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This paper introduces the framework and early implementation of a new program designed to develop more effective future faculty in engineering. The core of the program is based on our efforts regarding the recently developed Minor in Engineering Studies (MES). This program teams up effective engineering faculty to train, mentor, and evaluate a select group of graduate students to teach classes in our MES program. The goal is to help the engineering graduate students (the graduate educators) become better communicator and better educators by training non-engineering students in technological literacy classes. We believe that this practice will develop and enhance the effectiveness of the graduate educators as classroom instructors and that therefore this is the way to train effective future faculty in engineering. In this paper we introduce the conceptual framework of the MES and the results of the early implementation of this study.

Introduction

The quality of life and economic prosperity of the over 300 million residents of the United States are critically dependent on making wise choices on the use and further development of technology, addressing issues ranging from the formulation and implementation of energy policies to telecommunications. Addressing these issues is the mission of our 1.5 million engineers. To enable the future engineering workforce, as well as to educate the public with essential information about technology and technological literacy, requires enhanced efforts to train more effective engineering educators. The future engineering faculty at all levels will be responsible for educating their students as well as helping to educate non-engineers about technology[1-10]. We need to achieve effective technological literacy for the non-engineer 99.5% of U.S. citizens. Most of the country's leadership comes from this vast group of citizens who generally have only a vague understanding of the use of engineering and technology in the national interest. Engineering concepts are pervasive in decision making within industry, government, education, and health care, yet most decisions in these sectors are made by persons with little or no formal engineering education. It is apparent that we need to develop new engineers, with a new roadmap to the future of engineering practice, engineering research, and engineering education[11-24].

Motivation

The MES program is designed and implemented by the College of Engineering at Iowa State University to provide technological literacy to non-engineering students. The program started in 2006, and the first set of students participating in the program graduated in spring 2008. The main objective of the MES program is to provide the concepts and ideas of engineering and technology to students with non-technical backgrounds. The MES uses a contextual approach (e.g., learning electrical engineering by investigating how a cell phone works) that will make engineering relevant to the daily lives of non-engineering students. The classes are non-mathematical and are focused on applications, conceptual understanding, and big-picture items. The classes have no prerequisite and build on high school algebra.

Some of our most effective and successful faculty have an interest in teaching in the MES program; however, it is difficult to add new courses to their workload. Nonetheless, they are excellent resources for the program and can provide guidance, mentorship, and special lectures to help strengthen graduate educators' teaching skills and help them become more effective educators.

This project aims to address this problem by more efficient utilization of the best possible faculty as mentors to eager graduate students who would be trained and mentored to be the best educators they can be. We refer to these graduate students as graduate educators.

Minor in Engineering Studies: Program Objectives

To have a better understanding of the classes that the graduate educators teach, we provide a quick overview of the MES program.

The main objective for the MES is to provide a technological education to non-engineering students with various backgrounds. This is not an engineering degree. It should be noted that this is not a "minor in engineering" but a "minor in engineering studies." The students will not be trained as engineers (and cannot compete for engineering jobs), but will acquire a conceptual understanding of engineering, engineering design processes, technology, and technology-related concepts. This program is trying to build basic literacy in engineering, and the first goal is to provide students with a conceptual framework and working perspective so they can appreciate engineering and technological issues[25-27].

The program is designed to provide an effective minor to supplement the students' non-engineering degree programs. This proposed program is designed to help students who are

- not engineering majors but are interested in understanding "how things work"
- looking at directorship, management, technical marketing, sales, and related careers in an industry that continues to involve more technology
- possibly interested in public policy decisions impacting government, education, industry, religious institutions, health care, and other areas of societal impact, and/or
- thinking about working in bioengineering areas, but not on the technical side.

The MES program overall and its constituent classes were designed and implemented in 2006. All of the MES courses are designed with no prerequisite classes. In general, the program assumes that students have no background other than a high school degree. The program requires 21 credits for each student. There are three introductory classes (9 **total credits):** ES 260, Engineering: Getting from Thought to Thing; ES 265, Survey of the Impacts of Engineering Activity; and ES 270, Survey of How Things Work. In addition, each student should take 6 credits of junior- or senior-level classes from an approved course list of junior- and senior-level classes. These classes are offered by different faculty and are all related to understanding technology, technological development, and

social, ethical, and environmental aspects of technology. The rest of the total of 21 credits can be filled from the approved class list, including 2nd-year, 3rd-year, 4th-year, and graduate-level classes. Each engineering department is to offer classes in their field for such requirements. For this study the graduate educator will be helping teach the three introductory classes.

The Graduate Educator: Future Faculty in Engineering

We utilize a set of bright, eager-to-learn, and energetic graduate students to teach these classes. These students are selected from among those who are planning to be in education and become future engineering faculty. These students are likely to have opportunities to teach technical classes within their department or their program. That experience is very valuable and constructive for their technical training and for working with engineering students.

MES teaching is another opportunity to help the select group of students become more effective educators. The members of the selected group of students work with effective educators to teach MES classes. This limits the load on engineering faculty and instead uses their time to mentor graduate educators. By providing the right feedback and helping graduate lecturers to be more effective educators, the faculty will be helping to train more effective future engineering faculty members. By trying to educate students without mathematical and technological backgrounds, the graduate educators will be learning effective communication skills that are needed for best teaching approaches. They will also learn about effective instruction by helping students become an active part of the lectures. Since effective education is based on effective conceptual understanding and communication, this is an ideal platform for training future engineering faculty.

To help improve student educators through better mentoring, we utilize some of the most successful instructors among the engineering faculty to mentor the graduate educators. In addition, we have well-established faculty whose expertise can be utilized for this special training. It should be noted that some of the experts, such as distinguished professors of the Department of Educational Leadership and Policy Studies, as well as some of the most effective engineering faculty, are also members of the advisory committee for the MES program. Special seminars as well as one-on-one mentoring help the graduate students become better teachers. In addition, we are planning to bring in a distinguished national-level expert in technological literacy programs to provide seminars and help our team as a senior consultant. The team of the faculty and the experts will help train, mentor, and evaluate the graduate educators' performance. The experts will also visit students who are lecturing, to provide constructive feedback to assist them to become better educators.

It should be noted that some graduate educators will be moving from a research university to an environment with a greater emphasis on teaching. To help the educators become familiar with a focus other than research will be beneficial. Utilizing one of the experts—Professor John Krupczak—and visiting him at Hope College is one of the goals

of the program, to help the select educators become familiar with the different, teaching-focused education environment that is not present at our institution. According to *USNews*, 167 primarily undergraduate institutions (PUIs; that is, colleges and smaller universities) have engineering programs. Some of the graduate students at our research university who are interested in teaching are very likely to take positions at these PUI schools.

The Goal

By bringing the graduate educators into these classes and mentoring them with the supervision of experienced faculty members, the goal of the MES program is to:

- help the graduate educators be more effective teachers,
- help them understand how to set realistic class objectives and evaluate them,
- help them understand how to deliver effective lectures as well as create an active learning and engaging class environment, and
- bring new changes to these classes and make them more exciting by bringing different applications and examples (each student will be encouraged to add new applications and concepts that relate the subject to everyday lives).

Once the pilot study is completed and the faculty mentoring and student educator training programs are well defined, the students will be involved in developing new classes.

This study is expected to have several major consequences. First and foremost, having energetic, exciting, and well-mentored teachers for the three core MES classes will attract students into the MES program. In addition, this effort will help our future faculty be more effective educators.

Early Results

In spring and fall 2009 and fall 2010, the introductory classes were taught by a graduate educator, as defined by the project. The graduate educator had taught numerous laboratory and recitation classes during the last two years as a teaching assistant in the Department of Electrical and Computer Engineering. During the two terms he was a teaching assistant for an introductory electrical engineering laboratory and Engineering Studies class. This graduate educator was mentored mostly by the director of the MES program to establish the plan, weekly assignments and readings, projects, and ways to evaluate the Engineering Studies students' work. The graduate educator is a successful PhD student in engineering having technical skills in both electrical and computer engineering. With mixed feelings about how effective he could be, he started with his first lecture class. Throughout the last two terms the graduate educator developed a much more effective approach for the classes. The teaching evaluations and student comments improved significantly by the second term. Based on the course evaluations, his performance can be compared to some of our more effective faculty. This was done by mentoring and working with him to understand what makes a successful class with active student participation.. By the end of the first month of the class, his lectures were well developed, interesting, educational, and engaging for the students. He also developed a

much better knowledge base of general engineering and related fields, since he had to read and understand other engineering issues that were discussed in Engineering Studies. The Engineering Studies students highly rated this learning experience. At the end of the term, students wanted to take more classes from him. This particular graduate educator was transformed into a much more effective educator as a result of getting involved with the MES introductory classes. He believes that trying to think at the system level—the big picture—and trying to convey engineering concepts to the MES students really helped him be a better engineer, a better researcher, and a more effective educator. At the end of spring 2009, he won the award for being the best teaching assistant from the Department of Electrical and Computer Engineering, for conducting successful and engaging classes. The award was based on student evaluations and faculty feedback to the department. While this is just one example, it shows great promise that the proposed plan can work in transforming and creating effective future faculty in engineering.

Evaluation Process

The evaluation process is underway, and is in the process of being implemented during the Spring 2010 semester. Currently, the questionnaire and the instruments have gained final approval by the human subjects in research committee of ISU's Institutional Review Board, and will be implemented in April 2010. The most important objective is the effectiveness of mentoring and educating our select graduate educators to become better and more successful educators. Assessment of the program will be undertaken in different areas. First and most important, assessment will be conducted to evaluate the effectiveness of the mentoring program to train future faculty in engineering. Additionally, as part of the assessment we need to know the effectiveness of the program, mentoring, seminars, and feedback that are provided by the faculty and consultants to help the graduate educators become more informed about the tools and methods of better teaching.

Graduate educators are be monitored regularly and consistently throughout their progress through their graduation, and through the launch of their academic careers for those who graduate soon enough for monitoring to extend to that point. Surveys, focus group contacts, and individual interviews will be conducted, in conjunction with the Preparing Future Faculty program at ISU, with all participating students once a semester to provide a tracking of the trajectory of their professional career development. This record of their progress will be compared against the record of progress for a random sample of other graduate students in the College of Engineering with backgrounds and interests as similar as possible to those who participate in the enhanced professional development experience.

Another important aspect of the assessment effort will be to ascertain the effectiveness of educating the students enrolled in the MES program courses. Are the students learning better as a result of the graduate lecturers' leadership in their classes? This will be evaluated by comparing retention, graduation, time to degree, grade point average, course credits earned, honors and awards received, progress into more advanced studies (graduate and professional school), publications, funded and submitted grants and

contracts, and other relevant indicators of student academic progress and professional development achievement between MES participants and a random sample of non-MES students with comparable background characteristics and academic records.

Conclusions

This paper presents the concept and plan for a new training program, "Creating Effective Future Faculty in Engineering." This program is based on utilizing the most effective faculty at our institution as well as some of the national-level experts to help a select group of ambitious graduate students who aspire to become engineering faculty. The program is in the early stages of implementation. Upon mentoring the graduate educators and evaluating their performance, we will provide constructive feedback that will help the graduate educators improve their teaching effectiveness and become better and more effective educators.

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References

1. Augustine, N. (Chair), National Academies Committee on Prospering in the Global Economy of the 21st Century. 2005. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C.: National Academies Press.
2. Duderstadt, J. J. (Chair), National Academy of Engineering Committee to Assess the Capacity of the United States Engineering Research Enterprise. 2005. *Engineering Research and America's Future: Meetings the Challenges of Global Economy*. Washington, D.C.: National Academies Press.
3. Duderstadt, J. J. 2007. *The View from The Helm: Leading the American University during an Era of Change*. Ann Arbor, Michigan: University of Michigan Press.
4. Duderstadt, J. J. 2007. *Engineering for a Changing World: A Roadmap to the Future of Engineering Practice, Research, and Education*. Ann Arbor, Michigan: University of Michigan Press.
5. Flanagan, J. L. 2006. U.S. competitiveness and the profession of engineering. *The Bent of Tau Beta Pi*, 16–22.
6. Galloway, P. D. 2007. *The 21st Century Engineer: A Proposal for Engineering Education Reform*. Reston, Virginia: American Society of Civil Engineering.
7. Jamieson, L. 2007. Engineering education in a changing world In IEC DesignCon. International Engineering Consortium, Chicago.
8. Lattuca, L., P. Terenzini, J. F. Volkwein, and G. D. Peterson. 2006. The changing face of engineering education. *The Bridge*, 5–14. Washington, D.C.: National Academy of Engineering.
9. Ad Hoc Task Group on Engineering Education, Committee on Education and Human Recourses. 2007. *NBS Moving Forward to Improve Engineering Education*. Draft report, July. Washington: National Science Foundation.
10. Boyer, E. 1998, 2001. *Reinventing Undergraduate Education (The Boyer Commission Report)*. New York: Carnegie Foundation.
11. Clough, G. W. (Chair). 2004. *The Engineer of 2020: Visions of Engineering in the New Century*. National Academy of Engineering, Washington, D.C.: National Press.
12. Clough, G. W. (Chair). 2005. *Educating the Engineer of 2020: Adapting Engineering Education to the New Century*. National Academy of Engineering, Washington, D.C.: National Press.

13. Clough, G. W.. 2006. Reforming engineering education. *The Bridge*, Washington, D.C.: National Academy of Engineering.
14. Accreditation Board for Engineering and Technology. 1995. *The Vision for Change: A Summary Report of the ABET/NSF/Industry Workshops*. May.
15. Phillips, J. M. 2007. The expanding frontiers of engineering (editorial). *The Bridge* 37(4, Winter).
16. Vest, C. M. Vest. 2006. Educating engineers for 2020 and beyond. *The Bridge* 36(2, Summer).
17. Council on Competitiveness. 2004. *Innovate America: Thriving in a World of Challenge and Change*. Washington, D.C.: Council on Competitiveness. Available online at: http://innovateamerica.org/webscr/report.asp.
18. DPC (Domestic Policy Council) and OSTP (Office of Science and Technology Policy). 2006. *American Competitiveness Initiative: Leading the World in Innovation*. Available online at: http://www.whitehouse.gov/stateoftheunion/2006/aci/aci06-booklet.pdf.
19. NRC (National Research Council). 2006. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, D.C.: National Academies Press. Available online at: http://www.nap.edu/catalog/11463.html.
20. Ambrose, S. A., and M. Norman. 2006. Preparing engineering faculty as educators, *The Bridge* 36(2, Summer).
21. ASEE (American Society for Engineering Education) Engineering Deans Council and Corporate Roundtable. 1994. *Engineering Education for a Changing World*. Washington, D.C.: American Society for Engineering Education.
22. Baxter Magolda, M. B. 1992. *Knowing and Reasoning in College: Gender-Related Patterns in Students' Intellectual Development*. San Francisco: Jossey-Bass.
23. diSessa, A. 1982. Unlearning Aristotelian physics: A study of knowledge-based learning. *Cognitive Sciences* 6 (2): 37–75.
24. Felder, R. M., and R. Brent. 2004. The intellectual development of science and engineering students. Part I: Models and challenges. *Journal of Engineering Education* 93 (4): 269–277.
25. Mina, M. 2007. Work in progress—Minor in engineering studies: Teaching engineering concepts to non-engineering students. In *FIE '07, 37th annual*, T3H-1–2.10–13 October.
26. Mina, M. "Work in progress —The Role of engineering colleges in technological literacy programs" *FIE '08.Frontiers in Education, 38th Annual* Oct 2008, Saratoga, NY pp F3F-25 - F3F-26
27. Mina, M.; Gerdes, R. M. "Work in progress - a class called "How things work?" and its role in technological literacy programs" *FIE'09 Frontiers in Education,* 2009, 39th IEEE 18-21 Oct. 2009 pp.1 – 2