CRITICAL ELEMENTS FOR FUTURE PROGRAMS SEEKING TO ESTABLISH EXCELLENCE IN ENGINEERING EDUCATION THROUGH PROFESSIONAL QUALIFICATION OF FACULTY TEACHING IN HIGHER EDUCATION

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This paper presents three critical elements needed for any successful US program seeking to establish excellence in engineering education through professional qualification (and recognition) of faculty teaching in higher education. Building on concepts well grounded in the literature, the critical elements are: support by a ***nationally respected society or academy****, utilization of* ***qualifying criteria or standards at several levels****, and* ***flexibility in implementation*** *across a variety of university administrative structures and cultures.*

Introduction

The ultimate goal of this work is to help propel engineering education to a point where most faculty can be described as scholarly teachers. Such a vision is not unique. A recent guest editorial in the Journal of Engineering Education envisions a near-term future where engineering faculty are recruited and hired with primary scholarly responsibilities in engineering education (Soyster 2008). But what does this vision mean? An answer to this question could be explored through careful planning to create programs to establish formal certification or qualification. This paper seeks to establish a set of critical guidelines with which that planning can begin.

Two key pieces of work supporting the content of this paper have been developed by the authors. In (Schaefer and Utschig 2008), we outline existing models of professional qualification, development and recognition for those teaching in Higher Education selected from across the world. In (Utschig and Schaefer 2008), we discuss current opportunities and challenges existing in the US regarding professional education-related faculty development.

Considering the context presented above, we outline three critical elements in developing any formal teaching and learning faculty development system intending to produce widespread measurable improvements in student learning outcomes within engineering education.

Critical element #1: Programs will evolve and be supported by a ***nationally respected society or academy***.

Critical element #2: Programs will be supported by ***qualifying criteria or standards at several levels*** of expertise with clear criteria at each level and will include both practicum and training components.

Critical element #3: Programs will accommodate ***flexibility in implementation*** across a variety of university administrative structures and cultures.

Background

Key Programs and supporting Organizations

The Science, Technology, Engineering, & Mathematics Education Scholars Program (STEMES) trains future and first year faculty with the following goals (Center for the Integration of Research Teaching and Learning 2007).

- practice techniques for engaging students in active learning;
- teach with awareness of diversity in the areas of learning style, culture, age, gender, etc.
- develop confidence in creating effective learning environments for students and faculty.

The Preparing Future Faculty (PFF) program is extremely well established. It does not specifically offer a program targeting engineering, but does have a guide to developing programs in the Sciences and Mathematics (Pruitt-Logan, Gaff et al. 2002).

The NSF sponsored Southeastern University and College Coalition for Engineering Education. Another NSF funded coalition was the Foundation Coalition. Extensive documentation of these efforts is available at the coalition websites (Foundation Coalition 2005; SUCCEED 2008).

The College of Engineering and Engineering Technology at Northern Illinois University has just completed a college-funded initiative targeting the scholarship of teaching for their entire faculty (Scarborough and Vohra 2006). Program topics include outcomes and assessment, teaching and learning styles, learning theory, cooperative learning, and the use of teams.

The American Society for Engineering Education (ASEE) , and specifically the Educational Research and Methods Division (ERM) provides extensive support for education in engineering.

The NAE (National Academy of Engineering 2008) created CASEE in 2002 (Center for the Advancement of Scholarship in Engineering Education 2007). The center is "dedicated to achieving excellence in engineering education, education that is effective, engaged, and efficient." Its goals are stated as follows:

- Build the capacity for the conduct of high quality research on engineering education,
- Integrate engineering education research and practice, and
- Leverage the efforts and interests of relevant stakeholders.

Current activity within CASEE is centered primarily on the last of these three items. This paper provides a potential framework to connect those efforts to the second item.

Literature Supporting Alternative Teaching and Learning Methods

Much of the work in recent years about teaching and learning was articulated in the seminal work by Barr and Tagg describing a paradigm shift from teaching to learning. This concept has been increasingly taking hold in higher education (Barr and Tagg 1995). Prince & Felder have published a number of articles which draw upon a variety studies both within and outside of engineering contexts demonstrating the effectiveness of active and inductive teaching and learning techniques (Prince 2004; Prince and Felder 2006; Prince and Felder 2007). Smith et al provide additional support for the techniques outlined by Prince and Felder, but with a particular emphasis on student engagement (Smith, Sheppard et al. 2005). Freud has begun to build a comprehensive document articulating major research studies supporting the efficacy of specific types of teaching and learning (Freud 2007). He cites studies in the following categories: cooperative and small-group learning, active learning, problem-based learning, inquiry-based learning, challenge-based learning, peer-led team learning, workshop groups, and undergraduate research. Other more general resources are also available.

The Three Critical Elements

Critical Element #1

It will evolve and be supported by a ***nationally respected society or academy***.

A sponsoring society or academy needs to fulfill a number of requirements. Respect can be achieved through the quality and reputation of its members as well as through its influence across institutions. Next, the sponsor needs to be a stakeholder in the success of the program. It must also be able to commit resources to the program. Furthermore, it will need a highly visible personality as a champion and should be viewed independent of the institutions it serves. Finally, involvement in continuing research in engineering education is important. A core engineering society (or subgroup of such a society or societies) such as ASEE or NAE would appear to be an appropriate. An accrediting body such as ABET might become involved, too.

Building communities of practice through the sponsoring society will be facilitated through the proper choice of the society and adherence to the needs of the community. Key elements to guide these communities as they evolve should include 1. Determination of the primary intent of the community 2. Defining the domain and identifying engaging issues 3. Building a case for action 4. Identifying potential coordinators and thought leaders 5. Interviewing potential members 6. Connecting community members 7. Creating a preliminary design for the community (Wenger, McDermott et al. 2002). Some of these aspects (particularly numbers 2, 5 and 6) have been explored within the engineering education community.

Critical Element #2

It will be supported by ***qualifying criteria or standards at several levels*** of expertise with clear criteria at each level and will include both practicum and training components.

Different levels of certification represent the continuous evolutionary journey one undergoes as an educator. We propose three levels: Tier 1: Theory – foundations of teaching and learning. Tier 2: Scholarship – educational research and scholarly work in the field. Tier 3: Practice and Portfolio – reflective teaching portfolio development and peer mentoring.

Tier 1 Content: Theory

Learning styles/Learning processes: Broadly speaking, one may distinguish between 'deep learning', 'surface learning' and 'strategic learning' (Marton, Hounsell et al. 1997).

Learning theory: There are three main categories (philosophical frameworks) under which learning theories fall: behaviorism, cognitivism, and constructivism (Marton, Hounsell et al. 1997), with constructivism the current mode dominating research in engineering education.

Course and curriculum design: Course objectives, learning outcomes, technical content, course delivery, assignments and examination as well as appropriate assessment procedures have to be thoroughly planned and constructively aligned (Biggs 1999; Erickson 2002).

Constructive Alignment underpins requirements for program specification, declarations of intended learning outcomes and assessment criteria, and the use of criterion based assessment. It has two parts: (1) students construct meaning from what they do to learn (2) instructors align planned learning activities with the associated learning outcomes (Biggs 1999).

Active learning (student engagement) utilizes learning environments that allow "*students to talk and listen, read, write, and reflect as they approach course content through problem-solving exercises, informal small groups, simulations, case studies, role playing, and other activities -- all of which require students to apply what they are learning*" (Meyers and Jones 1992).

Assessment and Evaluation are essential ingredients in any teaching and learning system. A comprehensive discussion of both evaluation and assessment along with their differences can be found in (Beyerlein, Apple et al. 2007).

Teaching with Technology: Careful selection of technological tools can enhance content and student engagement in learning activities but complex approaches can be challenging and time consuming (Simonson, Smaldino et al. 2000; Levine 2005).

Tier 2 Content: Scholarship

In this level participants become engaged in a largely self-directed (and research-based) process of developing and understanding their own 'mental model' of teaching and learning in their personal context (Ramsden 2003). The goal of Tier 2 is to develop participants' ability to:

- Solicit, via an appropriate and formatively assessed research protocol, evidence of variation in the manner in which a sample of students approach their learning.
- Locate, interpret, and evaluate such evidence in theoretical terms appealing, in particular, to the research literature on conceptions of learning, approaches to learning, and the (qualitative and quantitative) modeling of learning outcomes.

- Consider the implications of the evidence gathered, and its theoretical import, in terms of developing a basis for reflective practice and personal actionable theory.

The content of this module is grounded in the literature on how student engagement and experiences in learning vary in terms of approaches to teaching.

Tier 3 Content: Practice

The final stage of the learning process for program participants is to become so-called reflective practitioners (Schon 1991) and develop a basis for reflective practice of their own teaching as well as personal actionable theory to vary and improve it. These participants continue their teaching and learning journey by developing a teaching portfolio (Baume 2003). Such portfolios document various types of evidence of a participant's personal development and progress related to multiple aspects of teaching and learning. Criteria describing elements of what should be included in a portfolio will need to be defined by the sponsoring society or academy in order to allow for a standardized certification process.

Experienced teaching practitioners will also help others understand what is happening in their respective teaching and learning environments. These faculty will participate in several types of teaching observation exercises such as peer observations in order to provide quality feedback and coaching through a variety of assessment tools.

Critical Element #3

It will accommodate ***flexibility in implementation*** across a variety of university administrative structures and cultures.

Each college and university deserves the authority to implement such a system in ways that make sense within its own institutional culture and administrative structure. Excellent general resources on organizational change exist in the literature. Also, see (Beyerlein, Apple et al. 2007; Utschig and Schaefer 2008) for a description of how these challenges in transformation manifest themselves in education-related faculty development.

Because each institution can approach their system independently, the intent should not be to prescribe the methods, but rather the standards to which they must rise as measured through the outcomes they achieve. These outcomes can then be held up to statewide or national standards reflected in critical element #2 and enforced via the sponsoring society as discussed in critical element #1. The system would thus reflect accreditation processes in that each institution writes their own outcomes and designs systems to achieve those outcomes in light of the accountability being tackled through an external entity. Keeping these guidelines in mind we recommend that individual institutions should control (1) specific curricula (2) content emphases or specialties (3) timelines (4) participants, instructors, and mentors (5) inclusion/weighting in the tenure process but should not control (1) certification levels (2) certification standards.

Conclusions

The very idea of "required" elements for faculty within any faculty development program relating to excellence in teaching and learning is fraught with emotion and will no doubt engender vigorous debate. This paper attempts to provide some structure to that debate by offering three critical elements for such programs: a nationally respected society or organization as a sponsor; a standards driven, multi-tiered approach to program curriculum involving aspects of education theory, scholarship, and practice; and flexibility for implementation within individual institutions such that they retain autonomy in striving to achieve the standards for excellence in engineering education sought through their faculty development programs.

It is time for engineering education to move into the national and international forefront. Let us educate the engineer of 2020 with the equally transformed and educationally prepared engineering faculty of 2020. Let us not fall behind the world, but strike out anew to lead it.

References

American Society for Engineering Education. (2008). "American Society for Engineering Education: About --> Mission and Vision." 2008, from http://www.asee.org/about/mission.cfm.

Barr, R. B. and J. Tagg (1995). "From Teaching to Learning: A New Paradigm for Higher Education." Change **27**(6).

Baume, D. (2003). Supporting Portfolio Development. Continuing Professional Development Series, LTSN Generic Centre.

Beyerlein, S. W., D. K. Apple, et al. (2007). Faculty Guidebook: A Comprehensive Tool for Improving Faculty Performance. Lisle, IL, Pacific Crest.

Biggs, J. (1999). Teaching for Quality Learning at University. Buckingham, UK, The Society for Research into Higher Education & Open University Press (McGraw-Hill Education).

Center for the Advancement of Scholarship in Engineering Education. (2007). "CASEE Home Page." 2008, from http://www.nae.edu/nae/caseecomnew.nsf?OpenDatabase.

Center for the Integration of Research Teaching and Learning. (2007). "The 12th Annual Science, Technology, Engineering, and Mathematics (STEM) Education Scholars Program." 2008, from http://www.cirtl.net/STEMES/.

Erickson, H. L. (2002). Concept-based Curriculum and Instruction, Corwin Press.

Foundation Coalition. (2005). "Foundation Coalition Home Page."2008, http://www.foundationcoalition.org/index.html.

Freud, J. E. (2007). Evidence for the Efficacy of Student-active Learning Pedagogies, Texas A&M University.

Levine, S. J. (2005). Making Distance Educating Work, LearnerAssociates.net.

Marton, F., D. Hounsell, et al. (1997). The Experience of Learning. – Implications for Teaching and Studying in Higher Education, Scottish Academic Press.

Meyers, C. and T. B. Jones (1992). Promoting Active Learning: Strategies or the College Classroom. San Francisco, Jossey-Bass.

National Academy of Engineering. (2008). "National Academy of Engineering Home Page." 2008, from http://www.nae.edu/nae/naehome.nsf

Prince, M. J. (2004). "Does Active Learning Work? A Review of the Research." Journal of Engineering Education **93**(3): 223-231.

Prince, M. J. and R. M. Felder (2006). "Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases." Journal of Engineering Education **95**(2): 123-138.

Prince, M. J. and R. M. Felder (2007). "The Many Faces of Inductive Teaching and Learning." Journal of College Science Teaching **36**(5): 14-20.

Pruitt-Logan, A. S., J. G. Gaff, et al. (2002). Preparing Future Faculty in the Sciences and Mathematics: A Guide for Change. Washington, DC, Council of Graduate Schools, Association of American Colleges and Universities.

Ramsden, P. (2003). Learning to Teach in Higher Education, RoutLedge Falmer.

Scarborough, J. D. and P. Vohra. (2006). "The Scholarship of Teaching: CEET Initiative on Teaching and Learning."

Schaefer, D. and T. T. Utschig (2008). A Review of Professional Qualifications, Development, and Recognition of Faculty Teaching in Higher Education Around the World. American Society for Engineering Education Annual Conference, Pittsburgh, PA.

Schon, D. (1991). The Reflective Practitioner – How professionals think in action. Cornwall, UK, MPG Books Ltd.

Simonson, M., S. Smaldino, et al. (2000). Teaching and Learning at a Distance: Foundations of Distance Education, Pearson.

Smith, K. A., S. D. Sheppard, et al. (2005). "Pedagogies of Engagement: Classroom-Based Practices." Journal of Engineering Education **94**(1).

Soyster, A. L. (2008). "Guest Editorial: The Business of Engineering Education." Journal of Engineering Education **97**(1): 3-4.

SUCCEED. (2008). "SUCCEED: Engineering Education Innovations from Some of the Best Minds in the Country." 2008, from http://www.succeed.ufl.edu/default.asp.

Utschig, T. T. and D. Schaefer (2008). Opportunities and Challenges in Professional Education-related Faculty Development in the US, under review.

Wenger, E., R. McDermott, et al. (2002). Cultivating Communities of Practice. Harvard Business School Press.

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