

2006-1042: DEVELOPING AN ENGINEERING EDUCATION RESEARCH COMMUNITY OF PRACTICE THROUGH A STRUCTURED WORKSHOP CURRICULUM

Maura Borrego, Virginia Tech

MAURA BORREGO is an assistant professor of Engineering Education at Virginia Tech. Dr. Borrego holds an M.S. and Ph.D. in Materials Science and Engineering from Stanford University. Her current research interests center around interdisciplinary collaboration in engineering education, including studies of the collaborative relationships between engineers and education researchers and how engineering faculty learn educational research methods.

Ruth Streveler, Colorado School of Mines

RUTH A. STREVELER is the Director of the Center for Engineering Education at the Colorado School of Mines and Research Associate Professor in Academic Affairs. Dr. Streveler holds a Ph.D. in Educational Psychology from the University of Hawaii at Manoa, Master of Science in Zoology from the Ohio State University, and a Bachelor of Arts in Biology from Indiana University at Bloomington. She is co-principle investigator of three NSF-sponsored projects: Developing an Outcomes Assessment Instrument for Identifying Engineering Student Misconceptions in Thermal and Transport Sciences (DUE - 0127806), Center for the Advancement of Engineering Education (ESI-0227558), and Rigorous Research in Engineering Education: Creating a Community of Practice (DUE-0341127).

Nancy Chism, Indiana University-Purdue University Indianapolis

NANCY VAN NOTE CHISM is Associate Vice Chancellor and Associate Dean of the Faculties at Indiana University Purdue University Indianapolis and Professor of Higher Education at Indiana University. She received her Ph.D. in Educational Policy and Leadership from The Ohio State University, her M.A.T. from Smith College in English and Education and her B.A. from Fordham University in English. Dr. Chism was director of Faculty and TA Development at The Ohio State University and served as President of the Professional and Organizational Development Network in Higher Education. She earned the Spirit of POD award with that organization as well as outstanding teaching awards at both Ohio State and Indiana Universities. Dr. Chism has been involved in several engineering education projects, including the assessment of the Gateway Coalition and the current Rigorous Research in Engineering Education project. Her publications are about many topics in teaching and learning and professional development in higher education, including assessment, instructional technology, diversity, and physical spaces for learning.

Karl Smith, University of Minnesota-Twin Cities

KARL A. SMITH is Morse-Alumni Distinguished Teaching Professor and Professor of Civil Engineering at the University of Minnesota. His research and development interests include building rigorous research capacity in engineering education, the role of cooperation and collaboration in learning and design; project and knowledge management and leadership; problem formulation, modeling, and knowledge engineering; and faculty and teaching assistant development. His Bachelors and Masters degrees are in Metallurgical Engineering from Michigan Technological University and his Ph.D. is in Educational Psychology from the University of Minnesota. Dr. Smith has been active in the Educational Research and Methods Division (ERM) of the American Society for Engineering Education (ASEE) for over 25 years and has served in many capacities, including Chair of the Division. He has published numerous articles on the active learning strategies of cooperative learning and structured controversy, knowledge representation and expert systems, and instructional uses of personal computers, and has written eight books including How to model it: Problem solving for the computer age, Cooperative learning: Increasing college faculty instructional productivity, Strategies for

energizing large classes: From small groups to learning communities, and Teamwork and project management. Karl is serving as Editor-in-Chief of the Annals of Research on Engineering Education.

Ronald Miller, Colorado School of Mines

RONALD L. MILLER is professor of chemical engineering at the Colorado School of Mines where he has taught chemical engineering and interdisciplinary courses and conducted research in educational methods for the past twenty years. He has received three university-wide teaching awards and has held a Jenni teaching fellowship at CSM. He has received grant awards for education research from the National Science Foundation, the U.S. Department of Education (FIPSE), the National Endowment for the Humanities, and the Colorado Commission on Higher Education.

Developing an Engineering Education Research Community of Practice through a Structured Workshop Curriculum

Abstract-- This paper reports initial assessment and research results from the NSF-funded Rigorous Research in Engineering Education (RREE) workshops. The workshops are funded for three years (from 2004 to 2006), and the workshop experience includes both a 5-day summer workshop and a year-long experience that allows participants to conduct a small education research project guided by a more experienced mentor. This paper focuses on the results of the 2004 and 2005 RREE workshops and changes made to the 2005 workshop to promote a community of practice. Implications are also drawn for those interested in building engineering education research capacity.

Three important changes were made to the workshop format to further promote formation of a community of practice in 2005.

- Allowing participants to group themselves into “intellectual neighborhoods” by self-selecting other participants with similar or complementary interests.
- Using participant-created posters both as performance outcomes, and as a venue for sharing ideas and obtaining feedback from fellow participants and workshop facilitators. (This included formal presentations at the end of the workshop.)
- Structuring a research methods session around facilitator-defined participant groups with similar research interests.

Initial results indicate that activities in the original workshop structure as well as the updates helped participants to focus on engineering education research questions of personal interest while building a community that extends beyond the week-long workshop.

1. Introduction

Calls for embracing more rigorous research in engineering education are emerging with increasing frequency [1-5]. The *Journal of Engineering Education* has reinvented itself as a research-based journal [6-7]. Both Lee Schulman of the Carnegie Foundation for the Advancement of Teaching and Gary Gabriele of the National Science Foundation chose this venue to argue in editorials that the same standards of rigor applied to technical engineering research need now be applied to engineering education [4-5]. Gabriele also explained that the Engineering Education and Centers Division of the National Science Foundation has “moved its engineering education programs from a focus on reform to an emphasis on research.” [5]. Likewise, national reports and commissions originating in the education disciplines are also calling for more rigorous education research, specifically the National Research Council (NRC) reports *How People Learn* [8] and *Scientific Research in Education* [9].

In response to calls such as these and the urgent need for rigorous engineering education research conducted by engineering faculty knowledgeable about the state-of-the-art in education research methods, the National Science Foundation has funded “Rigorous

Research in Engineering Education: Creating a Community of Practice” (DUE-0341127). The goals of this project are to:

- Create and present workshops for engineering faculty on conducting rigorous research in engineering education. Five-day workshops are held in Golden, Colorado each summer from 2004 through 2006 to train faculty participants. For more details see the project website [10].
- Sustain the development of this project through establishing a community of practice. The foundation for this aspect of the project is the work of Wenger and his colleagues [11-12].

The RREE workshops are positioned to assist in building engineering education research capacity in the engineering faculty community. A unique aspect of the Rigorous Research in Engineering Education (RREE) workshops is that they establish a structure and mechanism for training faculty to conduct rigorous engineering education research through a collaboration of engineering educators, learning scientists, and faculty developers (those who assist faculty in enhancing their teaching). Representatives from professional societies representing each of these groups served as workshop facilitators.

During the RREE workshop, participants develop a specific research question and research plan on a topic of personal interest. The deliverable of the workshop is a draft of a small-scale research plan. This plan is to be refined and carried out (with the help of a research mentor) during the following academic year. For more detailed information about the content of the workshop please see the project webpage [10].

The program uses Wenger, McDermott and Snyder’s model of a community of practice (CoP) [12]. The CoP approach is being embraced by many organizations, including for example, the American Association of Higher Education, and is receiving increased web support [16]. A previous publication [3] describes how the RREE workshops were initially structured and updated to create a community of practice. This paper focuses on (1) results from the 2004 and 2005 cohorts, (2) updates to the 2005 workshop structure, and (3) implications of this work for others interested in engineering education research capacity.

2. The Community of Practice Model applied to Engineering Education

Wenger et al. define a Community of Practice (CoP) as a unique combination of three fundamental elements: a *domain* of knowledge which is defined by a set of issues; a *community* of people who care about this domain; and the shared *practice* that they are developing to be effective in their domain [11]. The members of a community of practice need not be from the same discipline. In fact, the community can be strengthened and invigorated by drawing on the expertise of its various members.

We propose that the engineering education research community of practice is still forming and ripe for rapid expansion. Knowledge about how people learn engineering (and about how people learn, in general) and about best practices in educational research, are areas that would benefit from more contact between engineering faculty and educational researchers in other arenas. One of the desired outcomes of this project is the

opportunity for engineers to make professional connections with education researchers and with faculty development professionals. The collaboration is a result of partnerships between three groups who could be considered to be “intellectual neighbors”:

- The American Society for Engineering Education (ASEE),
- The Education in the Professions Division of the American Educational Research Association (AERA division I), and
- The Professional and Organizational (POD) Network in Higher Education.

The mechanism that was created was the formation of a new executive committee for the RREE that would have members from ASEE, AERA, and POD. The RREE workshops were also structured so that a team of facilitators would present the workshops. The team consists of at least one member from ASEE, at least one from AERA, and at least one from POD. A prior paper [3] describes the details of how the RREE workshop was structured based on the CoP model. Table 1 summarizes these features.

Table 1. Structure of the RREE Workshops integrating Community of Practice Literature. Reference [3] provides additional detail.

Community of Practice Recommendation from Wenger et al. [12]	Corresponding RREE Workshop Feature
“old-timers” welcome and mentor the “newcomers”	<ul style="list-style-type: none"> • “old-timers” from ASEE, AERA and POD as workshop facilitators • funding provided to attendees as honorarium for mentors from ASEE, AERA, or POD
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"> • workshop location allows for small group exercise and reflection (hotel next to a stream and bike/walking path) • time scheduled in the middle of the day for assimilation/reflection and unstructured discussion • reception to kick off the event on first evening • daily common meals (breakfast, lunch and dinner) • workshop room was set up with round tables, for (changing) discussion groups • workshop features interactive sessions (e.g., active and cooperative learning)

3. Data Gathering and Analysis Methods

All aspects of the study were approved through human subjects (IRB) review, and participants signed informed consent forms as the first activity of the workshop. Data sources include:

1. Observational and interview field notes from the formal and unstructured work sessions of the workshops.
2. Participant pre-tests and post-tests dealing with workshop content.
3. Participant workshop evaluations, including a journal highlights form.
4. Photographs of the evolution of each participant poster prepared to make public the evolving research design process (2005 only).
5. Journal summary forms on which participants articulated the major topics and purposes of their journals.
6. Workshop journals of 10 participants who volunteered to participate in this portion of the research. (All participants were asked; 10 volunteered.)(2005 only).

Participants in the 2004 cohort completed all forms anonymously. To ensure anonymity, each 2005 participant was assigned a randomly-generated ID number that is the only identifier on the pre- and post-tests, evaluation forms, and photos of posters and journals. Only the external evaluators have access to the list matching identities with ID numbers.

4. Results from 2004 Cohort

4.1 Expectations

Interviews conducted with a subset of the 2004 participants during the first days of the workshop revealed that participant and facilitator expectations were aligned. Participants indicated that they expected much of their time at the workshop to be devoted to formulating research questions and designing a study. They also expected to learn about research methods and resources that would be available to them. Most participants stated that their goals upon returning to their campuses were to do good studies and eventually publish them. Participants predicted that connections made at the workshop and on campus would help them in meeting their goals. They expected that time would be their chief constraint in executing their studies, but a few also expressed doubts that this work would be valued and a few also had concerns about resources. They expected that the mentoring component of the project would be helpful. They expected mentors to serve as a sounding board, facilitate development of accurate measures, point to resources, and connect to others doing similar work.

4.2 Workshop Evaluations and Learning Gains

Both satisfaction with the workshop and self-reported learning gains were correlated to engineering education experience for many of the survey items. More experienced participants—those with advanced rank, years in engineering education, or who had done a study, published or presented, or received a grant—reported significantly higher gains and higher satisfaction on the evaluations and pre- and post-tests. These items included satisfaction with organization and comfort of workshop, satisfaction with the communication skills of presenters, ability to conduct educational research and ability to apply results of educational research in teaching. Terms correlated to engineering

education experience included *structural knowledge, mental models, construct validity,* and *epistemology*. Concepts correlated to engineering education experience included strategies to maximize probability of transfer of learning, seeing ways to make a difference with learning within current model of learning, comfort in designing engineering education studies, and understanding the relationship between theory and measurement.

On an open-ended item on the feedback evaluation asking about learning gains, participants indicated that they learned much about the range of research methods applicable to engineering education, the definition of rigorous research, learning theory, the vocabulary of engineering education research, and teaching effectiveness. Analysis of the text statements made by workshop participants in another set of open-ended responses showed an overall increase in appreciation for the complexity of doing research and making applications to teaching, a deeper respect for theory in conducting research, and an increased interest in pursuing research and application to teaching.

4.3 Journals

Journal summary forms completed by the participants provided a more detailed record of learning highlights in the eyes of the participants. These can be grouped into two main sets of ideas—(1) increased understanding and (2) application of workshop content to teaching. The journal summaries also contained comments on the appreciation for the complexity of engineering education research and the importance of a theory base. Several participants described how they revised their research question or design in light of the information they encountered during the week, while others talked about applications they would be making to their teaching.

Participants were also asked on their journal highlights summary about the usefulness of the journal during the workshop. Those who appreciated the journal used it for several purposes. The majority indicated that they used it to record information and process ideas. Nine of the respondents indicated that the journal was used to refine their research questions and four reported that they used the journal to create a sort of handbook on doing research that would contain names and resources that would be helpful to them later.

4.4 Mentors and the Community of Practice

Of the nine respondents to the follow-up survey conducted one year after the 2004 workshop, four had an RREE-assigned mentor, while two others found mentors on their own. Nearly all respondents had found a collaborator, but not all called this person a mentor. All respondents with mentors indicated that the advice provided by their mentors was helpful. Mentors were able to, as one respondent put it, “warn us about significant pitfalls of different approaches,” as well as provide help with survey design, quantitative methods and other aspects of the project. When asked on an open-ended item on the e-survey to name those things that facilitated their project work, many listed the help of colleagues and what they learned at the RREE workshop as important positive factors. Resources such as literature, encouragement from their university, or funding were also listed as helpful. When asked specifically about the workshop experience, several

respondents identified the increased knowledge of research methods and proposal writing skills that they gained as helpful to their efforts. Others specifically mentioned that the workshop helped them with the design of their projects. Still others praised the workshop for providing increased knowledge of teaching approaches, cultivation of a network of colleagues doing similar work, and motivation to do this work. One commented:

The opportunity for collaboration and to develop relationships with other like minded individuals was priceless. I was able to create a collaborative relationship that will likely span my entire career and has already begun to branch off into other areas. The second benefit of the workshop related to motivation stemming from being a part of the developing community interested in rigorous research in engineering education. As a relatively new faculty at a teaching institution, reflection on the workshop experience still helps me to stay motivated on these endeavors.

On the original workshop evaluation, responses to the open-ended item on what participants liked best ranged from those who expressed appreciation for the opportunity to meet with other engineering educators and with experts in the field to those who singled out interactive and encouraging environment of the discussion during the sessions. These responses indicate that the RREE program is on track to establishing a community of practice in engineering education.

5. Updates to the Program Structure for Community-building among 2005 Cohort

In June 2005, the executive committee and facilitators met to discuss changes to the 2005 workshop program based on the experience and assessment results of the 2004 cohort. The discussion at this meeting was wide-ranging and produced several changes in the 2005 workshop format. Among these changes were:

1. Decreased focus on teaching, as time spent on teaching appeared to draw focus from rigorous research.
2. Developing a framework to aid participants in understanding the relationships between scholarly teaching, the scholarship of teaching and learning, and rigorous research in engineering education.
3. A greater emphasis on presenting in the cognitive apprenticeship model.
4. Allowing participants to group themselves into “intellectual neighborhoods” by self-selecting other participants with similar or complementary interests.
5. Participant-created posters used both as performance outcomes, and as a venue for sharing ideas and obtaining feedback from fellow participants and workshop facilitators. (This included formal presentations to small groups at the end of the workshop.) [17]
6. Structuring a research methods session around facilitator-defined participant groups with similar research interests.

Items 1 through 3 do not directly address the Community of Practice and will not be discussed further in this paper.

The 2005 workshop was structured around helping participants to develop a plan to research a question of personal interest with plenty of feedback from facilitators and fellow participants. The principal place to record evolving ideas and present them to others was a participant poster displayed throughout the week. An example of a final poster is presented in Figure 1. (There were also journals, which participants were instructed to use for reflection as opposed to note-taking. Participants followed these instructions and used the journal to varying degrees.)

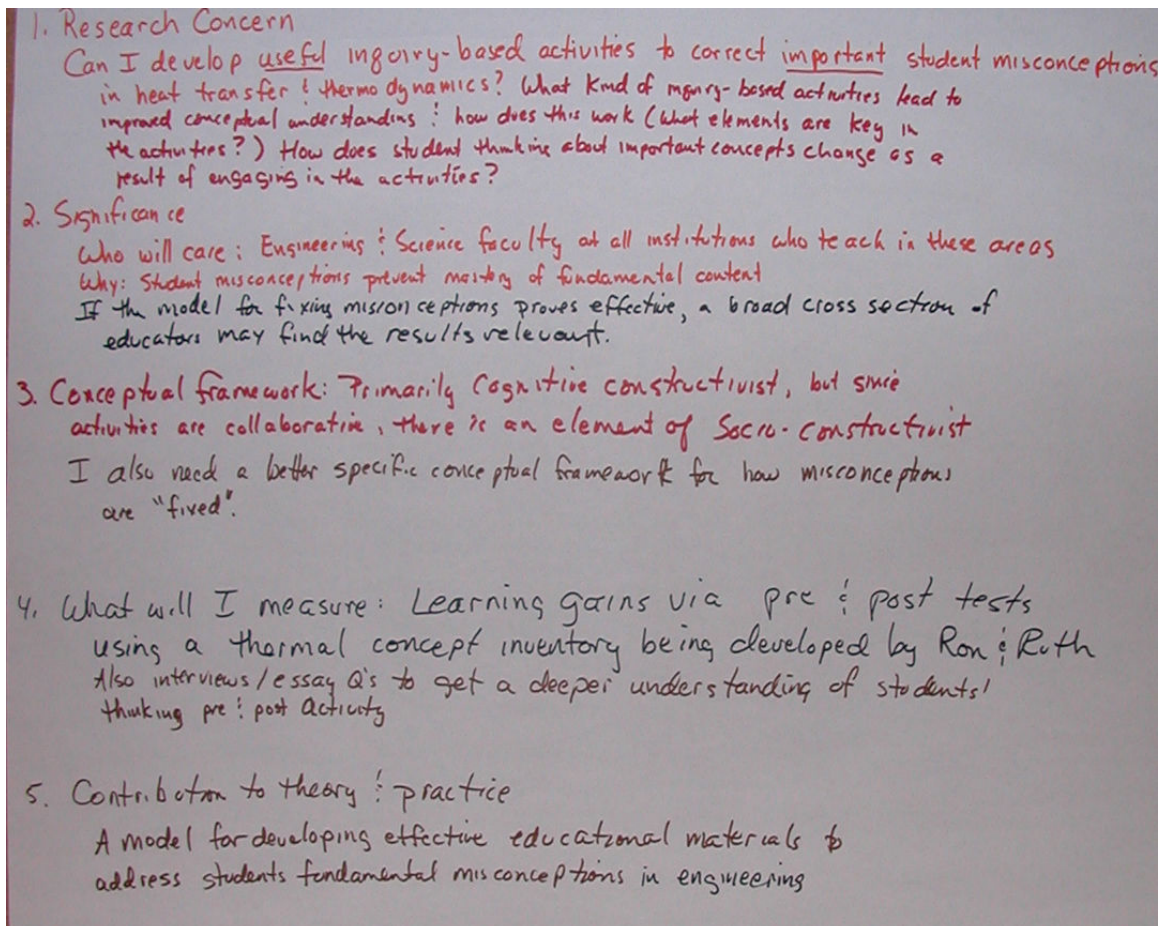


Figure 1. Example of Participant Poster.

At the end of day one, participants started their posters by attaching a sheet of paper to the wall with their name and "research concern," which is a nascent research question. Participants then walked around the room reading all of the other posters and leaving a sticky note if they thought the author was a potential intellectual neighbor. By the end of this session, nearly all participants had established intellectual neighborhoods with multiple other participants. Many were slow in moving to dinner that evening because of the lively conversations. The next morning, as instructed, participants sat with their identified neighbors. The structure for the remaining activities followed the general pattern of presenting content using cognitive apprenticeship, giving participants time to reflect or discuss, and asking participants to apply the knowledge to their own projects and add it to their posters. In this manner, posters were built up over the course of the

week to include all sections shown in Figure 1. The session on research methods consisted of a brief presentation followed by consulting sessions in which participants were divided into groups based on similar interests and research designs. The groups were created and led by facilitators. The final formal activity of the workshop was for participants to present their posters to their intellectual neighbors.

6. Comparison of 2004 and 2005 Cohorts

There is some evidence that the 2005 cohort noticed the increased effort by the facilitators to build community. Comparison of the 2004 and 2005 participant workshop evaluations reveals higher scores from the 2005 cohort on two notable items:

- “Opportunities to interact with other participants” (4.84 vs. 4.69 on a 5-point Likert scale in which 5 = excellent), and
- “Opportunities to get feedback from experts/facilitators” (4.36 vs. 4.26).

Analysis of the differences in the pre- and post-surveys shows considerable gains in knowledge. The overall mean gain on all items was 1.20 on a 5-point scale. Items ranked a full 1.5 points higher on the postsurvey than presurvey (in both 2004 and 2005) include:

- Being able to identify standards for rigorous research in engineering education
- Being familiar with the term “cognitive apprenticeship”
- Being able to identify examples of contextual variables that are used as independent variables in current educational studies
- Understanding the relationship between theory and measurement in educational research

Quantitative results align with the qualitative responses given by 2005 participants to open-ended items. Self-assessment of gains showed that all but four participants felt that their score analysis would show a gain. When asked why they think that the scores changed, most of those who predicted an increase indicated that the quality of the workshop and the active learning they experienced helped them to learn about the topics well. Three of the four who felt that the scores would be about the same indicated that they came to the workshop with substantial knowledge of the topics to be covered.

Of particular interest in the analysis of gains is the contrast between 2005 participants’ responses to a pre-survey item, which asked them to list approaches that are familiar to them in researching learning and the companion item on the post-survey, which asked which approaches they are considering using in their future work. On the pre-survey, fully 69% of respondents were unable to identify approaches. The post-survey responses showed a marked contrast to the previous uncertainty; only 13% of the respondents did not answer the item. The range and depth of paradigms (research approaches) and methods described in the post-survey were far more comprehensive than those in the pre-survey. Many respondents now discussed conceptual frameworks, which were not mentioned by anyone in the pre-survey. These answers show dramatic gains between pre- and post-survey. Examples include participants who went from being unable to identify an approach on the pre-survey to being able to write the following responses on the post-survey:

Starting with a theoretical model (situated learning and transfer), I will do some research on the work done within that model, as well as on research tools (surveys, rubrics, and interview questions). I will apply for IRB approval, recruit participants, and use selected tools to measure the variables I need to answer my questions (qualitative and quantitative; long-term follow-up).

Will do cross-sectional study utilizing quantitative assessment of skills pre- and post-implementation of instructor intervention.

I will choose between the three approaches: 1) phenomenology, 2) case study, and 3) grounded theory. Select the best applicable one and use it in my study.

Thus, preliminary assessment results from the 2005 cohort indicate that the increased focus on research over teaching has resulted in deeper understanding among participants of the important issues in conducting engineering education research.

6. Evidence of Campus-Level Community-Building

Participants in the RREE workshops were funded through two separate NSF awards. The first, which has been discussed in previous sections of this paper, requires an individual competitive application and provides a mini-grant to continue the work planned at the workshop. The second (NSF HRD-0411994) funded 3-person institutional teams selected by the institution's dean of engineering to attend three events including the RREE workshop. It was recommended that one member of the institutional team be an education or other social science faculty member and the other two engineers. Not all institutions were able to send all members of their teams, which provided an unique opportunity to observe how engineering faculty might benefit from "built-in" educational collaborators.

Consider the case of one mega-team, which had formed when two engineers missing their education team member combined with another institutional team interested in the same research topic: engineering student retention. The following describes an exchange observed when the team was working to select a theoretical framework for their study from among a categorized list provided in the workshop slides, following a presentation of the theories by one of the facilitators.

The discussion begins with motivational theories, which is one of the first categories on the list. There is some question among the engineers of whether motivational theories are most appropriate. The engineers have a problem with the motivation label: maybe lack of motivation is not the reason students leave engineering. At this point, the group has not discussed any specific motivational theories or defined motivation. They are basing their discussion on a shared assumption of the meaning of 'motivation.' They are then reminded by their education team member that the facilitator used retention as an example when presenting motivation theories. This is a big hint that they should consider them more closely. The education team member read aloud from notes taken on the

different motivational theories, then stressed to the engineers that they were the ones that worked with engineering students and would ultimately be the ones to select the theory.

One engineering group member jumped on task value theory as soon as it was mentioned [as a specific motivational framework], saying “I like that one.” After all three motivational theories were listed, he started to argue vehemently for task value theory. A less assertive engineer team member expressed preference for ‘goal orientation’ after pausing to consider all three. Vocal engineer team members begin applying task value theory to their problem, in terms of ‘is engineering worth it?’ They state that engineering students go through “all this work” and perhaps find no job at the end. Examples offered by various engineer team members then move to jobs and employment interest of engineering students. The education team member observes aloud that the discussion now really sounds like goal orientation theory. The rest of the group agrees. On their final rejection of task value theory, the point is raised by the team that task value theory was framed in the presentation as comparing two tasks, while interest in this research context is in the very large task of engineering itself, with no comparison tasks.

This exchange illustrates the ways in which an education collaborator can, with his or her own unique expertise, guide engineering faculty to effectively use their interests and experiences to study engineering education problems using rigorous research methodologies.

7. Implications

We end with some implications for those interested in building engineering education research capacity.

- Mechanisms for public display of evolving ideas (in this case, posters) and formation of “intellectual neighborhoods” facilitate communication and community-building among members with similar specific interests.
- Preliminary results suggest that there is value in encouraging interdisciplinary teams through workshop structures.
- There is value in establishing and nurturing both local and national-level communities of practice.
- Although the time and effort to bring together engineering educators, learning scientists, and faculty developers is considerable, it allows for a vital, diverse community. Forming new partnerships also allows for the effects of the new CoP to be widely disseminated and have a broad impact. The benefits of expanding CoPs are well worth the cost in time and energy.
- Formal mechanisms need to be in place to sustain a workshop-based community of practice, including electronic communication resources, networking venues, and assistance in locating mentors with complementary strengths.
- We continue long-term efforts for formal, lasting links between the professional organizations (ASEE, AERA Division I, and POD). These are likely to be in part

informational (such as webpages or organization publications) as well as social (welcoming events and special sessions at conferences and annual meetings).

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