Applying Research-Based Instructional Methods in the Classroom

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A demonstrable urgent need and interest appears to exist in both applying and conducting rigorous research in Engineering and Engineering Technology Education. In order to introduce and increase the rigor of education-related research in engineering and engineering technology programs, practitioners need skills in finding and applying previously tested instructional methods found in educational research literature. The successful NSF 03-558 Project *Rigorous Research in Engineering Education: Creating a Community of Practice* provided an opportunity to establish the structure and mechanism for training engineering faculty to conduct rigorous educational research through a collaboration of three collaborating groups:

- Engineering educators (American Society for Engineering Education),
- Learning scientists (specifically the Education in the Professions Division of the American Educational Research Association, and
- Faculty developers in higher education (the Professional and Organizational (POD) Network in Higher Education.)

This paper discusses the NSF-ATE funded adaptation of that successful program focusing on meeting the needs of two-year college faculty in applying and conducting rigorous research in engineering technology education and on the underlying research to support the hybrid delivery of the workshop materials and the support of the ongoing community of practice. The overall goal of the project *Applying Research-Based Instructional Methods in the Classroom* NSF DUE-0636505 is to facilitate the application and evaluation of research-based instructional methods by two-year engineering technology faculty in their courses. This goal is supported by the following objectives:

1. Customize and present, on-line and within a summer workshop, the content presented in the original RREE workshop to support applying rigorous research in engineering technology education.
2. Establish a faculty learning community, supported by synchronous and asynchronous communications in both face-to-face and web-based environments.
3. Assist engineering technology faculty in literature review research.

This paper focuses on stimulating a faculty dialogue on: What is Rigorous Research in Engineering and Engineering Technology Education? What is the value of conducting Rigorous Research? How is Rigorous Research different from Evaluation and Assessment? What opportunities exist for faculty to learn and apply these skills? This paper also focuses on discussing the underlying requirements for establishing a faculty learning community supported by synchronous and asynchronous communications.

Basic Questions

The first question to be answered is “Why do we conduct research?” Typically we conduct research to explore (discover something new), describe (document a phenomenon in detail), or explain (probe the dynamics of the phenomenon and how it

can be manipulated). The common element is that all these reasons are subject to the same rigorous research principles. What are the steps for conducting rigorous research? The National Research Council (2002) published six steps for defining rigorous research. Table one lists these six steps and supportive discussion.

Table 1.
Basic Steps for Conducting Rigorous Research[3]

Steps		Discussion
1.	Question: pose significant question that can be investigated empirically	A significant question is defined by the magnitude of the problem; how widespread; previous efforts to answer the question; its generalizability, and its overall impact if solved. An empirical investigation answers the question based on observation and experiment rather than just theory.
2.	Theory: link research to relevant theory	In the case of educational research the theoretical frameworks include: learning; motivation; development, and contextual effects.
3.	Methods: use methods that permit direct investigation of the question	What processes and measurement instruments do we use?
4.	Reasoning: provide coherent, explicit chain of reasoning	Develop the theoretical relationships and implications prior to conducting the experiment
5.	Replicate and generalize across studies	Where else can the results be tested? Are they repeatable?
6.	Disclose research to encourage professional scrutiny and critique research.	Disseminate the results for critical peer review.

What is apparent is the primary basis for difference between educational and engineering research is the differences in the theoretical frameworks (biology and psychology versus the physical sciences) and the measurement processes and supportive instruments. The answer to the second question (What is the value of conducting rigorous educational research?) should be rhetorical. However most college professors view themselves as experts in their content field and "good enough" in teaching, designing, and testing "effective" instructional approaches and delivery.

Educational institutions place great importance on assessment, (to measure student performance and attainment), and evaluation, (to judge its value, quality, importance, extent, or condition of something). Why do we need rigorous research? If, as educators, we choose to improve student performance and knowledge attainment, then we must know for sure (at a specific probabilistic risk value) that our improvement methods are effective and apply rigorous research methodologies. The next two sections provide supportive research for the structuring of faculty training and creating an effective community of practice.

Research on Structuring and Delivering Supportive Training

Houdeshell and Pomeranz (2004) cited research concerning underlying relationships between instructional taxonomy and instructional strategies[4]. Citing Ertmer and Newby, and supported by Spiro, etc., it is hypothesized that the requirements of the task to be learned define the instructional approach. For example, declarative and structural knowledge typically found in supportive sub competencies, utilized a low to medium

level of cognitive processing. A low degree of cognitive processing includes knowing the facts or steps (knowing what) and typically uses the behaviorist approach to learning the triad of practice/ reinforcement/ feedback for learning and memory instruction. It follows that in medium levels of cognitive processing (knowing why) schematic organization, analogical reasoning and algorithmic problem solving methods are appropriate. Examples of activities that require higher level thinking skills include case problems, simulations, situated learning, cognitive apprenticeships, and other constructivist approaches to instruction focus on knowing how [5, p 67-68, 6, p 24]. Successfully implemented instructional strategies for the higher-level taxonomies should include the use of nine situated learning design elements as defined by Herrington and Oliver (2000). These defined elements provide (1) authentic contexts, (2) authentic activities, (3) multiple roles and perspectives, (4) coaching and scaffolding, (5) access to expert performances and modeling, (6) promote reflection to enable abstraction and (7) articulation. These elements should (8) support collaborative construction of knowledge and (9) the use of authentic assessment techniques[7].

Related to delivery strategies, a recent meta-analysis by Lou, Bernard and Abrami (2006) of 103 studies of the effects of utilizing distance education versus classroom instruction on undergraduate achievement recommended that:

1. Systematically designed interactive multimedia be used to provide more effective web or media based student-content interaction;
2. Collaborative discussion among students be structured to use asynchronous communication media with some opportunity for peer face-to-face meetings for effective interaction;
3. Student-instructor interaction be encouraged through planned activities such as instructor participation in discussion board forums, question and answer chat sessions, and opportunity for face-to-face meetings with the instructor;
4. Students be provided with advanced information about DE courses so that they can better prepare, and be ready for the DE courses[8].

Table two provides a summary that indicates relationships among the cognitive level of knowledge, instructional strategies, and delivery modes. This approach, to be applied within the proposed grant, is to aid in the selection of the instructional and delivery strategies based on the knowledge taxonomy and appropriate deliver tools.

Table 2.
Relationship Between Instructional Taxonomy and Strategies[9-12]

Bloom	Anderson/ Jonassen	Reigeluth	Suggested Instructional Strategies	Suggested Delivery Strategies and Supportive Tools
Knowledge	Declarative knowledge	Memorizing information	Direct Instruction Gagne's Nine Events of Instruction Inductive Thinking	Reading print or web based materials and assessment
Comprehension	Structural knowledge	Understanding relationships		Web based learning objects and assessment

Bloom	Anderson/ Jonassen	Reigeluth	Suggested Instructional Strategies	Suggested Delivery Strategies and Supportive Tools
Application	Procedural knowledge	Applying skills	Simulation Models Experiential Learning Inquiry Learning Problem Based Learning	Face-to-Face small group Asynchronous Discussion board Email
Analysis Synthesis Evaluation	Metacognitive knowledge	Applying generic skills		Synchronous chat and video, audio conferencing

Learning Communities vs. Communities of Practice

The intent of the workshops, in conjunction with the research dialogue continuing beyond the workshop, is to transform the faculty "learning community" into smaller communities of practice that focus on collaborative testing common research questions. In order to create an effective learning community Bielaczyc and Collins argue that learning community activities must "first provide for collaborative construction of knowledge and individual development, secondly provide for sharing among the members their knowledge and skills, and third the activities must make the learning processes visible and articulated"[13]. Lin, X., et al. (1995) discussed approaches to the design and development of efficient learning communities. It was concluded that learning communities should: Provide students the opportunities to:

(1) Plan, organize, monitor and revise their own research and problem-solving;
(2) Work collaboratively and take advantage of distributed expertise from the community to allow diversity, creativity and flexibility in learning;
(3) Learn self-selected topics and identify their own issues that are related to the problem-based anchors and then identify relevant resources;
(4) Use various technologies to build their own knowledge rather than using the technologies as 'knowledge tellers';
(5) Make students' thinking visible so that they can revise their own thoughts, assumptions, and arguments[14].

Kaplan (2002) presented a blended instructional delivery model that supports the development of learning communities in three sequential segments: (1) Pre-event, focusing on ice-breaking and pre-event training, (2) Face-to-face learning event, and (3) Post-event for follow-on community activities[15].

Creating a functioning community of practice is more difficult. The task requires the community of practice to define itself along three dimensions: (1) What is it about? (2) How does it function through its mutual engagement? (3) What capability has the group produced over time[16]? A discussion of the proposed specific professional development activities follows, with an explanation of how the grant activities foster the establishment of a community of practice.

Rigorous Research Activities

The training format, based on Kaplan's training model, will allow us to apply effective methodologies to our learning space (classroom or on-line). The pre face-to-face

workshop activities, outlined below, provide a venue for introducing concepts and tasks that are benefited by review and reflection. The asynchronous nature of discussion boards allows for the sharing and extended reflection of many activities before attending the summer workshop. Of particular benefit is the formulating of the research question, researching the literature related to that question, and teaming up with another faculty member at another institution that is interested in testing that same or related question.

Pre-workshop Activities

Develop and support faculty webinars on applying and conducting rigorous engineering technology education research. As advocated by Clark (2000) program planners must evaluate the participant's skill sets, views, impressions, and needs in order to increase the likelihood of achieving the overall project objectives[17]. This evaluation will be done prior to the first webinars in order to decide if any supplemental webinars are needed for prerequisite training. These webinars will provide engineering technology faculty with the knowledge and tools to:

Describe and provide example application of important principles about how students learn and especially how students learn engineering technology.
Discuss the differences among: Scholarly Teaching vs. Scholarship of Teaching vs. Education Research; informal vs. formal
List and briefly describe common methods used in educational research.
Read and interpret education research articles applicable to engineering technology education.
Formulate the relationship between learning taxonomy and appropriate instructional design strategies after analyzing examples.
Create and share a list of possible research questions.
Formulate your research question

The webinars and subsequent use of a web discussion board during spring 2007 will allow participants to interface with the instructional leaders who provided the face-to-face instruction at the original Rigorous Research workshops on which this proposal is based. These webinars will be offered prior to the proposed summer 2007 workshop. These webinars provide an opportunity for participants to "ice break" and internalize the concepts and readings presented at the webinars prior to the summer workshop. The project PIs and both NJCATE and NCME have experience in providing and supporting webinars, conference calls using *Skype*®, and discussion boards. For example, the participants, after reviewing examples, would review their own instructional materials as to the appropriate linkage between the instructional taxonomies and strategies, as described in table two, and would post their findings on the discussion board within a course management shell followed with a conference call initiated by a Principal Investigator.

Developing and Sustaining An On-line Community

The development and sustaining of an online community is difficult at best. However, given the relatively short duration time prior to the summer workshop, developing a successful online community is achievable. But sustaining the community after the summer workshop will be more difficult. Cothrel and Williams (1999) researched fifteen online communities to determine their performance and success. They developed five questions that address the

readiness of the potential community and discussed seven axioms necessary to develop and to maintain a healthy online community. The project team plans to address the readiness conditions and apply the axioms within the implementation of the grant proposal.

Table 3.
Conditions and Axioms for a Healthy Online Community[18]

Readiness Conditions	Axioms
Are members relatively isolated from one another?	Focus on the means not the ends.
Do members share information among themselves already?	Focus relentlessly on the needs of the members.
Do members need information to do their work?	Resist the temptation to control.
Do the people who lead or influence the members of the group support the idea of on-line collaboration?	Don't assume the community will be self-sustaining.
Is the subject of their work or common interest something they can be passionate about?	Consider environmental factors.
	Extend community building beyond the discussion space.
	Seek out and support members who take on informal roles.

Summer and Post Workshop Activities

The summer workshop, as outlined in Table four to be held at the thousand acre Cataloochee Ranch in the Smokey Mountains will provide the perfect setting for face-to face discussion and reflection. The participant's deliverable at the end of the workshop will be a defined plan for conducting research.

Table 4.
Rigorous Research in Engineering Technology Summer Workshop Agenda

Date	Activity
Sunday, July 22 6:30-8:pm	Opening reception Cataloochee Ranch, Maggie Valley, NC
Monday, July 23	Introductions and sharing research questions and organizing participants by tables
	Research questions: Work on poster
	Conceptual frameworks: Finding a conceptual framework that is appropriate for your question
	Conceptual framework continued: Questions and more work on posters this time adding conceptual framework.
	Example - Research design and measurement: Fundamental principles and examples.
Tuesday, July 24	Measurement: More work on posters
	Qualitative and quantitative research methods in educational research
	Discussion, examples, questions Poster work
	Research study in Cognitive Transfer
Wednesday, July 25	Research methods: More work on posters
	Finding collaborators: Some pointers.
	Working with Human Subjects
Thursday, July 26	NSF Post-workshop community and activities
	Post-knowledge survey
	Working on and reporting about your research plan in small groups
	Suggestions for next steps
	Workshop ends at noon

The post-workshop communications during the Fall and Winter of 2007-08, utilizing on-line web conference and follow-up discussion board postings, focus on seeking, supporting and sharing implementation issues in the conducting of rigorous research at their institutions, and the results to the broader professional community for review and comment. Specifically the post workshop activities focus on:

- Conducting formal educational research at their respective campuses.
- Interacting with their community of practice by sharing results and issues utilizing synchronous and asynchronous tools.
- Implementing the results of education research to improve teaching and delivery methods.
- Submitting or co-submitting a paper to the ASEE annual or regional conferences and/or participate in a session at the ATE PI Annual Conference in October 2008 to present and discuss their research findings.

Impact and Summary

Sustaining the impact of the training is accomplished by capturing and posting the webinars, published individual faculty results, and a webpage outlining the process through MERC and NETEC Resource Centers and supporting an ongoing faculty learning community, supported by additional webinars and synchronous and asynchronous communications in web-based environments. The resource centers will also have developed skills in supporting faculty in literature review research, problem definition development, proposal writing, and presentation of their educational research findings. Resource centers are expected to continue to provide these services as part of their overall mandate. Of greater importance is the establishment of the core of engineering technology educators that have applied rigorous educational research at their college. This cadre becomes a starting point for continued faculty development efforts at their home institutions.

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