AC 2009-441: CULTIVATING AUTHENTIC ENGINEERING DISCOURSE: RESULTS OF FACULTY DEVELOPMENT EFFORTS

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Cultivating Authentic Engineering Discourse: Faculty Development Efforts

Abstract[1]

This paper presents an emerging model for engineering faculty development with a focus on increasing the capacity of faculty to actively engage learners using an innovative approach of introducing counterintuitive modules and model elicitation into the classroom. The model encapsulates the faculty development efforts of the project, Cultivating Authentic Discourse for the 2020 Engineer, supported by a grant from the National Science Foundation (NSF) in the Course, Curriculum and Laboratory Improvement (CCLI) program. Evaluation of the project provides compelling evidence that faculty members are changing their approaches to pedagogy, experiencing transformation in their senses of professional identity, and becoming engaged in a community of co-learners of STEM faculty participants. The key elements of this emerging model include: 1) fostering awareness of inquiry modules and their role in student learning; 2) creating awareness of teaching and learning theories and their roles in classroom instructional practice; 3) providing time, resources, and a supportive environment for developing counterintuitive modules; and 4) creating a collaborative community of experts in engineering and pedagogy to engage in discussions on issues of teaching and learning.

Introduction

Faculty development activities are widely accepted as a structured vehicle for higher education faculty in non-education disciplines for learning pedagogical methods to improve classroom environments and enhance student learning. Brent and Felder[2] point out that faculty in science and engineering, however, tend to be more resistant to engaging learner-centered methods in their classrooms due to their potential to "lower standards and inflate grades" (p. 1). The paucity of literature on engineering faculty development corroborates this conjecture of faculty resistance. Nonetheless, the literature does reveal pockets of intense development efforts in which engineering faculty are learning and adopting active teaching methods, resulting in improvement of student learning and development of teaming and design skills.[2, 5, 12]

This paper presents an emerging model for engineering faculty development with a focus on increasing the capacity of faculty to actively engage learners using an innovative approach of introducing counterintuitive modules and model elicitation into the classroom.[8] These modules focus instruction on a few core engineering concepts and create opportunities for students to investigate various conceptual phenomena using inquiry methods of learning. Such methods increase the likelihood that students will deepen their conceptual understanding as they make sense of and derive meaning from phenomena under investigation.[1,3]Embedded in the faculty development activities are reflection and investigation of learning theories. This work is led by the University of Texas El Paso (UTEP) and is supported by a grant from the National Science Foundation (NSF) in the Course, Curriculum and Laboratory Improvement (CCLI) program. In

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addition to faculty in Engineering and Education at UTEP, participants include STEM faculty from Baylor University, University of Texas Pan American, the New Mexico State University, and Prairie View A&M University.

Defining Faculty Development

We define faculty development as a structured approach to support: 1) development of awareness of teaching and learning theories and methods, 2) motivation to change instructional strategies and to try new strategies, and 3) reflection on strategy implementation. First and foremost, participating faculty members must become aware of the nature of the innovative approach of using modules to pique students' curiosity about key engineering concepts. Contemporaneously the faculty members need to be aware that there are learning theories that support the rationale for using these modules for deepening student understanding. Our underlying assumption is that all participants come to this space with different experiences and knowledge bases and, therefore, will develop differently in terms of their pedagogical expertise. Developing an awareness of the modules and underlying theories may motivate faculty to continue their own investigation into the connections between teaching and learning.

For this project, participating faculty members were given modest stipends for their participation, which was a significant motivating factor. Given the literature on engineering faculty motivation for introducing active learning approaches, this likelihood is not optimistic. Nonetheless, we believe that through participation in this project, faculty who have adopted these approaches are likely to experience success in their classrooms, and as a result of this success, they are likely to "recruit" other faculty.

The primary faculty development activities for this project were annual workshops and monthly virtual meetings using a web-based tool developed expressly for this project, the Virtual College Meeting (VCM).

Project Activities

The various project activities have revolved around demonstrating and supporting the development of counterintuitive modules and active learning methods for implementing the modules, as well as providing a forum for active reflection in faculty development workshops and Virtual College Meetings (VCMs).

Using Counterintuitive Modules

Once participating faculty members saw demonstrations of the use of counterintuitive modules and understood their purpose, 62 percent of participants developed and implemented discipline-specific modules in their classrooms during the first year of the project. Some faculty developed more than one. The modules that were developed include a study of trusses, bolted joints, friction brakes, cantilever beam designs, and rolling friction puzzles.

Active Reflection

Various faculty development activities provided venues for the participating faculty members to actively reflect on and critique the implementation of counterintuitive modules in their own and each other's classrooms. These venues were: 1) two-day face-to-face, interactive workshops, and 2) monthly web-based VCMs.

Faculty Development Workshops. The first faculty workshop in Year 1 of the CCLI grant was to develop awareness of these counterintuitive modules and of the supporting learning theories. The objective of the first workshop was for the participating faculty to begin to develop appropriate modules for core concepts in their own disciplines. The project principals demonstrated modules that had previously been developed while participants acted as learners in order to investigate how students' curiosity might be piqued. Discussion among workshop participants centered on how students acquire misconceptions and how these misconceptions can be countered through investigation of counterintuitive modules. The video, *A Private Universe* (http://www.learner.org/resources/series28.html), was shown; this video demonstrates that students acquire misconceptions that may never be overtly revealed and probed in classroom activities. Workshop participants also read and discussed a book chapter[9] on how a university faculty member in physics taught physical science to education majors using inquiry methods. His students were engaged in examining their misconceptions to reveal the true nature of a physical phenomenon of motion. During the workshop discussion, education faculty facilitated a discussion to clarify issues of inquiry-based instruction. Finally, faculty participants brainstormed ideas for developing their own counterintuitive modules, which they then elaborated and tested in their classrooms during the first year of the project.

In the second year of the project, another faculty development workshop was held. All of the previous workshop's participants returned and several new faculty also participated. Given the modest amount of the project stipend, such continuing and developing interest in the project is encouraging. During this second workshop, several faculty showed video clips or demonstrated the implementation of their counterintuitive modules in their respective classrooms. Then, together with the other participants, they reflected on what did and did not work in the conception and implementation of the modules. Co-principal investigators from the College of Education clarified concerns and issues in pedagogy and/or learning theory. Participants also read a theoretical paper on situated cognition,[4] which provided them with another theoretical perspective on learning. Evidence suggested that faculty participants had begun making connections between theory and practice, a critical element in developing learner-centered pedagogical methods.[6, 10]

Virtual College Meetings (VCMs). The VCMs are monthly meetings conducted by teleconferencing technology (VoIP). Nonthreatening venues for faculty to share successes and shortcomings, the VCMs have been used to circulate and discuss educational research papers, highlight new ideas from participating faculty, and have participants identify possible solutions to specific teaching problems posed by participants. Faculty often describe activities in their classrooms and have the Virtual College community engage in helping to celebrate success or offer alternative approaches. The frequency of the VCM allows participants to support one another while they are implementing their ideas, rather than waiting for the next annual workshop.

An Emerging Model

The elements we have incorporated into our faculty development activities are coalescing. As we gather data and see evidence of faculty transformation of perspectives on teaching and learning, we are clarifying the key elements of this emerging model, which include: 1) fostering awareness

of inquiry modules and their role in student learning; 2) creating awareness of teaching and learning theories and their roles in classroom instructional practice; 3) providing time, resources, and a supportive environment for developing counterintuitive modules; and 4) creating a collaborative community of experts in engineering and pedagogy to engage in discussions on issues of teaching and learning. These elements are realized in this project through the structured activities of the annual workshops and the VCMs.

Evidence of Impact

Data collection in the form of interviews and focus groups with faculty participants, post-workshop evaluation forms, and audio/video recording of classroom activities and workshops is ongoing. Video and audio recorded data are transcribed and analyzed using discourse analysis and an interative process of coding for emergent themes.[7, 11]

During the first project year, the workshop focused on developing inquiry-based cases. Feedback from participants suggested that they felt relatively confident in their abilities to identify concepts to probe using counterintuitive modules; however, they needed specific help to determine how to implement these modules as inquiry-based cases in the classroom. We used this feedback to design the second annual workshop to model the way we use these cases in our classes; that is, we used an inquiry/investigative approach to our workshop. We showed video clips of case implementation, and the faculty whose classes were featured in the videos described the decisions they had made in design and implementation, as well as what they learned through implementing them. This provided participants with examples of how to use the material in a classroom and sparked discussions about alternative designs for implementation. Faculty also read and discussed articles on learning theory and applications to classroom teaching. These discussions created an opportunity for participants to connect theory with classroom practices for implementing the project modules.

Evaluation of the workshops is based on analyses of transcripts of the workshops' activities and feedback from participants on the workshop evaluation forms. We summarized three key themes that have emerged through this analysis that exemplify the achievement of the aims of faculty development. These themes are transformation in faculty's approaches to pedagogy, transformation in their senses of professional identity, and the development of a community of co-learners of STEM faculty participants.

Transformation in Pedagogical Approaches

Faculty showed ample evidence in the workshop discussions that they were beginning to rethink their teaching. One faculty member, for example, described how he was beginning to use active learning and cooperative groups. Another, whose case implementation was demonstrated through video clips during the second annual workshop, described the use of learning journals in his class and suggested that these had had a positive effect on students' abilities to use the discourse of thermodynamics. He also talked about how writing a formal lesson plan to accompany his module had helped him to think through the implementation and be more effective. One faculty member posed a question about exactly how open-ended a counterintuitive problem should be, and other faculty quickly engaged in a discussion of the issue. Faculty also wanted to consider issues of assessment as related to the cases, and there was productive discussion about the role of formative assessment and the affordances of inquiry approaches for following the development

of students' thinking and understanding. Faculty also showed evidence that they were connecting what they were seeing and experiencing in the implementation of the modules to teaching and learning theories. One faculty member, for example, posed a question about how inquiry-based pedagogy contrasted with the Socratic method. His colleague reflected aloud about what had been happening with his students in his design course, framing his comments in terms of theories of situated cognition and cognitive apprenticeship which were presented in the article participants read for the second workshop.

Transformation in Professional Identity

Faculty were also beginning to describe changes in their perceptions of themselves as educators. One faculty member, for example, talked about beginning to see himself as a co-learner with his students, and another shared how his thinking about pedagogy was changing as he has begun to use physical models and cooperative learning groups in his classroom.

Development of a Community of Co-Learners in Engineering Education

Throughout the workshops, there was ample evidence that the project is helping participants to develop a sense of a community focused on improving engineering education. A faculty member, for example, talked about how he had adopted modules and techniques from other faculty in the project. Faculty also were clearly learning from watching the video clips of module implementation. The discussion which ensued furthered the learning process, as participants asked questions of the faculty whose modules were featured and debated alternative approaches to implementation. Thus, the workshops created a safe space for sharing ideas and perspectives, reflecting, and collaborative learning.

Beyond the workshops, the meetings of the virtual college showed further evidence of the development of a community of educators interested in improving engineering education. These meetings are being recorded and will be analyzed and reported on in the future.

Conclusion

Given the relative paucity of intensive faculty development in Engineering, the model for faculty development emerging from this project shows promise for replication at other institutions or within consortia. Evaluation is ongoing, however, and what remains to be seen is the extent to which these efforts are sustainable and how viable they are for replication.

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