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## EMPIRICAL RESEARCH

# The Importance of Community in Fostering Change: A Qualitative Case Study of the Rigorous Research in Engineering Education (RREE) Program

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Reform of engineering education continues to be a national priority. However, despite strong external support and funding, change has been slow. Recent research suggests that for institutional change to succeed, change agents within an institution need to form and maintain communities of like-minded individuals. This emphasis on community formation highlights the importance of Communities of Practice (CoP) as a vehicle for change. This article describes one CoP that emerged as an outcome of the Rigorous Research in Engineering Education (RREE) program that was funded by the National Science Foundation. The structure of the RREE might be used as a model for other programs intending to enact institutional change. These types of programs may play a crucial role in activating change and may be particularly useful in settings where there is no or little local support for change. Oftentimes, change initiatives tend to focus on the intervention of individual change agents while not attending to the benefits offered by a community-building approach. Successful change strategies are often built by teams of researchers who are capable of working together across institutional structures to extend the reach of their work. Consequently, this paper documents how intentional community-building activities can be used to initiate change.

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**Keywords:** communities of practice; institutional change; educational reform

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## Introduction

The US Engineering Education Research (EER) community experienced an important pivot point in the mid-2000s. The premiere journal in the field, the *Journal of Engineering Education*, was repositioned as a scholarly journal, that is, the research journal for engineering education (Lohmann, 2005), Departments of Engineering Education began to be formed (Benson et al., 2010; Haghighi, 2005), and the National Science Foundation began emphasizing scholarship in engineering education to “move from a focus of reform to an emphasis on research” (Gabriele, 2005, p. 286) in engineering instruction. The National Academy of Engineering report, *Educating the Engineer of 2020* (2005) recommended that:

Colleges and universities should endorse research in engineering education as a valued and rewarded activity for engineering faculty and should develop new standards for faculty qualifications.

Also, during this period, the Engineering Education Research Colloquies (EERC) (The National Engineering Education Research Colloquies, 2006) were conducted to propose a research agenda for engineering education (The Research Agenda for the New Discipline of Engineering Education, 2006).

In conjunction with this newly developed research agenda came the emergence of research centers across the United States intent on formalizing this new approach to research (Fortenberry, 2006; Haghighi et al., 2008). These centers, while targeting different populations, had a similar objective: to promote a scholarly approach to engineering education

through building and curating relationships with other institutions as well as national and international collaborators. At the same time, the National Science Foundation invested in research programs intent on engaging engineering and social science researchers (Felder, Sheppard & Smith, 2005). One such program was the Rigorous Research in Engineering Education (RREE): Creating a Community of Practice (CoP) (DUE-0341127), whose primary goal was to increase the number of engineering faculty members prepared to conduct high-quality engineering education research.

Faculty of varying academic ranks and at institutions that span the breadth of categories based on the Carnegie classification participated in the RREE workshops over the course of three years. **Table 1** summarizes the rank of faculty and the type of institutions of participants.

Some of the immediate benefits of the RREE were documented through annual evaluation reports. Additionally, Borrego (2007) investigated the “conceptual hurdles” RREE participants experienced during the workshop as they learned about engineering education research. However, these documentations of RREE focused on immediate and short-term impacts of the workshops. To explore how an intervention like the RREE might have fostered enduring change, we investigated the long-term impacts of the experience on nine participants and then reflected on what the findings of this investigation suggest about ways to foster change in other contexts.

## Literature Review

There is a breadth of research that spans studies investigating the design and development of communities of practice. Similarly, change theories and models have been studied extensively in social science research. Here we provide a brief snapshot of previous literature on these two broad categories: communities of practice and change models.

### Communities of Practice

Communities of practice (CoP), as defined by Wenger, one of the pioneers of this framework, are “the basic building blocks of social learning systems” (2000, p. 229). The phrase “community of practice” refers to a group of individuals who share similar interests in a phenomenon and come together in a structured manner to engage in shared practices to create new knowledge. This coming together, however, is more than just a group of people working on a particular task (Barab & Duffy, 1998). Instead, each individual must be tasked with a “legitimate role in society through community participation and membership” (Barab & Duffy, 1998, p. 49).

Through legitimate peripheral participation, defined as “the process of knowledge generation, application, and reproduction” (Hoadley, 2000, p. 290), communities of practice are capable of having significant influence on participants’ learning, perceptions of meaning, and identity development. Learning happens through *participation* because people begin to embody the knowledge and principles associated with a context as they engage in the world around them. However, “learning is not just acquiring skills and information, it is becoming a certain type of person” (Wegner et al., 2002, p. 12). This is the definition of identity development in the context of a CoP.

Dall’Alba (2009) posits “the process of becoming a professional occurs through continual interaction with other professionals as well as those outside the profession. It is misleading to attempt to separate the individual from engagement with others in this process of becoming” (p. 42). Also, Hoadley (2000) recommends “learners must have access to experts and must either perceive themselves to be members or aspire to membership within the community in which expert practices are central” (p. 291). Other researchers (Barab & Duffy, 1998; Hoadley, 2000; Wenger et al., 2002) discuss the need for social interaction between members within the community as one does not “become a professional in isolation” (Dall’Alba, 2009, p. 42). In that vein, Wenger et al. (2002) laid out principles that should be considered when creating the setting for a CoP to emerge. Of importance to the RREE are these two principles:

- Develop both public and private community spaces: community activities should provide the opportunity for large-group interaction as well as one-on-one relationship building engagements (p. 28).

**Table 1:** Rank and institution type of RREE participants.

Rank at time of RREE	Institution Type	
	Public	Private not-for-profit
Assistant Professor	41	5
Associate Professor	32	16
Full Professor	22	11
Other	18	4
Total	113	36

- Focus on value: a community's activities should be designed to provide value to its members' organization as well as cater to the members' own individual reasons for participating (p. 28).

### **Change Models**

Change is often discussed as if solely dependent on an individual employing a rational analysis of the current state versus some future state. However, Borrego and Henderson (2014) state "mounting evidence suggests that the most successful diffusion occurs through personal interactions between individuals or in small groups" (p. 229). We contend that the engineering education community may be overlooking the essential role that building a community plays in the change process.

### **Diffusion of Innovation**

Rogers' Diffusion of Innovation is a predominant model of how change occurs. On the individual level, the innovation process is defined as "the mental process through which an individual passes (1) from first knowledge of an innovation, (2) to forming an attitude toward the innovation, (3) to a decision to adopt or reject, (4) to implementation of the new idea, and to (5) confirmation of this decision" (Rogers, 2002, p. 990). However, individual adoption is just one piece of the puzzle because diffusion transcends the individual. Diffusion "is the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). This definition conveys the main elements of the diffusion process beyond the individual, namely the innovation, communication channels, time, and the social system. Further, Rogers (2010) opines:

Diffusion investigations show that most individuals do not evaluate innovation based on scientific studies or its consequences [...]. Instead, most people depend mainly upon a subjective evaluation of an innovation that is conveyed to them from other individuals like themselves who have previously adopted the innovation. This dependence on the experience of near peers suggests that the heart of the diffusion process consists of the modeling and imitation by potential adopters of their network partners who have adopted previously (p. 18).

Interaction between members of a social system is, therefore, critical for the diffusion of innovation to foster change. We believe there is room for further exploration of the shape and context of these interactions.

### **Recent Studies of Diffusion of Innovation in Engineering Education**

In 2010, Borrego, Froyd, and Hall surveyed US engineering departments to determine their awareness and use of seven engineering education innovations. Their findings revealed faculty are aware of innovations, have the interest to find out more, and perceive the new teaching method is perhaps beneficial. However, faculty often get stuck in the trial phase and then either give up or modify the innovation to the extent that it no longer works. The authors conclude that faculty need support in the trial phase. This conclusion highlights the utility of being connected to a community of users of the innovation who can provide advice or encouragement while new adopters are trying out the innovation (Borrego, Froyd & Hall, 2010).

In an extensive dissertation study, Siddiqui (2014) investigated curriculum change within the framework of the Engineer of 2020. He interviewed 33 engineering faculty who had been part of curricular reform efforts on their respective campuses. His findings pointed to the need for a *systems approach* to change because change efforts must go *beyond* any one individual's decision that a course of action (the innovation) is superior to the status quo. This means that initiating and maintaining any change to the organization's prevalent culture requires movement at all levels of participation. Consequently, Siddiqui contends people must form communities to bring about change as "the openness and engagement of a substantial number of faculty members is crucial for the development of the change process in any institution" (p. 180). One key recommendation from Siddiqui's work is that change efforts create supportive spaces that foster the development and sustainability of the community.

### **Movement Approach to Educational Reform**

Inspired by the recurring argument that change efforts sometimes fall short in the face of the complexity of educational systems, Parker Palmer (1992) reflected on the "distinction between an organizational approach and a movement approach to change" (p. 10). In his view, a movement approach is fueled by the opposition that usually slows down—or completely stalls—organizational approaches to change. To change an organization, the movement approach operates outside the paradigm of the organization. Individuals who want to bring about change must embrace and learn to live with this apparent paradox. Palmer identified four distinct stages to bring about change through the movement approach: 1) individuals decide to stop leading *divided* lives, meaning individuals stop hiding their true selves and make the choice to publicly declare their passions; 2) these individuals find and support each other and band together; 3) these groups then find their voice and make public the issues they care about; and 4) the vision of these individuals becomes supported by the emergence of alternative rewards and the system is changed. While these four stages are independently observable, they do not proceed linearly but rather iteratively and concurrently (Palmer, 1992). In previous studies, the academic experiences and

growth of engineering education scholars were mapped to Palmer's approach to change (Smith et al., 2004; Pitterson et al., 2016). This paper seeks to extend that discussion of change by exploring how it is enacted through workshops intentionally designed to foster community-building, particularly the RREE.

The CoP framework and change models discussed earlier all seek to highlight the role of community-building activities in creating the opportunity for and fostering change. Taken together, the preceding literature supports the design of change initiatives aimed at bolstering community-building among participants. Particularly, our study is informed by the CoP framework. We seek to evaluate how the workshop activities designed using this framework impacted participants' development as engineering education researchers specifically looking at the tenets of a CoP—learning, meaning, and identity. The nature of our research supports an evaluative approach to understanding how participants' experience in the RREE program fostered their ability to join an emerging community of researchers and experience enduring change.

## Methodology

The aim of this study was to evaluate the long-term impact of participation in the Rigorous Research in Engineering Education (RREE) workshops to identify how a community-building experience like RREE might have fostered enduring change. Specifically, we asked how the workshops affected the participants' thinking, their work and that of their colleagues, and their departments and institutions. To address these questions, interviews were conducted with a sampling of former RREE participants to learn about the longer-term impact of the project.

Participants for this study were recruited from the group of 149 who previously participated in the RREE workshops. A purposeful sampling of these individuals was done, making an effort to recruit individuals who represented the variations found within the group of RREE alumni. A subgroup of 30 individuals was targeted who were representative of the demographics and diversity of the larger RREE alumni population (see **Figure 1**). This subgroup included:

- Alumni from the three cohorts of the RREE workshops
- Participants from a wide range of institution types
- Faculty at the assistant, associate, and full professor levels

An interview with one participant was used as the pilot for the interview protocol. The remaining 29 RREE alumni were contacted by email and invited to participate in the study. A total of nine RREE alumni were interviewed. **Table 2** summarizes the final nine participants, their rank and institution type. **Figure 1** summarizes the sampling procedure described above.

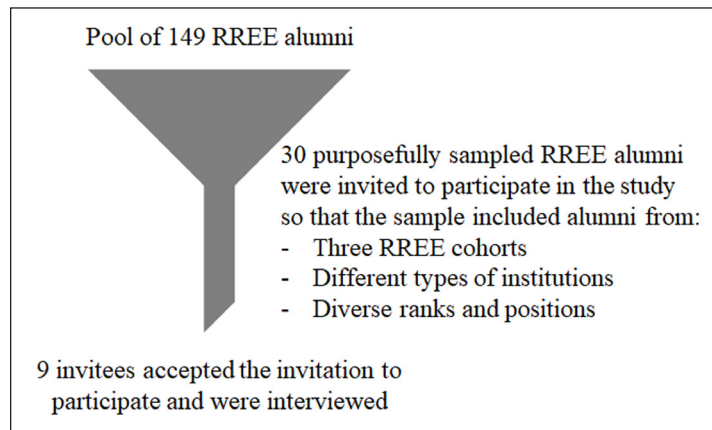
Semi-structured interviews (e.g., Sanjek, 1990; Spradley, 1979) were conducted to engage participants in in-depth conversations about their RREE experiences, their engineering education research, their involvement in the engineering education research community, and the perceived impact of RREE on their own campuses. The final interview protocol included the following questions and sub-prompts:

*Their RREE experience:*

1. Why did you decide to participate in RREE? What were your expectations or hopes going into the workshop?
2. What do you feel that you got out of the workshop? (short-term and long-term)
3. What kinds of connections did you make through RREE?

**Table 2:** Study participants summarized by rank and institution type.

Pseudonym	Rank at time of interview	Institution type
Andy	Associate Professor	Large, state university
Cathy	Non-tenure-track	Large, state university
David	Associate Professor	Large, state university
Edward	Associate Professor	Large, state university
Janet	Assistant Professor	Small, private liberal arts
Joanne	Assistant Professor	Engineering-focused university
Matthew	Professor	Mid-sized private college
Nick	Associate Professor	Large, state university
Robert	Professor	Large, state university



**Figure 1:** Sampling procedure.

*Their engineering education research:*

1. Have you done any engineering education research since RREE?
2. Have you collaborated with anyone on those projects? Or have you interacted with any other scholars regarding the projects? In what ways?
3. Other than research collaborations, how else do you interact with other people doing engineering education research?
4. What advice would you give other engineering scholars who might want to connect with people to do this type of work?

*Their involvement in the engineering education research community:*

1. What do you think of as the “engineering education community”? How do you define that?
2. How active would you say that you are in the engineering education community? What do you do to participate in this community? Conferences? Publishing? Formal or informal ways of connecting?

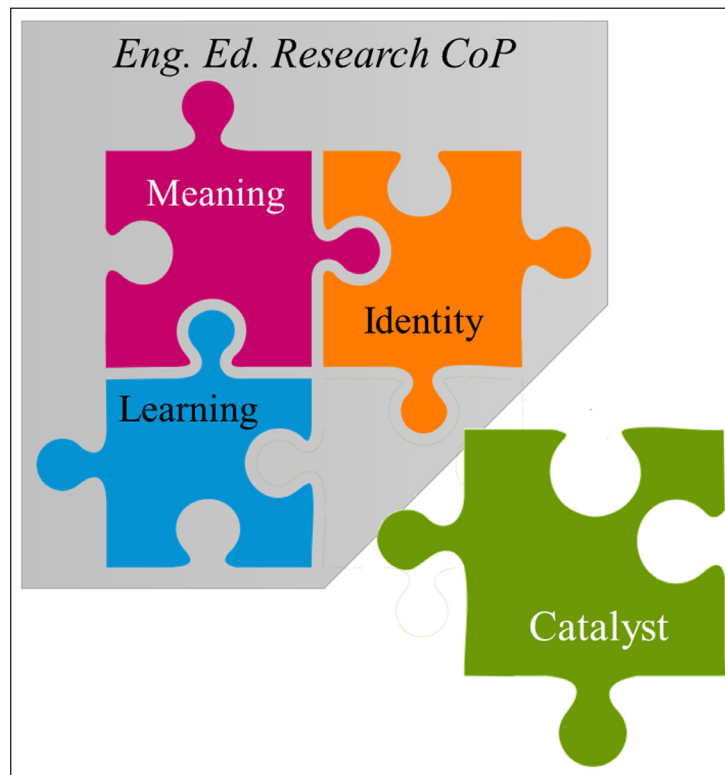
*Perceived impact of RREE on their campuses:*

1. How would you describe the climate on your campus regarding engineering education or engineering education research? For example, what “counts” as engineering research? Does it include education research?
2. Has the climate on your campus changed in the last few years? If so, what kind(s) of changes have you seen? What factors do you think led to these changes?

Each participant was interviewed once by telephone for approximately 45 minutes about three to five years after they attended the RREE workshop. All interviews were conducted by the same researcher to maintain consistency. This researcher, an anthropologist with expertise in conducting research of this nature, had not been involved in RREE and had no pre-existing connections to the workshops or the participants that could have affected the nature of the conversations. The interviews were audio recorded, transcribed and cleaned. The cleaning process involved removing all identifiers such as names of people, institutions, and any other identifiable information before sharing the data with the research team.

## **Analysis**

All interview transcripts were qualitatively analyzed (e.g., Glaser & Strauss, 1967; Corbin & Strauss, 1998) using an inductive method. An initial codebook was created based on the research questions. Two researchers coded a sample of transcripts independently and compared their coding. The code list was then revised to more accurately capture data related to the research question. When the code list was finalized, all nine transcripts, including the transcript from the pilot interview, were coded. Next, themes in the data were identified. Four initial themes were proposed: learning, collaborating, mentoring, and catalyzing. After initial themes were determined, each transcript was re-coded with a particular emphasis on each theme. The themes were once again revised after discussion with the research group. The learning and catalyzing themes remained, collaborating and mentoring were merged into a theme called “identity” and a new theme entitled “meaning” was created. It should be noted that the word “identity” was used in the sense that Wenger (1998) meant it—focusing on the development of certain personal traits that are the results of learning within a specific social context.



**Figure 2:** Summary of the impacts of the RREE reported by participants.

### Findings

Findings indicate that RREE had multiple types of long-term impacts on these nine participants that facilitated their entry into and increased their participation in the engineering education research community. Four types of impacts emerged as those most frequently mentioned by participants. Three of these impacts map well to Wenger's notions of learning, meaning, and identity as related to communities of practice (Wenger, 1998; Lave & Wenger, 1991). A fourth type of impact also emerged, which seemed to be an outcome of the combination of the other three pieces: RREE as a catalyst, meaning that the participants' experiences in the RREE workshop provided an impetus that propelled them into taking action and turning their interest in engineering education research into actual practice. **Figure 2** summarizes the four impacts found and the relationship between them.

**Table 3** illustrates the themes, their definitions and the number of participants who described them in their interviews. In addition, the types of impacts identified as most important for individual participants appeared to be related to the nature of the climate at their home institutions.

Next, we describe and provide examples of the four types of impacts found in the data. It is important to note that each participant talked about several types of impacts from RREE, and no one experience fits completely within a single category. The participants were likely to have experienced other impacts as well, which either did not come up in the interviews or we have chosen not to highlight them in this paper. However, we have extracted excerpts that are representative and illustrative of trends that were identified across the group. More detailed case studies are presented later in the paper. The four case studies were selected because they provide thicker descriptions of how participants described these impacts, and how the impacts fit into the larger context of the participants' journeys toward increased participation in the CoP.

#### **Learning: What is rigorous research in engineering education?**

*Learning* is used here to refer to the ongoing process of constructing knowledge that is central to a CoP, or as Wenger describes it, "the learning by which newcomers can join the community and thus further its practice" (1998, p. 49). Impacts cited by participants were coded for *learning* if the participants discussed new knowledge gained during the workshop about the field of engineering education research.

Eight of the nine interviewees felt that RREE advanced their knowledge about engineering education research. Participants discussed what they learned from RREE in several ways, including learning about educational research theories, specific research methods, what 'rigorous research' really means, and general knowledge about the field of engineering education research.

**Table 3:** Type of impact, their definitions, and number of participants who mentioned the themes.

Themes	Definition	Number of participants
Learning	Understanding what is (and is not) 'rigorous' research in engineering education	8 of 9
Meaning	Creating and synthesizing knowledge about engineering education methods and theories	9 of 9
Identity	Being part of the RREE community and/or part of the larger EER community	9 of 9
Catalyst	How participating in the RREE project was instrumental in initiating change in a participant's perspective about their current research endeavor and subsequent development of careers in engineering education	4* of 9 *All those who mentioned <i>lack of support</i> mentioned the RREE as a catalyst. <b>No one</b> who mentioned a <i>supportive</i> environment mentioned this theme.

For example, Janet was new to engineering education research and went into the workshop specifically seeking knowledge of the field. Looking back at her RREE experience, Janet felt that she

got enough [out of RREE] to know what I didn't know, which was a huge step forward. Going in, I just didn't have any idea how this worked, what was involved. And coming out, I said, now I kind of know what the pieces are. I don't know how to do them all, or I don't know how to do most of them, but at least I know what I need to go look for now.

Nick had done a small amount of engineering education research prior to RREE, but found that his RREE experience

did cast or frame engineering education research in a different light, because you know, in my discipline-specific research, of course, the edicts of research are all well laid out. And I think ASEE [American Society of Engineering Education] had just put out a format for what engineering education research should look like. ... So I think it did frame that in a different light after spending the four and a half days [at RREE].

In addition to gaining this broad perspective on the field, Nick also gave an example of something very specific that he learned at RREE and later incorporated into his own work: "One thing I learned at RREE was the existence of...a Statics Concept Inventory. ... The first time I heard about that was at the RREE, and then I was able to follow up on that."

Even those who came to RREE with significant prior experience gained some new knowledge about the field. For example, Cathy had been very involved in engineering education research and issues of teaching and learning prior to RREE. For Cathy, RREE provided "an opportunity for learning some of the challenges of connecting engineering folks and education folks."

#### **Meaning: Constructing and negotiating the meaning of this CoP**

*Meaning* is understood here as something that is negotiated by the CoP and as "a way of talking about our (changing) ability—individually and collectively—to experience our life and the world as meaningful" (Wenger, 1998, p. 5). As such, impacts on participants were coded for *meaning* when the participants discussed the process of figuring out and constructing what *rigorous research in engineering* means.

In all nine interviews, the topic of what is or is not *rigorous research in engineering education* was discussed by the participants. Specifically, the participants talked about 1) how to define engineering education research, 2) who participates in the practices defined as engineering education research (providing an additional way of characterizing what this work is or is not), and 3) the perceived "fuzziness" or fluidity of the community boundaries, hinting at an ongoing process of negotiation of what this work is or is not and who does it.

For example, in defining the CoP, Robert highlighted the common research interest shared by group members:

It's a group of people that are really interested in how students learn something. So, there's always the old sort of quandary about... 'Well I don't know why the students didn't learn this. I gave a lecture on that.' I think what a lot of us realize is, you know you presented the material, but that doesn't mean they learned it. And how do we make sure that students really learn what the material is? So, if I were to categorize most of the people that I've met [in this CoP], that's really I think sort of the overriding commonality between everyone. You know, what can we do that optimizes how much the students learn?

Janet defined the CoP by describing various levels of participation (core, active, and peripheral), as well as emphasizing community members' shared notion of "good work," which may be taken to mean rigorous research in engineering education:

I would sort of look at it as a bull's eye target. [There are] the people in the center who are the people who are really getting the multimillion-dollar grants, they're at the centers, they're doing the big projects. ... And they're doing it kind of full time. At least that's my impression. And there are a lot of us, a ring or two out, we sort of know who those people are and know what they're up to and we're pretty knowledgeable on that level, but ourselves, we're not producing at that level and we're not known at that level. **We know that they are doing good work** [emphasis added], we recognize good work and we're hoping to be able to do good work in our own time. And then I think there's probably another ring or two of the people who show up at ASEE, which is where I was before I went to RREE, and bring a paper that gets accepted, but it's basically what I did on summer vacation, about what I did in my course this year. Here's a book report. And some of them probably have some sense that that's unsatisfying, it's not what they want to be doing, but they're not sure how to move to the next level.

Along similar lines, Nick talked about how he had developed his own understanding of the meaning of rigorous research in engineering education before, during, and since the RREE workshop:

In the beginning, the way I defined it was you try a new thing in the class, without any scientific formulation. You just try it. And if it works, and again, what does it mean that it works? ... And I did realize when I started reading a little bit of the literature that engineering education research is no different than doing research in your discipline. You know, that you need to have a hypothesis, and you need to set up an experiment, collect data, and the survey instruments have to be calibrated or validated, and you know, there's enough science behind it, it's just not a bunch of questions that are thrown at people. And so I really think my definition has changed, and I think it is as intense and as complete as discipline-specific research, at least in the engineering field.

Several participants alluded to the meaning of the community in their comments about the fluidity of its boundaries, including who does or does not do this type of research. For example, as Joanne reflected,

Part of the reason that the edges of the [engineering education research] community are so fuzzy is that there are people who are in it all the time who have titles and business cards that make it very clear that they're members of that community. And there are other folks who are—who do a chunk of work in that area, but for whatever reason are not 100% of their time [doing] engineering education, teaching, and research. ... We all should be part of the engineering education community. But it means more to some people than others.

#### ***Identity: Identifying as a member of the CoP***

Identity is also an integral part of the social learning that takes place in CoPs and can be seen as "a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities" (Wenger, 1998, p. 49). Wenger also asserts that, "the formation of a CoP is also the negotiation of identities" (1998, p. 149). Following this notion of identity, impacts on participants were coded for identity when the participants discussed in various ways how they came to think of themselves as members of the engineering education research community.

All nine of the participants talked about ways in which their RREE experience increased their identification with both the RREE community and the broader engineering education research community. In these comments, it became apparent that the RREE workshops gave these participants a greater sense that they were now truly part of this particular community. This was indicated when they identified themselves as practitioners and also when they commented on others' perceptions of them as legitimate members of this CoP. The participants' observations about others' perceptions often came across in discussions of networking and collaboration. For example, some participants expressed that post-RREE it was easier to connect with colleagues to form collaborations on engineering education projects because they now were recognized by others as legitimate members of the community.

As Matthew reflected,

I have a good network of people that are interested in this work. And I certainly didn't meet all of them at RREE. But I met some of them at RREE. And it also gave me the confidence to kind of go off and do more projects in this area and to kind of establish, at least, a small reputation in this area that made it easier for me to contact people and say, you know, 'You want to work with me?' ... I think prior to RREE, I'm not sure I would have thought of actually contacting them as friends and saying, 'I want to do a research project together.'



Similarly, Andy noted that although he “didn’t even realize it was such a burgeoning field until I went to RREE and ASEE and started connecting with these people,” he did in fact meet several people who he continues to see at conferences and other venues. He reflected that, “there are a few individuals I keep running into who are really working hard to try to—*like myself* [emphasis added], to try to make sense of this, to do significant research to try to get this part of our careers jump started. And those have been very, very invaluable.” By commenting that colleagues who are doing engineering education research are “like [him]self,” Andy implied his identification with the broader CoP, especially since his RREE experience.

Joanne highlighted the important role of RREE in giving participants, such as herself, a connection to the CoP that is recognized by others and which provides a starting point for networking with other members of the community. She noted that in an interdisciplinary field such as engineering education research, “You’ve got this higher networking cost. You’ve got a more difficult time finding a home for your work.” For Joanne, going to RREE helped facilitate the networking that had been a hurdle for her. She commented:

And simply by meeting a few extra people, being able to walk into a room and see somebody you know and walk up to them and say, ‘Hi.’ That’s a huge confidence boost. And I think that because most of the people who are looking at community and CoP are established members of the community, they forget that very simple, small benefit down at the bottom of the list, and how powerful it is to the new folks.

For others, the networking they did at RREE not only helped them start new research projects, but also helped them make career moves. Jill acknowledged the role of RREE in the re-framing of her professional self, and credited the connections she made at the workshop with her finding a new position at another university:

My participation in RREE and my connections with that world, I put it in my bio as a professional development thing and a connectedness, and those connections that were made through RREE are definitely a factor in my being hired at [new university].

#### ***Catalyst: Propelling participants into action for change***

In addition to the three types of impacts discussed above, four of the nine interviewees reported impacts that were meaningful for them, yet did not fit neatly into the learning, meaning, or identity categories. We are calling this type of impact *catalyzing*, and by this we mean instances in which the RREE experience enabled these participants to make the leap from simply being interested in engineering education research to actually conducting a research project. Each of the participants who talked about the *catalyst for change* type of impact also mentioned other important impacts that fell into the categories of learning, meaning, and/or identity; however, significant pieces of their stories fell outside of these three categories and seemed to merit closer examination. The participants’ discussions of how the other three types of impacts worked in combination to result in a push toward becoming more active participants in the engineering education research community were especially intriguing. Those who reported that RREE had a *catalyst for change* type of impact talked about it in a variety of ways, such as providing a road map or mechanism for doing engineering education research, “forcing” them to get started on a research project, giving them the confidence to start conversations with other scholars that led to collaborations, or even having an “epiphany” about how to do this type of work.

For example, Matthew recalled that:

I was an engineering faculty member who had started doing some educational research but had no real education background and was looking for kind of the mechanism to take my research to the next level.

He then attended the RREE workshop, which

gave me some specific incentive to contact someone to be a mentor and participate on the project, and it gave them enough money as enough of an excuse to kind of, you know, clear some time off their calendar to work with me. ... RREE gave me a more, kind of fundable framework for doing engineering education projects. And that fundable framework makes it easier to contact people that you already kind of knew and liked, but to propose some formal fundable collaborations.

For Andy, “RREE sort of cracked open the door to a whole new discipline. ... It’s like this whole new world opens for you.” Andy recalled that

I did have sort of an epiphany [at the RREE] about what the difference was between assessment and evaluation and doing research. ... What I'd been trying to do with before was...try to measure the input, try to measure the output, which is always really hard with people as opposed to engineering systems, and look at the difference between the input and the output. And what [RREE] really turned me on to was the fact that you have to not only measure the input and the output to see if there's a change, but you have to apply a theory to try to understand what's going on inside the system. And that sort of theoretical underpinning of some of these things is sort of what, over time, I've gotten more and more an appreciation for.

Later in this paper, we will further explore the *catalyst* type of impact. Although this was not the most frequently mentioned impact, it becomes significant when we look at who did or did not mention it. The four participants who indicated that RREE had a *catalyst for change* type impact all described the climate of their home institutions as posing various types of barriers to doing this type of work. In contrast, those who did not mention the catalyzing effect all worked in settings that facilitated, at least to some degree, their doing engineering education research. The catalyst impact is also important to examine because it seems to be a key for building capacity in engineering education research. Getting started on engineering education research projects—the core practice for this CoP—is often a hurdle for scholars, and the RREE model seems to have effectively given many participants sufficient impetus to clear that hurdle.

### **Stories that illustrate common themes**

To provide a fuller picture of the *catalyst for change* type of impact, and to place this impact within the broader context of participants' journeys into and within the CoP, four individuals' stories or case studies are presented here.

The stories of Edward, Andy, Joanne, and David were selected because they represent common themes that were found across multiple participants' interviews. Additionally, these stories provide a thick description (Geertz, 1994) of the participants' perspectives rather than fragmented excerpts of their stories. They also illustrate the important role that context or climate can play in what people need and ultimately gain from experiences such as RREE. In particular, these stories demonstrate how the catalyst for change type of impact is especially important for participants coming from contexts in which engineering education research is not strongly supported.

Edward and Andy describe situations where they felt that their institutional climate was a barrier to doing engineering education research. For each of these participants, the RREE experience provided the necessary boost for them to move ahead and do this type of work despite the contextual barriers—one by finding a way to make it work at his home institution, and the other by seeking out a new institution with a climate more conducive to this work. In contrast, Joanne provides an example of a situation where the institutional climate was not a barrier. For Joanne, a catalyst was not as crucial, and RREE's most significant impact was the networking that allowed her to increase her identification with and deepen her participation in the broader CoP. In the final story, David experienced the change from a less supportive to a more supportive environment.

#### **Edward: "Participating in RREE forced me to actually do something"**

Before participating in RREE, Edward had been doing some work in faculty development, and his interest in the education side of engineering was growing. He had "made a couple of little attempts" at doing rigorous research in engineering "without really knowing much about what I was doing." Getting started with engineering education research was not an easy task for Edward, largely because this type of research is not supported—and does not "count"—in his department. He noted that,

I'm probably the only one on this campus really doing engineering education research like this. You know, really rigorous stuff. There's plenty of people that are interested in teaching and that have done faculty development stuff. ... So there's that environment for it. But when it comes to research, no, it doesn't count.

He went on to point out that even though he recently got an NSF grant to do engineering education research—which would seem to validate the work—his department chair still had the perception that,

Well, that's just education. That doesn't count. ... I've gotten, you know, various awards and things for teaching. So, there is some recognition. But I would say, bottom line, you know, I put in a pre-review package for promotion to full professor. And it really got shot down at the department level. And actually, the college was kinder, but it **really** got shot down at the department level. Because of the level of, the rate of publication in engineering stuff.

Edward did not expect the climate in his department to change any time soon, noting that, "there's no desire to hire" more people doing this kind of work.

Despite the barriers posed by his department, Edward had been interested in engineering education issues for quite a while before RREE came along and he continued looking for a way to learn more about this type of research. When he heard about RREE, it seemed like the perfect opportunity to do so. He had been

looking for the opportunity, and I was kind of scratching my head. And this thing just popped up in my email. And, you know, that was perfect. Exactly what I wanted to do. And I got lucky enough to be able to go that first year.

Reflecting on his RREE experience, Edward felt that participating in the workshop gave him “the start of understanding how education research really is performed, what you do.” Other impacts included his adoption of qualitative research methods (which he did not know much about before RREE), networking with other engineering education scholars, and some research collaborations post-RREE. However, for Edward the greatest impact of RREE seems to have been the “boost” it gave him, acting as the catalyst he needed to move him from simply being interested in engineering education issues to conducting his own rigorous research in this area.

One way that RREE helped Edward was by providing a mini grant. A small grant (\$2000) was budgeted into the initial proposal for the workshop to encourage participants to design and conduct small projects in tandem with other people they met while at RREE. “What that did,” he recalled, “was it gave me the money to actually do something. And so rather than sitting there in a workshop and saying, ‘Yeah, mm hmm, OK, I understand. That makes sense.’ Right? You’re forced to go ahead and actually do something and figure out what you really do understand and what you don’t. And really make your own path, which is what I did.”

At the time of the interview, Edward had several engineering education research projects underway, both on his own and with collaborators, that he felt may not have been possible without the impetus provided by RREE. RREE helped him move from having an interest in engineering education research to starting projects—particularly collaborative ones—in a couple of ways. The mini grant provided a boost by giving him the financial means (and imperative) to fit this kind of work into his schedule. RREE also gave him the confidence, knowledge, and focus that made it easier for him to approach people (at conferences, for example) and start the type of productive conversations that could lead to collaborations.

Reflecting on the pathway into engineering education research, he hypothesized that it would be difficult if a person did not have the kind of focus that he did after completing the RREE workshop. He commented that even if someone were to attend the right conferences (e.g., ASEE or AERA [American Educational Research Association]), but came in thinking, “I don’t even know what I’m doing,” the conversations that would ensue would not be as productive. He reflected that:

You can go to meetings. You can go to ASEE, you can go to AERA and listen, and then try to talk to people. And you can meet a lot of people. It’s a very open group. But...I’m not sure that that gets you an opportunity. Really, the only way I think you can do it is to figure out how to run your own little mini project. I mean, that’s why I think RREE, and then the follow-ons are going to be so good. Because otherwise, you’re just sort of, to me...I just think you’re overwhelmed, or you’re just sort of swimming in this area. You don’t really know what to look at.

Whereas if a person has already done a project, or has at least begun focusing on a specific topic, he or she will be more likely to notice relevant papers and understand others’ research better, which helps lead to stronger connections with potential collaborators. As Edward pointed out, “I think that’s where it comes in, because you have specific things to talk about. So, I can list a whole ton of other people that I’ve met at these meetings that I think are really neat people to talk to. But I’m not sure that anything’s ever going to come out of it. Because, you know, our areas don’t necessarily overlap.” What’s really necessary, he felt, to spark and fuel collaboration is to “have a project and seeing where there’s some complementary possibilities that you can do together. I think you have to have – at least for me, I think, I had to have an idea of what I was doing to be able to do that.” For Edward, RREE provided him with that essential idea, and he moved on from there.

Despite the challenges posed by his home department, Edward continued to engage in collaborations with colleagues on his own campus and elsewhere. As he reflected, “You know, I wasn’t hired to do this, I just do it.”

**Andy: “This is my real passion,” but “I’m trying to lead a double life.”**

Like Edward, Andy applied for the RREE workshop with the goal of turning his interest in engineering education into actual research projects. He found that RREE did give him the boost he needed in terms of refining his research goals and strengthening his certainty that this was something he wanted to pursue. However, his department had not been very supportive of his doing this sort of research (i.e. work that lies outside of traditional engineering topics), which led him to consider alternate ways for him to follow his interests and do more engineering education research.

Before attending RREE, Andy had been “pursuing engineering education somewhat completely on my own without knowing a lot of the stuff that was going on with ERM [the Educational Research Methods division of ASEE] or even ASEE.” He explained that on his campus, “I’m about the only person in engineering who’s pursuing this seriously.” RREE seemed to be “an opportunity to start to learn more about [engineering education research], and I didn’t even realize it was such a burgeoning field until I went to RREE and ASEE and started connecting with these people.”

Attending the RREE workshop solidified or confirmed for Andy that engineering education research was an area that he really wanted to pursue. He realized that, “this is my real passion. If [a recent grant proposal] gets funded, I think I really am going to steer completely in this direction. [...] I’m beginning to realize that people in psychology, social sciences, humanities who do good research...are really, really good at what they do.” However, Andy acknowledged that he had some barriers to overcome before he could easily change his course in the direction of engineering education research. He explained that, thus far, he had some difficulty in getting this type of research agenda going—so much so that he has considered making significant career changes:

I sort of had the impression that I could do this in addition to maintaining my other research. And it hasn’t really worked out that way. So, I’ve really sort of been teetering on the edge of a career change right now. ... Am I going to be able to try to keep both things going, albeit both at half speed? Do I want to get out of this and go back to my original research? Or do I want to sort of get out of my original research and do this full time?

Andy attributed at least some of this difficulty to the climate at his institution. He said that doing research outside the boundaries of traditional, technical engineering is “really a fight, I think, at my institution.” In addition, he felt a bit isolated at his institution, being the “only one” doing engineering education research and lacking local collaborators for projects. He reflected that, “I feel like where I am and who I have to collaborate with makes it very, very difficult for me to do research like [the RREE facilitators] and what some of these other people who are in departments of engineering education are able to do.” He felt that his efforts to actively enter the field of engineering education research had moved slowly so far because “I still don’t know enough, and I don’t have the colleagues locally to help me select and decide what the important problems are.”

I see myself locally as trying to rally the troops. Because I have to. I’m really – I’m one of these people who needs to belong, who needs to be surrounded by people who can support me during moments of doubt. And that’s something I don’t have, so I’m very much trying to create my own community here, and finding it very hard to do that, with mixed success. I have trouble with the long-distance collaborations, just because I’m swamped with things I have to do because I’m trying to lead this double life. So, I do sort of step into the community occasionally, at the conferences, meet people, talk to people, and then I sort of withdraw and do my own thing. I’ve not really found a way to maintain the kind of collaborations—at [an institution with a focus on Engineering Education] it would be much different, I think. I could just step out of my office and go talk to people. But I can’t do that here so I’m really—because we get no support for travel whatsoever. Unless I bring in money, I can’t go to the conferences. So it’s really picking and choosing which conferences I go to since I’m trying to lead this double life.

***Joanne: “I have the world’s most supportive department,” but “RREE helped me connect to the broader community”***

Unlike some RREE participants, Joanne’s home institution has provided a very supportive climate for doing engineering education research. That climate was actually a factor in Joanne’s seeking a position at that school. She reflected that, “I found a perfect option. It’s a great balance. I’m actually rewarded for spending time with undergraduates, but I’m also doing high-level funded research. And the powers that be think that’s just great.” When asked if her department was supportive of her work, she replied, “In my department, absolutely. In my college, it depends on who you’re talking to. I have the world’s most supportive department.”

When Joanne heard about RREE, she was looking for a way to move her current engineering education research further along, rather than needing an initial boost to get started. She recalled that she decided to apply for RREE because she was “looking for more training, specifically in engineering education research. I had a minor in education and an engineering PhD, so I spoke enough of the language that I could sound good. But I needed that assistance, and I needed that assistance from people who truly understood both worlds, instead of just from one side, or one side at a time.” Before attending RREE, Joanne had done a few engineering education research studies, but reflected that “I’m not sure I would have truly called it research, based on what I know now.”

Unlike Andy and Edward, Joanne felt that the greatest impacts of the RREE workshop were new knowledge and opportunities for networking, which map, respectively, to the *learning* and *identity* types of impacts described above. As she reflected, “I got several things [from RREE]. One is that systems view. I feel confident blending both worlds now. Another is an ability to articulate, particularly to focus on my campus what the heck it is that I do.” When asked if she would be doing education engineering research if she had not gone to RREE, she replied:

I would still be working in the field, but I wouldn't have some of the opportunities that I have now, and I'd be doing studies, but I wouldn't have a research agenda. And I'm not sure I understood how different those two are until after the path that RREE sent me down. So some of it is the conversations and what I learned there, some of it's the conversations with folks since then, and some of it's other directions that those conversations have sent me. Organizations I've joined, conferences I went to that I wouldn't have otherwise.

Joanne went on to describe the networking opportunities that RREE provided. "I met a lot of people, people who I can pick up the phone now and say, 'Hey, I'm putting together X, I need someone to do Y, would you be willing?'"

Joanne gave an example of a collaboration that occurred in part because of the connections she had made at the RREE workshop. She and a colleague at her home institution were considering submitting a proposal for a study based on their campus. However, they realized that they would need additional collaborators and would need to look outside of their university to find them:

One of the first things that we realized is that everyone who is qualified on our campus to do the research part—both of us—were involved as participant instructors. And so if we did the data collection and analysis as well, we will bias—or potentially could bias our study. So we picked up the phone and called someone that we'd met and gotten to know at RREE. Because when you're handing over a chunk of your studies to someone else to run, you want to know that they know what they're doing, and that they're going to have follow-through. ... And she said yes based off of a three-page research outline, because she had gotten to know us well enough as well, that she knew that she wasn't being harassed to put her name on something that was iffy.

Joanne was very aware of the important role that institutional climate plays in pursuing research interests outside the tradition of one's department, such as engineering education research. She reflected that in order to really be able to do this type of work, "You either have to have someone really good who can shelter you on your campus...or you need some sort of flag you can raise that causes everyone else to kind of go, well, OK, I guess that person must know what he/she is doing." Joanne explained that those "flags" are sometimes funding for the research, like NSF awards. She encouraged people who are considering branching out to a new area of research outside of their disciplinary tradition (such as engineering education research) to:

know what the expectations are for your own institution. And make a decision. Are those the expectations that you want to live with? ... So if this is something that you really want to do and you don't want to wait, then one thing you need to do is take a look at where you are and is that the right place for you. ... Once you're in the right place, whether you were there all along or you had to move to get there, again, know what the expectations are ... Because you can adjust things based on those expectations.

No matter what type of climate scholars find at their home institutions, Joanne emphasized the value of reaching out and connecting to the larger engineering education research community. Joanne was fortunate to have found a home for herself at an institution that supported her interest in engineering education research. As a result, she had already begun doing engineering education research prior to attending RREE, and the potential *catalyst* impact of RREE was not significant for her. However, she did appreciate RREE's role in helping her connect with and participate in the broader CoP. For example, after attending RREE Joanne made a point of going to engineering education conferences, such as ASEE. There, she found that, "people very quickly took me under their wing. That's one of the really great things about this community. It is a lot of people who practice what they preach. And since these are the folks preaching things like CoP, they actually do it."

The important role of campus climate is illustrated in the following story.

**David: "It's the support you get from the administration that I recognize as being the key."**

In the case of one participant, David, a change in department chair brought a change in the departmental climate, which removed some of the barriers he had been facing along his pathway into engineering education research. When David began doing engineering education research, it was clear that in his department, education-related research, publications, or awards did not "count" in the same way as technical engineering research. This posed some difficulties for David as he worked toward promotion to full professor. However, because he felt so strongly that engineering education research was a direction he wanted to pursue (a conviction that was confirmed by his RREE experience), he continued to work in this field, despite knowing that it might not help advance his career. Once he got promoted, he planned on talking with his chair about his interest in focusing mainly on education research rather than technical research, but in the interim he felt "stuck."

Before David reached the point of going up for promotion, his department undertook a search for a new chair. The person chosen as the new chair turned out to be much more supportive of nontraditional faculty paths, and David felt comfortable

going to him and discussing his wish to “wind down” his technical research and “switch over to just education stuff.” Although the chair let David know that such a switch could still pose difficulties for promotion, he was open to thinking about “ways to get around that, and ways that he felt he could support me and things he thought I could do that would help develop a case for promotion.”

This made a significant difference for David, who began to feel that his work and accomplishments were valued in his department. This seemed to boost his morale and energized him to escalate his involvement in education research. He reflected, “It’s the support you get from the administration that I recognize as being the key.” He emphasized the importance of having a supportive environment for following a nontraditional path like his, asserting that, “You have to have someone that you feel that you can talk to, that’s going to support you. ...You can’t do it on your own.” David’s story illustrates the vital role of community in supporting professional growth. While participants reported that the RREE provided an off-site community, local community is also very important.

These three elements (learning, meaning, and identity) interact to function as a catalyst to help faculty gain the knowledge, social networks, and confidence to make changes in their research practice. This catalytic function is particularly important for faculty who describe their campus climate as “not supportive” of their engineering education research efforts. Implications are that RREE-type programs can provide faculty with the catalyst for change to overcome this barrier.

## Discussion

The findings of this research serve to demonstrate that the use of a community of practice model to build research capacity in engineering education can have significant impacts on newcomers’ entry and continued engagement. In addition to learning about educational research methods and theories, the nine participants highlighted in this paper felt they were part of the engineering education research *community* and had the confidence to engage with others and form collaborations. This is important not only for building research capacity but also in bringing about change.

### *Fostering a Community of Practice*

The RREE project was intentionally designed to foster a CoP. These workshops were intended to build the engineering education research community by establishing “the structure and mechanism for training faculty to conduct rigorous engineering education research through a collaboration of engineering educators, learning scientists, and faculty developers” (Borrego et al., 2006, p. 2).

In keeping with the three elements of a CoP described by Wenger et al. (2002), the RREE project’s domain of knowledge was the emerging rigorous approach to engineering education research, the community was a group of participants with various disciplinary backgrounds drawn from various institutions, and the shared practice was characterized by the activities the participants engaged in during and after the workshops were completed. The three levels of participation as discussed by Wenger et al. (2002) (depicted in **Figure 1**) were also mirrored in the structure of the workshops: the core group was represented by an executive committee of the RREE, the active group was represented by the facilitators of the workshops, and the peripheral group was represented by the participants in each cohort.

The structure of the workshops was also developed based on the CoP recommendations of Wenger et al. (2002). **Table 4** summarizes how the workshops were designed to align with these recommendations. Our findings suggest that, as we had hoped, the RREE did foster the emergence of a CoP. Therefore, designers of other learning environments may want to incorporate the structural elements listed in **Table 4** in their designs as a mechanism to encourage the growth of other kinds of CoPs.

**Table 4:** How the design of RREE workshops aligned with CoP recommendations (R. Streveler, Smith, and Miller 2005).

Community of Practice Recommendation from Wenger et al. (2002)	Corresponding RREE Workshop Feature
‘old-timers’ welcome and mentor the ‘new-comers’	<ul style="list-style-type: none"> <li>• ‘old-timers’ from ASEE, AERA, and POD as workshop facilitators</li> <li>• funding provided to attendees as honorarium for mentors</li> </ul>
members of community have a variety of informal spaces to meet in ad hoc pairs or small groups for further discussion	<ul style="list-style-type: none"> <li>• workshop location allows for small group exercise and reflection</li> <li>• time scheduled in the middle of the day for assimilation/reflection and unstructured discussion</li> <li>• reception to kick off the event on first evening</li> <li>• daily common meals (breakfast, lunch, and dinner)</li> <li>• workshop room was set up with round tables for (changing) discussion groups</li> <li>• workshop features interactive sessions (e.g. interactive and cooperative learning)</li> </ul>

### **Implications for Promoting Change**

As RREE participant David mentioned earlier in the paper, “you can’t do it on your own.” But what happens when there is no one at your home institution who supports your work? We now triangulate our results with ideas from two other researchers who have studied change: Siddiqui and Palmer.

#### Forming neighborhoods

Siddiqui (2014) studied participants in another engineering education research workshop and found that “the established perspectives or standpoints of individuals in the prevalent paradigm can prevent [members] from moving to a perspective in an alternate paradigm” (Siddiqui, 2014, p. 161), meaning faculty trying to institute change may find their efforts blocked by opposing colleagues. Therefore, it is not surprising that a critical mass of change agents is needed to be able to bring about institutional change.

Programs like the RREE can become catalysts for helping people find each other and for giving people the confidence to seek out collaborators at other institutions. RREE participants spoke about the RREE as a way that people interested in engineering education research found each other. The RREE project itself exposed participants to other researchers who had similar interests and research ideas. Siddiqui describes this phenomenon as allowing people to “come together in a neighborhood” (Siddiqui, 2014, p. 233). The design of the RREE provided this opportunity and our participants reported leaving the workshops having made connections they did not have before and setting the intention to work on research projects with other participants who have similar ideas.

#### The movement approach

We also feel our work resonates with the four stages identified by Parker Palmer’s *movement approach to change*, which thrives amidst opposition (Palmer, 1992). According to Palmer, change begins when people choose to leave behind “divided lives” and become whole. Andy’s comment about leading a “double life” very explicitly invokes this stage. Parker calls this *finding integrity* (Stage 1). People then begin to find others who share their views and interests (Stage 2, *corporate support*), and once support is found they then can *go public* (Stage 3) and can begin to institute change by adding their voices to the community discussion. These stages are exhibited repeatedly in RREE participants’ interviews. Participants discuss their new-found identity as a legitimate engineering education researcher and their confidence to engage others in collaboration. In Stage 4, the community challenges the system to create alternative rewards that can sustain the vision brought about by the change. This stage is represented by the formalization of systems that recognize and reward the efforts of change agents. For example, since the RREE workshop several engineering education departments and centers have been formed through which numerous students have graduated with PhDs and have been gainfully employed as engineering education researchers.

Overall, this study has demonstrated that to some degree that for change initiatives to be successful, it is not enough to just have change agents find each other. Instead, we argue change initiatives create opportunities for agents to find each other through which they can further explore commonalities and develop relationships that were discussed extensively by our participants. These relationships will lead to long-term collaboration which in turn can result in creating communities of practice.

### **Limitations**

This study utilized a qualitative approach to explore the lingering impact of a series of workshops designed to develop a community of practice as new engineering education researchers entered the field. Because of its qualitative nature, the study yielded unambiguous results that might not be generalizable to the whole engineering education research community. Our goal was to recruit 30 participants intentionally chosen from the entire group of 149 attendees. However, the resulting study had nine participants. To help address the low participant numbers, we provided thick descriptions of our participants’ perspectives in our findings. As our goal was not to generalize our findings, we deem this number of participants to be appropriate.

All project and subsequent research activities were designed with the CoP as the initial framework. Consequently, the analysis and results were framed using the CoP framework, which may have biased our results. Palmer’s movement approach was only included in the study to guide the discussion. Future studies can seek to use the movement approach or any other change model at the onset of designing a study of similar nature.

The sample of participants leaned heavily on those from the 2005 and 2006 cohorts. We only included one participant from the 2004 cohort because for the first cohort participants were selected only on a first-come first-serve basis. However, in 2005 and 2006 a much more intentional approach was instituted that rated participants’ applications on the intellectual merit and broader impact of their research and on their institutional support.

## Conclusion

The RREE set out to model a CoP to facilitate people's entry into and participation in the field of engineering education research. This paper describes changes in RREE participants' identity as engineering education researchers, their understanding of the meaning of *rigorous research in engineering education*, and their knowledge about the methods and theories of engineering education research. These findings are consistent with Wenger's proposal that a CoP will impact the learning, meaning, and identity of its participants. Perhaps of most interest is that the RREE took on the role of a catalyst for the nine participants in our study who did not experience being supported by their institution and thus the RREE served as a way for these isolated members to enter the community of engineering education researchers. Both Palmer (1992) and Siddiqui (2014) stress that in order for change to begin isolated individuals must first "find each other." In this sense, the community-based philosophy underlying the design of the RREE impacted these participants individually and helped them feel part of the engineering education research community.

We believe the power of social networks to bring about change has been overlooked in the engineering education research community. We propose that when designing an intervention to bring about change, attention should be paid to ways to foster the social aspects of an intervention. By *social aspects* we mean including time for reflection and informal conversations in the intervention design, providing opportunities for people to self-organize and find others who share their interests, and providing the physical space where ad hoc groups can gather. Because the RREE intended to build a CoP, we made sure there was protected time and physical space for pairs and small groups to interact. The location of the RREE workshops were intentionally chosen to provide participants with a relaxing physical atmosphere. The layout of the facility and the unstructured time built into the workshop days provided participants the opportunity to reflect alone and with each other, process the information they had learned, and cultivate personal and collaborative relationships with their fellow participants. With this in mind, workshop designers must allow time and space for participants to meet each other. Instead of scheduling every moment with content to be learned, it is important to provide time for participants to connect with each other. More broadly, we challenge the community of change researchers to consider the importance of social factors in fostering enduring change.

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## Competing Interests

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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