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Moving from the 'Scholarship of Teaching and Learning' to 'Educational Research': An Example from Engineering

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Abstract

In their 2005 book, *The Advancement of Teaching*, Huber and Hutchings state that the "scholarship of teaching and learning… is about producing knowledge that is available for others to use and build on." (p.27). Can viewing the scholarship of teaching and learning (SoTL) as an educational research activity help to make SoTL findings more available to faculty and easier to build on? This chapter describes a year-long experience for engineering faculty that prepares them to conduct rigorous research in engineering education.

Introduction

The late Ernest Boyer introduced the "Scholarship of Teaching" as one of four interdependent dimensions of scholarship, with the scholarships of discovery, integration, and application rounding out the quartet (Boyer, 1990). In the 15 years since this work

was published, the Scholarship of Teaching (now more commonly called the Scholarship of Teaching and Learning or SoTL) has taken hold, and the promotion of SoTL is often a major activity of faculty development centers (Sorcinelli et. al, 2006).

Involvement in SoTL usually begins with faculty's interest in how students in their own classrooms are learning (Huber & Hutchings, 2005), and the purpose of SoTL is to improve learning by improving teaching (Boyer,1990). Thus SoTL tends to be very personal and situated in one person's classroom. The very personal nature of SoTL might lead to context-specific results that could be difficult to generalize and apply to broader settings. In some disciplines, this may lead to perceiving the impact or significance of results as being limited.

Recently, there have been calls for increasing the impact of SoTL results. Faculty have been urged to "go meta" with their studies and look at broader questions of how students learn that go beyond the specifics of their individual classrooms (Hutchings & Shulman, 1999; Schroeder, 2005) But what does "going meta" really mean? And what models can we provide to faculty to help them do this? This article provides an example from engineering education that may be useful both as a mechanism for further the discussion of SoTL, and as a model that could be applied to other disciplines.

The example used in this article is the "Conducting Rigorous Research in Engineering Education: Creating a Community of Practice" or RREE project. The RREE is funded by the National Science Foundation for three years to prepare three cohorts of 20

engineering faculty to conduct rigorous engineering education research. The year-long experience begins with a summer workshop and is followed by each participant conducting a systematic engineering education research project throughout the year. The projects are often small scale and informal. However, they are intended to assist in building engineering education research capabilities. Participants must pay for their travel to the RREE site, but all other expenses, such as lodging, meals, and materials, is covered by the RREE budget.

Faculty participants come from institutions across the US and must apply to the RREE. In 2004, selection was made on a first-come, first-served basis. About 80 engineering faculty applied to be part of the RREE during the week the application was posted on the project website.

Due to the demand for participation, more stringent criteria for selection were created in 2005. Participant selection in 2005 was based on three criteria: the individual's (1) readiness to participate [including their past involvement in engineering education conferences and projects, and the strength of research questions submitted as part of their application], (2) the broader impact of their participation [as evidenced by their role as a national or campus change, and their local and/or national involvement with groups who are underrepresented in engineering] and (3) the degree of support for engineering education research on their campus [based on the strength of a letter of support from their Dean or Department Head, and campus policies that support engineering education research.] Each application was independently scored by two project coordinators. Even

with these stringent criteria, about 45 engineering faculty applied to be part of the 2005 RREE.

Conducting Rigorous Research in Engineering Education

The context in engineering education

As in most disciplines, the majority of engineering education studies to this point have been classroom and curriculum focused. Several factors now point to readiness of the engineering discipline to move from SoTL into the realm of engineering education research (Gabriele, 2005). New engineering education departments have recently been created (Haghighi, 2005), and more stringent criteria were developed for publishing in the premiere US journal in this field, the *Journal of Engineering Education* (Felder, Sheppard, & Smith, 2005). In order to support more rigorous studies in engineering education, the National Academy of Engineering has founded the Center for the Advancement of Scholarship in Engineering Education, and the American Society for Engineering Education will sponsor a year of dialogue about scholarship in engineering education in 2006.

A description of the project

The National Science Foundation funded "Conducting Rigorous Research in Engineering Education: Creating a Community of Practice" (RREE) as a mechanism for preparing current engineering faculty to be part of this move towards more rigorous research. The RREE provides preparation, guidance, and a community as part of a year-long experience

for engineering faculty. Following acceptance, participation begins with an intense workshop experience, a 5-day summer workshop held each year from 2004-2006. The learning objectives of the summer workshop are:

- List and briefly describe important principles about how students learn and especially how students learn engineering
- List and briefly describe common methods used in education research
- Read and interpret education research articles to inform an engineering education
- Conduct informal or formal education research at their respective campuses

An assumption of the RREE is that in order to increase the rigor of engineering education research, engineering practitioners need to be introduced to the literature, methods, and paradigms of educational research. This project provides an opportunity to establish the structure and mechanism for preparing faculty to conduct rigorous engineering education research through a collaboration of engineering educators, faculty developers, and learning scientists. The collaboration is a result of partnerships among three groups:

- **Engineering educators** (the American Society for Engineering Education [ASEE] – the lead on this project),
- **Faculty developers** in higher education (the Professional and Organizational Network in Higher Education [POD].)
- **Learning scientists** (specifically the Education in the Professions Division of the American Educational Research Association – [AERA Division I]), and

The RREE experience is designed by an Executive Committee whose members represent each of the three collaborating organizations. The Executive Committee designs the RREE workshop and follow-up activities, and selects workshop facilitators who also represent all three organizations. A main task of the Executive Committee is to determine the best format for helping engineering researchers become engineering education researchers.

In 2004, the first year of the project, the RREE had a Scholarship of Teaching and Learning flavor with frequent mention of how results from research could be used to improve teaching. There was a strong emphasis on theories of student learning and less emphasis on other (non-cognitive) theoretical frameworks, or on research methods. Additionally, one of the 2004 learning objectives was "participants will be able to use the results of educational research to improve their curricula and/or teaching methods." This again highlights the 2004 RREE's focus on SoTL. This objective was dropped after 2004. Because the RREE is designed to prepare faculty to conduct rigorous engineering education research, it was decided that the 2005 and 2006 workshops should focus on educational research, not improving teaching. And with this in mind, the workshop was redesigned by the Executive Committee to make a clearer distinction between teaching improvement and educational research.

The Executive Committee considered three questions:

- "What paradigm shifts are needed for engineering faculty to conduct engineering education research (as compared to research based in their discipline)?"
- "What skills and knowledge are needed to do this?"

- "What format is best to provide the above?"

Using information gathered at the 2004 summer workshop, the Executive Committee first tackled the question of paradigm shifts. It was noted that engineering researchers use a consistent and implicit theoretical framework, these might be called the "laws of nature," and the methodology for pursuing certain kinds of questions is often standardized. Thus engineers do not usually need to choose from a variety of theoretical frameworks, nor do they need to consider various measurement or research methods. They are often not aware that more than one theoretical or conceptual framework exists in some disciplines or that two frameworks might be equally useful to help answer a particular research question.

It was also noted that rather than investigating a research question, the 2004 RREE participants usually were most interested in assessing a teaching method they were already using to prove that this method "worked." Their projects were very personal and classroom-based. In short, the 2004 RREE participants were pursuing the Scholarship of Teaching.

The Executive Committee felt that the issue of paradigm shifts should be addressed explicitly, and on the first day of the workshop. The Committee decided that three comparisons should be highlighted to help faculty make the transition to being full-fledged engineering education researchers. The differences that are now highlighted in the RREE are:

- The differences between engineering research and educational research
    - Here the differences include the need to locate one's research in an appropriate theoretical framework, and the need to select from a variety of measurement techniques and research approaches. As mentioned earlier, these decisions are often implicit in engineering research.
- The differences between assessment and research questions
    - The assumption here is that assessment questions generally answer the question of "what" or "how much" – in this case this would be a "what" or "how much" question about learning. Research questions often deal with the "why" or the "how" of the question (Paulsen, 2001). Because engineering accreditation boards now place a high value on assessment of learning outcomes, this is a particularly important distinction to make to engineering faculty and one that is salient to them.
- The differences between scholarly teaching, the Scholarship of Teaching and Learning (SoTL), and rigorous research in engineering education.
    - The Executive Committee viewed this as a continuum and discussed different levels on the continuum. Table 1. summarizes these levels. Levels 1, 2, and 3 are taken from Hutchings and Shulman (1999). Level 4 was added by the RREE Executive Committee [see acknowledgment section.]

Insert Table 1 about here

Cognitive apprenticeship

The RREE Executive Committee decided that after each of the three comparisons discussed above (engineering research vs. educational research, assessment vs. research, and SoTL vs. rigorous research in engineering education) were made on the first day of the summer workshop, the remaining four days of the workshop should be modeled as a cognitive apprenticeship (Brown, Collins & Duguid, 1989; Collins, Brown & Newman, 1989). Topics for the remainder of the workshop included: developing "good" research questions, choosing an appropriate theoretical framework, and deciding upon proper measurement and research methods. Each of these topics was discussed and modeled using relevant examples. Participants then practiced the topics by developing a research poster. Participants worked in self-selected groups consisting of "intellectual neighbors" who had similar research questions and interests. The poster, which was viewed as a performance outcome, summarized the design of the study which would be conducted during the following year. The poster also served as a guide for feedback from fellow participants and workshop facilitators. Project funds provide small amounts to support the research project and to engage a research mentor who can help participants with research design and/or analysis.

Assessment of the 2005 workshop

Each year, assessment of the RREE is conducted by two assessors. Assessment measures include: (1) pre- and post-surveys of (a) knowledge that is specific to the workshop and (b) comfort with and self-confidence with conducting educational research, (2) evaluator reviews of research journals kept by the participants (3) observations and interviews

conducted by the evaluators, (4) evaluation of research posters, and (5) assessment of the quality of projects conducted after the year-long experience.

This fifth assessment measure, quality of the final project, is the best measure of the success of the RREE. However, due to the length of time needed to conduct, and then evaluate, the research projects, this measure will not be discussed in this article. Assessment from pre- and post-knowledge surveys, discussion of the content of research journals, and evaluator observations and will be discussed in this paper.

Pre- and post-surveys results are listed in Tables 2 and 3. Table 2 focuses on participant satisfaction with the program as well as the degree to which the participants' felt program objectives were met. Table 3 lists the gain score from pre- to post-test on comparable items of the 2004 and 2005 knowledge surveys.

As one can see from looking at the tables, most items are comparable from 2004 to 2005. However, there is a shift in attention from learning about cognition to learning about research methods. There is also more confidence in being able to conduct research studies in 2005. These results are to be expected given the shift in emphasis between the 2004 and 2005 RREEs.

Insert Tables 2 and 3 about here

Analysis of the participant research journals from 2005 showed that about a quarter of the entries emphasized the scholarship of teaching to rigorous research continuum, which shows this discussion did have an impact. Similarly, there is also a distinct shift in 2005 with respect to attention to research rather than teaching issues.

Perhaps the most telling evaluation data comes from evaluator observations of group discussions from 2005. The evaluator observations relating to the SoTL to rigorous research model are summarized below.

Participants' understanding of the SOTL to Rigorous Research model was manifested in an appreciation of the need for generalizability in research studies. On the first day of the workshop, when these concepts were presented, the observer recorded individual instances of disagreement. Some participants first interpreted the content to say that if education work is not widely generalizable, it cannot be good. One participant asked the small group she was working with, "If you do something in your classroom, isn't it automatically generalizable?" which may be indicative of an engineering approach to experimentation. The only indicators of agreement at this point were comments made during large group discussion led by the facilitator to wrap up the activity.

The following day, several individuals indicated understanding and acceptance of generalizability as an important goal of rigorous educational research. Groups were asked to list the characteristics of a good research question. Groups listed attributes including generalizability, "universal significance," contribution to society, and the ability to lead to more questions. The facilitator then asked the groups to clarify the meaning of

"significance." The groups concluded that personal significance and passion are important and that to be successful, it is important to publish results and link projects to "something bigger."

By the end of the week-long workshop, participants were still considering generalizability. When qualitative research methods were introduced, one participant asked how the focus on understanding a specific setting relates to the need for generalizability stressed earlier in the week. During the final poster presentations, one participant explained the motivation for a research project involving participants from three universities. He explained that, in his case, generalizability was limited due to small class sizes at each of the institutions. But when studies are combined, the ability to draw conclusions relevant to a variety of settings is powerful.

In summary, the concepts the group had the biggest problems accepting were the need for generalizability, the need for a theoretical framework, and the need to carefully consider measurement (in no particular order). This resistance may be caused by the fact these issues (generizability, theoretical frameworks, and need to consider measurement) are steps that are implicit or "skipped" in engineering research.

Conclusions

It may be useful to think of faculty participation in the teaching and learning process as a continuum: with excellent teaching at one end of the continuum, and rigorous educational research on the other. Additionally, faculty developers may want to think about how to

prepare interested faculty to venture into the realm of educational research. This direction toward educational research may serve as a guidepost for faculty who would like to "go meta" with their studies.

When developing programs to help faculty make this switch to educational research, one needs to keep in mind the paradigm differences between disciplinary research and educational research. Paradigm shifts may be as important (or more important) to making the transition to educational researcher, as are obtaining the requisite knowledge and skills. The experience with the RREE program has shown that paradigm shifts are difficult to make, and it takes time to incorporate "steps" in research design that are required in educational research, but may be implicit in one's own discipline. Therefore, programs that prepare faculty to make this transition need to be long-term. A few hours, or few days is too short of a time for these changes to be assimilated by the faculty.

Lastly, it is our hope to spur discussions about new directions for SoTL. While respecting the value of the personal studies usually conducted in SoTL, we suggest that some faculty may be interested in studies which could more strongly tie their findings to educational or learning theory. This kind of work has the potential to be truly interdisciplinary, with work done by disciplinary experts informing the work of learning scientists, and learning science informing the work of disciplinary experts.

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References

Boyer, E. L., (1990). *Scholarship reconsidered: Priorities of the professoriate.* San Francisco: Jossey-Bass.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18* (1), 32-42.

Collins, A., Brown, J.S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching and crafts of reading, writing, and mathematics. In L. B. Resnick, (Ed.), *Knowing, learning and instruction: Essays in honor of Robert Glaser*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Felder, R.M., Sheppard, S.D., & Smith, K.A. (2005). Guest editor's foreword: A new journal for a field in transition, *Journal of Engineering Education, 94* (1), 7-10.

Gabriele, G.A. (2005). Guest editorial: Advancing engineering education in a flattened world. *Journal of Engineering Education, 94* (2), 285-286.

Haghighi, K. (2005). Guest editorial: Quiet no more: Birth of a new discipline. *Journal of Engineering Education, 94* (4), 351-353.

Huber, M. T., & Hutchings, P. (2005). *The advancement of learning: Building the teaching commons*. San Francisco: Jossey-Bass.

Hutchings, P., & Shulman, L.S. (1999). The scholarship of teaching: New elaborations, new developments. *Change, 31*(5), 10-15.

Paulsen, M.P. (2001). The relationship between research and the scholarship of teaching. In C. Kreber (Ed.), *Scholarship revisited: Perspectives of the scholarship of teaching,*

New directions for teaching and learning, Number 86, Summer 2001, (pp.19-29). San Francisco: Jossey-Bass.

Schroeder, C. (2005, October). Going "meta" with SoTL: Research-based frameworks as the missing link. Presented at the Annual Conference of the Professional and Organizational Development Network in Higher Education (POD), Milwaukee, WI, October, 2005.

Sorcinelli, M. D., Austin, A. E., Eddy, P. L., & Beach, A. L., (2006). *Creating the future of faculty development: Learning from the past, understanding the present*. Bolton, MA: Anker.

Table 1. Levels of Rigor in Inquiry

Level of inquiry	Attributes of that level
Level 1: Excellent teaching	Involves the use of good content and teaching methods
Level 2: Scholarly Teaching	Good content and methods *and* classroom assessment and evidence gathering, informed by best practice and best knowledge, inviting of collaboration and review.
Level 3: Scholarship of Teaching	Is public and open to critique and evaluation, is in a form that others can build on, involves question-asking, inquiry and investigation, particularly about student learning.
Level 4: Rigorous Research in Engineering Education	Also is public, open to critique, and involves asking questions about student learning, but it includes a few unique components. (1) Begin with a *research* question not an *assessment* question. Assessment questions often deal with the "what" or "how much" of learning, while research questions more often focus on the "why" or "how" of learning (Paulsen, 2001). (2) Tying the question to learning, pedagogical, or social theory and interpreting the results of the research in light of theory. This will allow for the research to build theory and can increase the significance of the findings. For example, studies about teaching thermodynamics can be redesigned to become studies, based on cognitive theory, which can help explain why certain concepts in thermodynamics are so difficult to learn. (3) Paying careful attention to design of the study and the methods used. This will enable the study to hold up to scrutiny by a broad audience, again creating a potential for greater impact of results.

Table 2. Ratings Results: Participant Feedback
2004 versus 2005 (1st-2nd columns)

	2004	*2005*
General Workshop Satisfaction		
How would you rate the quality of the following:	Scale: Excellent=5 through 1=Poor	
Organization	**4.28**	**4.55**
Comfort (room, temperature, food)	**4.67**	**4.27**
Appropriateness of schedule pacing	**4.08**	**4.25**
Program		
How would you rate the quality of the following:	Scale: Excellent=5 through 1=Poor	
Overall importance of topics	**4.49**	**4.49**
Quality of content	**4.38**	**4.32**
Opportunities to be actively engaged	**4.67**	**4.66**
Organization of sessions	**4.08**	**4.49**
Communication skills of presenters	**4.64**	**4.52**
Amount of time allocated for your planning work	**4.33**	**4.23**
Opportunities to interact with other participants	**4.69**	**4.84**
Opportunities to get feedback from experts/facilitators	**4.26**	**4.36**
Goal Attainment		
To what extent do you think the following workshop goals were achieved?	Scale: 5= To a great extent through 1=Not at all	
-Participants will be able to list and briefly describe important principles about how students learn and especially how students learn engineering	**4.10**	**3.73**
-Participants will be able to list and briefly describe common methods used in educational research	**3.87**	**4.15**
-Participants will be able to read and interpret educational research articles	**3.97**	**3.97**
-Participants will be able to conduct informal or formal educational research at their respective campuses	**3.79**	**3.98**
-Participants will be able to use the results of educational research to improve their curricula and/or teaching methods	**3.87**	**N/A**

Table 3. Self-Reported Post-Knowledge and Gains 2005-2004 Cohort Results on Comparable Items

Item	Gain04	Gain05
Content familiarity: How would you rate your knowledge of the following? (5=Know a lot through 1=Know Very Little)		
How engineering research and educational research differ	0.41	1.16
Designing research questions with educational issues in mind	1.36	1.18
Quantitative research methods in educational settings	0.97	1.07
Qualitative research methods in educational settings	0.74	0.79
Understanding educational studies	0.82	0.97
Applying educational studies	0.69	0.79
Venues for presenting results of educational research (journals and conferences)	1.08	0.85
More specific content knowledge: How familiar are you with the following terms or names? (5= Can define well through 1= Cannot define at all)		
Cognitive apprenticeship	2.33	1.88
Epistemology	1.21	1.24
Construct validity	1.36	1.12
Design experiment	0.38	0.35
Mental models	1.36	0.74
Self-reported knowledge (open-ended): How well can you answer the following questions? (5=Can answer well through 1= Cannot answer at all)		
What are standards for "rigorous research" in the STEM disciplines?	2.36	2.42
What do you see as the relationship between theory and measurement in educational research?	1.51	1.53
Describe the differences between experimental, relational, and descriptive studies.	1.56	1.25
Thoughts on leaving: (please choose a value and write a brief response to the open-ended item): (5= Very comfortable through 1=Not at all comfortable)		
How comfortable do you now feel about designing educational research studies?	0.83	0.99