s drive to maintain stable interpersonal relationships, and the ways in which belongingness can enhance intrinsic motivation. Autonomy refers to an individual’s sense of control over their choices and behaviors. SDT posits that, while humans have an innate motivation towards activity and change, individuals whose psychological needs are unmet may quickly lose this motivation. Thus, an emphasis is placed on the ways in which an individual’s environment can meet these needs (Ryan and Deci, 2000; Deci and Ryan, 2017). For example, being told to make a specific change in one’s instructional practice with no space for adjustments may hinder a person’s autonomy, thereby causing a decrease in their intrinsic motivation for the implementation.

From the complexity of interaction between intrinsic

and extrinsic factors, a continuum forms (Ryan and Deci, 2000): on one end, an entirely unmotivated person has no motivation to perform an action, internal or external; on the other, an intrinsically motivated person performs an action based entirely upon intrinsic factors such as personal enjoyment, interest, or inherent satisfaction. Other points along the continuum blend these intrinsic factors with extrinsic factors—such as avoiding punishment or seeking rewards—to form variations of extrinsic motivation. While any type of intrinsic or extrinsic motivation can lead to a change in behavior, lasting change through personal growth and development is most supported by intrinsic factors (Ryan and Deci, 2000).

For faculty, the motivation to adopt new pedagogical content into their classrooms often combines intrinsic and extrinsic factors (Bouwma-Gearhart, 2012; Chaney, 2003; Harnish and Wild, 1992; Jackson et al., 2022). Extrinsic factors such as reward structures and other incentives to attend faculty development have been found, in some cases, to be a primary motivator in initiating participation (Chaney, 2003; Lowenthal et al., 2013; Harnish and Wild, 1992). For example, many faculty members are motivated to attend professional development activities by offers of stipends or release time from administrators (Lowenthal et al., 2013; Harnish and Wild, 1992). However, while extrinsic motivators are effective change initiators, intrinsic motivators are needed to maintain these changes. When professional development meets intrinsic needs for personal interest, improved competence, perceived value, and greater autonomy, lasting changes to teaching practice become more likely (Raneri, 2017; Schieb and Karabenick, 2011; Wallin, 2003; Weimer, 1990). Therefore, organizations which provide extrinsic motivation to become involved as well as opportunities to develop intrinsic motivation stand a greater chance of achieving their sustained adoption goals. KEEN might be one such organization—with the ultimate goal of integrating EM into engineering classrooms, KEEN attempts to leverage both extrinsic motivators (such as sponsored workshops or funding for related projects) and intrinsic motivators (enjoyable and meaningful events, social connectedness, and opportunities for improving competence) (Jackson et al., 2022). KEEN’s relative success with leveraging intrinsic and extrinsic motivators, however, remains understudied.

Sustained Adoption and Engineering Education Organizations

In order for educational research to have impact on a larger scale, innovations need to be integrated within classroom settings. As noted above, sharing innovations with educators performing the actual teaching is critical for advancing the state of educational quality (Jackson et al., 2022). Thus, the dissemination must be done in a way that makes the innovation easy to bring into the classroom. For example, developers may propose small-scale activities (Cuban, 2013), provide more resources such as

detailed lesson plans (Ellsworth, 2000; Fullan, 2000), or engage directly with adopting faculty (Besterfield-Sacre et al., 2014; Borrego et al., 2010; Ellsworth, 2000) to ease the process of change. These elements of curriculum design are captured in the Designing for Sustained Adoption Assessment Instrument (DSAAI), an evaluation rubric based on change theory, systems of education, and effective dissemination strategies (Stanford et al., 2015; Stanford et al., 2017). By examining the rubric during the development phase, researchers can identify possible strengths and weaknesses in their dissemination plans. KEEN's structure as a foundation-funded organization focused on engineering education is one mechanism for sharing pedagogical innovations that adheres to many of the principles highlighted in the DSAAI.

KEEN and other engineering education-focused, foundation-funded organizations are unique because they do not offer a singular method of change communication; rather, they fund and encourage many different methods for propagating and disseminating their innovations. Since their methods are more complex, these organizations have received little formal study as a method of dissemination (Riley et al., 2021). Other research suggests that KEEN is well-aligned with the DSAAI's constructs related to sustained adoption, possibly making their organization a model for sustained adoption methods for research-to-practice in the future (Riley et al., 2021; Mallouk et al., 2022). This research focuses on additionally investigating how KEEN motivates participating faculty to adopt research-to-practice changes within their classrooms and which forms of professional development provided by KEEN were the most influential in that process.

Methods

To address the research questions, we conducted six one hour-long semi-structured interviews with faculty members from a single mid-Atlantic university. This university is a KEEN-partnered institution, meaning that faculty and staff at that institution are encouraged to participate in KEEN sponsored professional development activities. Faculty who identified as previously participating in EM-related professional development programs, both University- and foundation-sponsored, were invited to complete a survey deployed by the research team (Riley et al., 2022). Quantitative results of the survey were analyzed using social network analysis and are published elsewhere (Riley et al., 2022). Interview participants were identified through this survey by indicating that they were interested in participating in follow-up interviews. In total, 44 faculty members were identified as having previously participated in EM-related professional development programs, though only 38 remained at the university at the time of survey deployment. Out of this sample population, 11 faculty members participated in the survey, and we had a total of six subjects consent to the follow-up interviews.

Participant Pseudonym	Teaching Experience	Willingness to make classroom changes (Scale of 1-5)	Role
Mermaid	5-10 years	5	Lecturer
Douglas	10+ years	4	Full professor
Lynx	5-10 years	4	Lecturer
Raccoon	10+ years	5	Full professor
Geronimo	5-10 years	5	Lecturer
Badminton	3-5 years	4	Lecturer

Table 1. Participant Attributes (self-reported via survey)

The authors acknowledge that the six faculty were both willing to participate in the professional development opportunities provided by KEEN and self-selecting to participate in a study about adopting classroom pedagogy related to KEEN's professional development opportunities. Characteristics of the participants within the study can be found in Table 1. Human subjects' approval was obtained prior to data collection and analysis.

Of the six participants, four are considered lecturers (teaching-focused faculty with no research obligations) and two are full professors (faculty with both teaching and research obligations). Despite the lack of a research requirement, two of the lecturers are involved in research. All participants rated themselves highly in their willingness to make changes in their classrooms: on a five-point scale, each participant rated themselves either a 4 ("often") or a 5 ("constantly / every semester") in response to the question "On a scale of 1-5, how often do you make changes in the way you teach?" from the survey.

Data Collection

Interview questions were developed based on responses to a survey (Riley et al., 2022) about making changes to educational practice. Each interview had four major sections (Table 2). Interviewers generated personalized questions for each participant based on their survey responses. The overall purpose of these interviews was to understand what EM faculty professional development sources the faculty member accessed when making changes to their classroom and why, as well as how, faculty members decided to make changes, and how they evaluated the changes they made.

Interviews were conducted over Zoom and transcribed using Zoom's auto-transcription service. The research team edited these transcripts for correctness and clarity (proper capitalization and punctuation, etc.).

Data Analysis

The edited and anonymized transcripts were deductively coded by two researchers individually, then discussed together until a consensus was reached (Miles et al., 2019). The interviews were deductively coded in two ways: first, by characterizing the professional development offerings used by the professor along the propagation-dissemination continuum through the DSAAI (see Appendix A); and second by analyzing the instructor's motivation to use said tools and make classroom changes through the IMI (see Appendix B).

The original DSAAI functions as a quantitative scoring rubric used in evaluating innovation-sharing products and plans. Here, the researchers have utilized its core constructs as a qualitative codebook, adapted from Mallouk et al., 2022. When examining the interview transcripts, coders applied sub-codes (from Appendix A) to instructors' descriptions of KEEN EM professional development which they used in making changes to their classrooms. This analysis allowed the researchers to understand which of KEEN's EM professional development offerings were being used by faculty, as well as what aspects of these offerings faculty find most helpful in making changes.

To gain perspective on how faculty members' motivation towards adoption of entrepreneurial mindset (EM) in their classrooms is derived, researchers used the Intrinsic Motivation Inventory (IMI; Ryan, 1982), a survey instru-

Interview Phase	Sample Interview Questions
1 - An overview of the faculty member's role at the university	Describe your role at [university] and the teaching, service, and research activities you engage in.
2 - Details on professional development offerings mentioned in survey list questions / free response (e.g., workshops, conferences, journal articles, textbooks, etc.)	What activities did you participate in as part of [workshop / conference / etc.]?
3 - Process and evaluation of a specific pedagogical change	Could you describe a change that worked and became part of your regular teaching practice?
4 - Plans for continuing involvement with EM, if any	In the future, are there any other entrepreneurial mindset professional development activities that you would be interested in participating in?

Table 2. Sample Interview Questions

ment theoretically grounded in self-determination theory (SDT). The IMI consists of seven constructs—interest/enjoyment, competence, effort, pressure, choice, value, and relatedness (Ryan, 1982). The choice (i.e., autonomy from SDT), relatedness, and competence subscales map to Deci and Ryan's three psychological needs for intrinsic motivation (Ryan and Deci, 2000). The interest/enjoyment subscale acts as a self-reported measure of intrinsic motivation. The perceived effort and perceived value subscales capture the ways in which individuals internalize the importance of a given activity, and how much effort/energy they dedicate to it (Deci et al., 1994). The remaining subscale—pressure—captures extrinsic motivating factors that may affect motivation (Ryan, 1982). When examined together, these constructs can characterize the type of motivation an individual might feel to engage in a particular activity. In this study, these constructs were used to describe and examine the motivation of an instructor to engage with EM-related professional development activities, and their motivation to integrate EM activities into their classrooms.

The research team used a two-cycle coding approach: first, transcripts were coded deductively using the sub-codes from Appendix B to capture motivational factors identified by the faculty members during engagement with EM Faculty Professional Development; second, additional magnitude codes were applied to capture the faculty member's perception of that factor's presence (positive or negative; Miles et al., 2019). For example, an instructor's comment that attending a KEEN conference was fun, interesting, or enjoyable would be coded as Interest/Enjoyment +, while a comment claiming that a paper about EM was boring or uninteresting would be coded as Interest/Enjoyment -.

Results and Discussion

This section answers the two research questions associated with this study. Research question 1 analyzes the attributes of professional development which encourage sustained adoption of new classroom practices using the DSAAI as a codebook. Research question 2 analyzes the impact of faculty motivation on the likelihood of EM adoption using the IMI as a codebook.

RQ 1: What attributes of entrepreneurial mindset professional development lead to sustained adoption of EM pedagogy amongst engineering faculty members?

Though we investigated a number of attributes of professional development through the DSAAI, the most salient codes were related to engagement strategies. This included engaging with instructors and levels of engagement.

Engaging with Instructors. KEEN has varying levels of faculty engagement with their professional development offerings. Some events involve participants

listening to talks from researchers in the field, while others engage the instructors directly, sometimes even extending beyond a single event. The participants in these interviews noted that they found instructor engagement within KEEN professional development events to be the most supportive, as some participants describe:

"We had, like, monthly meetings with other people who are in the program, and they would give you insight on how you could develop whatever your idea was a little bit more. I [Mermaid] thought that was the most useful aspect of [the workshop], because I probably wouldn't have done what I said I was going to do if I hadn't had somebody keeping accountability for me."

Additionally, Geronimo talks about how they felt other faculty members within the KEEN network could help them grow as a professional:

"I'm hoping that with KEEN, EM, I can make some connections with people that are outside in industry that can actually help me do a lot more. I know KEEN is mostly education professionals, but there's all—yeah, the—the Advisory Board and stuff, there's a lot of industry professionals that can be useful to research as well."

Instructor engagement as part of these EM professional development workshops also came in the form of direct mentorship from those who developed the innovation. Badminton pointed out that *"without the mentorship, probably I'd have already gotten behind and totally forgotten about integrating entrepreneurial mindset."* Similarly, Geronimo emphasized how engaging with faculty that were already a part of their social networks helped them to realize how EM could improve other aspects of their professional careers, such as through the clubs that they advise, *"when [faculty member] taught me about KEEN, they kind of showed me that this is something I can use for [club]."* This mentorship provided by other faculty members, both pre-existing and new connections within one's professional network, encourages sustained adoption among faculty members.

Earlier research from this project found that faculty members who engage with others in a professional development group like KEEN might be more interconnected through participation in different professional development opportunities (Riley et al., 2022). Additionally, peer-to-peer connections may help encourage faculty members to adopt new pedagogy and reduce the associated barriers to entry of doing so (Cross et al., 2021; Cutspec, 2004; Egwuonwu, 2022). Mentorship provided through KEEN which extends past the constraints of the associated workshop may further give faculty members the opportunity to keep asking questions and actively hold them accountable for their adoption strategy (Cross et al., 2021; Froyd, 2001; Melsa et al., 2009; Supiano, 2023).

Levels of Engagement. Engagement strategies can also be measured on a more straightforward con-

tinuum. While there are many types of engagement and support, the DSAAI categorizes engagement into 'active' (working directly with instructors, providing funding, responding to feedback, etc.) and 'passive' (providing documentation, written lesson plans, etc.) types. All but one interview participant described both active and passive types as being helpful as they made changes to their pedagogy.

Though it seems like many faculty members used a balance of both active and passive engagement strategies to their advantage, Badminton notes that engaging with more passive methods was *"not as engaging as when I did [KEEN workshop]"* but later noted that workshops that had *"a lot of the actual application of engineering mindset"* captured their attention better. Participants who mentioned active types of engagement often included detailed descriptions of activities from workshops and conference events. Lynx describes:

"We brainstormed a specific project, so the output of that training was that you were going to develop a KEEN card based on a project in your class. So we went through several different things. I don't remember exactly all the steps that we took, but we had a rough draft of that by the time that we finished the workshop."

Some participants noted that the active engagement that occurred at the conference or workshop extended past the end of the event as well:

"We had monthly meetings with other people who are in the program and they would give you insight on how you could develop, whatever your idea was, a little bit more. I [Mermaid] thought that was the most useful aspect of that [workshop]."

"I [Lynx] did just follow up with [name], he was the coach, so I did just follow up with him regarding writing the KEEN card. And did meet with our groups as well at the end, I think it was in November or December, with the group and just talked about how it went and so forth."

Finally, Lynx enjoyed the process of actively engaging in KEEN workshops so much that they are helping to develop publications on their experiences: *"part of the KEEN workshop that I did last year was the ICE workshop and I created a project which I actually then implemented in [course] in the fall and I'm currently writing a KEEN card about that."* This suggests that active forms of engagement with faculty through workshops were critical to many faculty members' adoption of EM-related content to their classrooms.

Research propagation (as opposed to dissemination) encourages faculty members to be actively involved with others when adopting new classroom pedagogy (Froyd, 2001). Active engagement through KEEN-sponsored workshops was continuously emphasized in the faculty interviews as being a driving force behind classroom-

based pedagogical change. This is related to another study which shows that faculty find active engagement through workshops to be one of the most effective strategies in the propagation paradigm (Khatri et al., 2013). Furthermore, Khatri et al.'s study highlights that professional societies can be key to executing the propagation strategy most effectively, which suggests that organizations like KEEN may be much more successful at coordinating more active research-to-practice strategies than other groups.

Passive types of professional development offerings include reading journal articles or other pieces of writing or watching lectures or videos on the topic of interest. These types of professional development were used most frequently as supportive tools; for example, Badminton describes browsing KEEN's website for new ideas: "I just type in the topics and I look at what others have done, and maybe I tweak it a little bit, and then I will use it in the class." Our data indicated that the most used passive resource provided by KEEN was their Engineering Unleashed website and the KEEN cards found there. This suggests that for this group of faculty members, the most influential passive resource KEEN provides is a central location where they can learn about and share ideas for classroom implementations that they have used themselves.

Another passive resource identified by Douglas included listening to stories provided by other faculty members at different events:

"One of the things they do is they identify some of the people who have a really compelling story to tell and they do these TED-style talks. So there'll be a session at the conference, where each of these people, four or five of them, spend about 10 minutes giving a TED-style talk describing their. . . usually it's a project or a classroom activity that they've identified is likely to be portable."

As seen in other research as well as above, KEEN's professional development offerings align well with the DSAAL (Stanford et al., 2015). Activities (workshops, mentorship experiences, networking) and products (developing KEEN cards) which stood out to faculty members were usually active (Besterfield-Sacre et al., 2014; Ellsworth, 2000) and involved collaboration with mentors and/or other faculty members (Besterfield-Sacre et al., 2014; Borrego et al., 2010; Ellsworth, 2000). One unexpected finding from the interviews was the frequency of the "passive" code; however, our participants identified that the resource they used most frequently through passive engagement was the KEEN cards. These cards are less formal than a typical conference or journal publication, perhaps making them an easier avenue for faculty to access.

These adoption mechanisms appearing simultaneously exposes what may be a hidden strength of organizations like KEEN. Rather than presenting a single active or passive form of EM professional development, KEEN provides potential adopters with a variety of options to

choose from. While active EM professional development might be useful when a faculty member is first introduced to a concept, innovation adopters seem more likely to fall back on passive resources as they learn more about the subject and about their personal needs relating to it (Datnow, 2020; Garcia-Huidobro et al., 2017; Riley et al., 2021).

RQ 2: In what ways does faculty members' motivation affect their ability to adopt content or practices related to EM into their classrooms?

Of the IMI's seven constructs capturing motivation, five appeared frequently in faculty interviews: value, effort, interest/enjoyment, relatedness, and competence. All five of these constructs represent aspects of intrinsic motivation in self-determination theory.

Perceived Value. The perceived value and usefulness of EM professional development offerings was discussed frequently, as was the value of EM in the classroom. For example, Lynx said that "[KEEN] just helps me in the classroom, and that's really my goal, you know, is to just keep growing as a professor." Badminton stated that "the workshops work, the activities work, the, you know, the active learning actually works." Perceived value and usefulness of an activity is a crucial component of continued motivation to engage in the activity (Deci and Ryan, 2000). Value was often identified in the form of recommendations or endorsements to participate in particular professional development activities, for example: "the workshop really gave me [Badminton] a lot of insights. They're amazing. Really good, I highly recommend that workshop. . . That's how I got the first idea." Many described EM as being valuable to overall teaching performance: "So anything and everything that helps me [Raccoon] do my job better I'll embrace, and entrepreneurial mindset is one of those things." Badminton even described an overall change to teaching strategy brought on by a particular experience with EM professional development: "When I used to prep, I used to just learn the materials. . . I've never thought of 'what's the learning objective?' I don't see it that way. . . [EM] really helped me change my strategy in teaching, and actually preparing."

This finding aligns with previous work suggesting that professional development offerings aligned to faculty needs are often most successful (Lian, 2014). When properly aligned, the perceived value of an experience as it relates to professional goals can be a strong extrinsic motivator for faculty hoping for promotions or tenure (Eros, 2011; Maskit, 2011).

Effort. All our interview participants demonstrated a strong effort in incorporating EM into their classrooms. As Douglas noted, "I've been trying to do [EM] with literally everything in every day, every example, every class I teach." Mermaid was even more straightforward in their expressions of effort, stating "I've gone above and beyond what is normally expected." In addition, a few participants de-

scribed future plans that required significant or extended effort, including developing new class projects and entire courses. For example, Raccoon outlined a course examining the engineering process behind the moon landing and credited their experience in EM professional development activities as the primary inspiration for this undertaking. Mermaid noted that "I have some lofty goals, but, you know, little by little, step by step," and Lynx elaborated that "I just never have time to actually continue to, you know, analyze all [the student response] data, because I'm always teaching. So that is one thing I'd love to be able to, like, do a deeper dive of." This implies that effort is not only incidental to the process, but an expected part of it for which instructors actively prepare.

While the DSAAL asserts that no single professional development offering should expect an instructor to expend unreasonable effort, once effort has been expended, it is unlikely that an individual will abandon the activity and "waste" this perceived effort (Arkes and Blumer, 1985). Efforts exerted by faculty as a result of these professional development opportunities may be influenced by the university which employs these faculty members being a KEEN-partnered institution. However, these findings suggest that KEEN's professional development offerings can encourage classroom changes that require considerable effort from faculty to implement, and that pursuing these changes increases faculty motivation to maintain them. To truly understand if this is intrinsically motivated or not, a comparison should be made to faculty at an institution not affiliated with KEEN.

Interest/Enjoyment. All six participants discussed finding EM professional development interesting and enjoyable in some way. For example, Raccoon said of KEEN conferences that "every time I go to them, I come back energized with new ideas and new things to do" and that they "do get excited, I absolutely get excited to go to these conferences." Mermaid shared a passion for a particular professional development series, stating that "we're doing that professional development on storytelling which I think is super cool." Many participants shared a general interest in improving their classrooms through the integration of EM, for example: "I'm [Douglas] interested in, you know, creating some sort of connection between [core] courses, so that the students can see in a more explicit way what the core curriculum is actually teaching them." Faculty members who recalled being interested in or enjoying particular professional development offerings often pointed to extended use of the concepts they learned by attending. For example, Mermaid, who noted high interest and enjoyment in the story-telling workshop, also described how they integrated this into the classroom: "I'm always telling the students, like, to tell a story with their presentations, with their lab reports, with their design reports. . . because, really, that's—I mean, hopefully what they're trying to do. It's just a different way of formatting the story."

Interest and enjoyment play an important role in intrinsic motivation. An individual who finds an activity interesting and enjoyable, perhaps even adequately challenging, is more likely to stick with it and find success according to self-determination theory (Deci and Ryan, 2000; Ryan, 1982; Schuller and Saleh, 2020). In many cases, faculty members who demonstrated interest and enjoyment in specific EM concepts or KEEN professional development offerings also discussed utilizing these concepts/resources over an extended period, indicating that interest and enjoyment may be related to sustained adoption (Klaeijns et al., 2018; Raneri, 2017).

Relatedness. While many faculty members noted individual concepts and professional development activities as being fun, “cool,” or interesting, many also mentioned enjoying the time spent with other faculty and instructors during those activities. For example, Mermaid noted that they “really enjoyed, like, meeting people during those things because I got to meet people who are like minded.” Raccoon describes their experience networking with KEEN members as follows: “I shared some of my, you know, property charts and fun thermal stuff at them, and then they shared some of theirs. I think that exchange of ideas was wonderful.” Douglas said that “I went to my first KEEN Conference, it was like ‘oh, some of my favorite people are here.” This sentiment is a part of self-determination theory’s relatedness factor, which captures the motivational impact of a sense of belongingness in a community. Douglas went on to explain the impact of this feeling of belonging had on their motivation to continue their involvement with KEEN and EM:

“I feel like the subset of people who are attracted to [EM] are the subset of people who are really, genuinely excited about undergraduate engineering education and really passionate about it. . . And they’re also the kinds of people who are good peer mentors. The kinds of people who you just want to spend your time with.”

Relatedness is identified by Deci and Ryan (2000) as one of the three psychological needs for intrinsic motivation. The drive to continue engaging with EM brought on by a sense of belonging implies that relatedness may also be a predictor of sustained adoption (Chiu and Chai, 2020; Sparks et al., 2016). Participants who felt “at home” with members of KEEN also described feeling excited to return to conferences and workshops, thereby supporting their intrinsic motivation to work with EM.

Competence. Multiple participants mentioned that business and entrepreneurship were “not their [Lynx] area,” while some mentioned specific aspects of EM being difficult to work with, such as Mermaid who felt they were “really bad with the curiosity.” A few mentioned struggling with specific activities related to EM, and Badminton said of their EM classroom activities, “sometimes it works, sometimes it doesn’t. So those times that it doesn’t, it’s probably my fault.” Self-determination theory posits that individuals may be motivated to participate in an activity

if they perceive it as an opportunity to grow and improve (Deci and Ryna, 2000). It is likely, then, that recognizing a deficiency in a particular subject may contribute towards intrinsic motivation for improvement (Beijaard, 2019; Tsui, 2018). Many participants reflected on growth following involvement with KEEN and EM topics, Badminton states that:

“Sometimes it’s hard to change that, all your mindsets that you’re used to. . . I didn’t know about pedagogy—teaching pedagogy. I didn’t know about active learning, I didn’t know about entrepreneurial mindset. So I have grown. . . I really appreciate everyone’s efforts on really infusing entrepreneurial mindset. Because I know that it works.”

If potential for growth is the motivator that the participants claim, then it may be that KEEN’s framing of the entrepreneurial mindset as a tool for both classrooms and professional development contributes to the success of their resources (Jackson et al., 2022). As Mermaid stated, “I don’t see, like, just KEEN being the way to grow, but every opportunity to get as, like, a way to keep growing.” When instructors like this perceive EM as a path towards personal growth, they may become more intrinsically motivated to participate (Bouwma-Gearhart, 2012; Harnish and Wild, 1992; Jackson et al., 2022; Raneri, 2017).

Overall, these findings suggest that faculty members who integrate EM into their classrooms may be highly intrinsically motivated to do so. This is likely due to a combination of the community that KEEN maintains through professional development offerings and the faculty members’ own desires to learn, grow, and engage with EM. This community at the studied institution could be a by-product of KEEN’s involvement with the university. By being a partner institution, it is possible that this community is supported in ways that other universities are not. However, as Geronimo pointed out, “I mean, sure, there’s a classroom aspect of this, but it’s also, like, a personal change. . . it’s important that you are open minded, especially when you’re trying to develop yourself and your—you know, your own career, right?”

Conclusions

Educational research, as a field, aims to find and communicate the best possible methods for teaching. Unfortunately, the complexity of the research-to-practice process leaves it vulnerable to weaknesses and break points (Borrego and Henderson, 2014; Melsa et al., 2009; Supiano, 2023). Researchers and the organizations they belong to may not communicate their innovations in the most effective ways (Borrego and Henderson, 2014; Rogers, 2010). In addition, instructors may not be receptive to making changes. By examining KEEN’s EM professional development approaches, we were able to examine the success of a particular educational organization from the perspective of potential adopters.

KEEN’s primary organizational goal is to graduate “engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work” (Kern Entrepreneurial Engineering Network, n.d.a). Thus, KEEN has provided a plethora of professional development offerings to help faculty engage with and adopt content related to EM into their classrooms. Interview analysis suggests that faculty members most often access EM professional development that aligns with the DSAAI’s guidelines for sustained adoption but tend to rely on more passive resources (such as published lesson plans available in KEEN cards or journal articles) as they become more familiar and comfortable with EM. Faculty members who make successful changes also tend to align with intrinsic motivation constructs associated with change-making.

Elements of the research-to-practice process are not as independent as they may seem; from our participants, we found that KEEN’s EM professional development must meet the faculty members’ specific needs (both active and passive resources, especially important for new adopters of EM), and the faculty members must learn to recognize their own deficiencies to engage appropriately with organizations like KEEN. Knowing this, KEEN and similar organizations might be able to provide more effective resources (such as a balance between active and passive engagement strategies) and target faculty members who demonstrate greater intrinsic motivation to make lasting changes to their classrooms.

Limitations

Currently, these results are limited by their focus on a singular foundation-funded organization, and data collection performed at a single institution. As a result, we also had a small number of faculty members participate in the interviews for this study, which may limit the transferability of the results. Furthermore, the institution where this study took place was a KEEN-partnered institution, thus faculty are encouraged to participate in KEEN or EM professional development opportunities. This may incentivize the faculty in this data set to adopt classroom strategies related to EM more willingly than other faculty.

List of Abbreviations

DSAAI	Designing for Sustained Adoption Instrument
IMI	Intrinsic Motivation Inventory
KEEN	Kern Entrepreneurial Engineering Network
SDT	Self-Determination Theory

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Appendices

Appendix A.

DSAAI Codebook

Construct	Sub-Code	Definition
Product Type. <i>What sort of content of pedagogical change is required?</i>	Implementation does not require substantive change in pedagogy or course content (C1)	C1A. Technology to make existing instructional activities more efficient or C1B. Organized learning activities
	Implementation requires use of new course pedagogy (C2)	Sub-Code serves as definition.
	Implementation requires use of new course content (C3)	Sub-Code serves as definition.
	Implementation requires use of new/revised course content/pedagogy (C4)	Sub-Code serves as definition.
Features. <i>What are the characteristics of the innovation in terms of how much user modification is possible, how much instructors must change their current approach to use the innovation, how much cooperation or administrative buy-in is required, and what sorts of resources are required?</i>	User Modification Encouraged	Expectation that users will be inspired to develop their own principles and design their own materials/implementation since no set framework is provided (must change principles)
	Change to Normal Teaching Practice	Individual instructors need to radically change their current teaching approach or course syllabus in a way that is likely at odds with their comfort level; plus spend a substantial amount of time learning about and implementing the product
	Cooperation / Administration Required	Requires active involvement of multiple instructors (possibly from multiple departments) and departmental and/or institutional approval

Appendix A. (continued)

	Resources Required	Requires substantial investment of new resources
Development. <i>What stakeholder information was integrated into the development of the innovation?</i>	Student Learning/Attitudes Data from Developers	Collected student learning and attitudes data in courses taught by developers
	Student Learning/Attitudes Data from Non-Developers	Collected student learning and attitudes data in courses taught by non developers
	Instructor Use Data from Developers	Collect instructor use data in courses taught by the developers
	Instructor Use Data from Non Developers	Collect instructor use data in courses taught by non developers
	Stakeholder feedback/ input / more broad	Sub-Code serves as definition.
Dissemination Plans / Venues. <i>Created based on interview content from previous study (Mallouk et al., 2022)</i>	Personal Connections	Sub-Code serves as definition.
	Faculty Development Workshops/Opportunities	Sub-Code serves as definition.
	Conferences	Sub-Code serves as definition.
	Stories	Sub-Code serves as definition.
	Papers	Sub-Code serves as definition.
Adoption Support Provided. <i>What support does KEEN provide to potential adoptees?</i>	Supplying materials	Materials that can be adopted without taking a lot of instructor time OR Materials in modular fashion that can be adopted piecemeal OR Materials that are similar to what instructor already do
	Advice/guidance	Instructor guides, implementation guides, or FAQs; guidelines/advice for

Appendix A. (continued)

		implementation in different environments; Includes Follow-Up (if related to materials/advice)
	Engaging with instructors	Engaging other instructors in development or review of instructional strategies and/or materials OR Leveraging existing instructor development communities (e.g., POGIL, PLTL, SERC, professional societies) OR individual consultations (can be follow-up)
	Funding	Money given to potential adopters to aid in the integration of the work
	Shared Language / Framework	A framework or set of definitions / shared language is shared with adopters to help make sense of the innovation
Propagation Strategies: Engagement. <i>What has KEEN done to communicate the innovation?</i>	Passive	Passive means conference/meeting presentations, journal articles, websites) are the primary communication channels
	Active	There is an extensive plan for attracting, training, and supporting and/or following up with potential adopters

Appendix B.

IMI Codebook with Magnitude Coding Notation Added

Code	Definition
Interest/Enjoyment (+/-)	Was the faculty development interesting/enjoyable? Was the resulting intervention interesting/enjoyable?
Competence (+/-)	Does the faculty member perceive their intervention as being good / effective? Are they proud of the product? Do they feel confident in their teaching and professional abilities?
Effort (+/-)	How much effort did the faculty member put into developing their innovation? How long did they "stick with it"?
Pressure (+/-)	Did the faculty member perceive any outside pressure to make use of the intervention?
Choice (+/-)	Did the faculty member feel that they had a choice in participating in the faculty development? Did they feel they had a choice in implementing the intervention?
Value (+/-)	Did the faculty member see the value of the faculty development? Did the faculty member observe a "Value-added" effect in students?
Relatedness (+/-)	Does the faculty member feel a sense of connectedness and/or belonging with others in the field?