Work in Progress: Online Engineering Education Certificate Program

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Online Engineering Education Certificate Program: Work in Progress

Abstract

The paper, which is work in progress, describes a proposal for an online Engineering Education Graduate Certificate program. The program targets current and future engineering educators, both in academia (community colleges and universities) and in industry. The goal is to improve the quality of engineering teaching and training by empowering students to become better and more knowledgeable engineering instructors through their understanding of educational theories and applications. The program intends to be fully online, with a combination of asynchronous and synchronous instruction.

The proposed certificate program includes plans for four online courses: Engineering Course Design, Assessing Learning and Teaching in Engineering, Principles of Engineering Teaching and Learning, and E-learning Course and Training Development in Engineering. Besides the coursework, the online certificate program will also incorporate a Teaching Internship course, which should give students the opportunity to put their engineering education knowledge into practical application.

Introduction

To become a professor, instructor, or trainer in engineering, whether in academia or in industry, an individual is only required to have a degree in engineering. In academia, this is generally a PhD (for universities) or a Master's Degree (for community colleges) in engineering. While students are in their engineering program, training and exposure to educational theories and teaching methods often is either limited to short seminars or completely absent from the education of engineering professors, instructors, and trainers. More significant educational training is needed for engineering educators on educational theories and best practices in pedagogical methods, both before and after receiving teaching or training positions.

Gion Svedberg analyzed the classical teaching culture in engineering education and compared it to a set of six teaching principles. Based on this analysis, he concluded that "teachers adhering to the traditional teaching culture in engineering cannot possibly obtain good or effective teaching"[1]. According to Svedberg, this happens because "teachers in engineering at universities tend to teach in the same way as they have experienced during their own studies"[1]. This means that the classical teaching culture is perpetuated because there is not sufficient training in proper teaching practices for engineering educators. Though Svedberg was specifically discussing engineering educators at universities, the same conclusions apply to those at community colleges and engineering trainers in industry.

Professional development for educators is not new, even for engineering educators. Such programs exist in several forms, at many universities throughout the world, including graduate engineering education certificate programs. Though these programs exist, they are limited to the faculty or students at that particular university. The proposed program offers a widespread dissemination of these best practices in evidence-based teaching methods, via online instruction and certification. This study presents the progression of the development of an online certificate

program for engineering professionals employed in positions of pedagogical leadership and training, both in academia and industry worldwide.

Existing Engineering Education Programs

Benson and her colleagues discussed in 2010 the state of Engineering Education departments in the United States. At the time, there were four departments of Engineering Education: Purdue University, Virginia Tech, Utah State University, and Clemson University, some of them offering certificate programs in engineering education[2]. The current image is slightly broader, and there are existing certificate programs specifically in engineering education to provide faculty development opportunities for engineering professors, instructors, and trainers (Table 1).

Table 1: Graduate Certificate Programs in Engineering Education at Different Institutions

Institution	Academic Unit	Requirements	Comments
Purdue University	School of Engineering Education	• 10 graduate credits • All core courses, 3 on pedagogy • A semester-long Mentored Teaching Experience course (1 credit)	• Teaching and Learning in Engineering Graduate Certificate • Admission requirement Bachelor's degree from an accredited institution
Virginia Tech	Department of Engineering Education	• 13 graduate credits • Core courses on engineering pedagogy • Practicum in the Engineering Classroom course • Required 1 course from Pedagogy List • Elective list includes more research focused courses	• Engineering Education Graduate Certificate • Admission requirement include either enrolment in masters or doctoral program or Bachelor's degree in any engineering field or Mathematics / Physical or Biological Sciences
Clemson University	Department of Engineering & Science Education	• 11 graduate credits • 1 credit hour Practicum • Courses in Pedagogy, Educational research Methods and Professional Preparation	• Certificate in Engineering and Science Education • Admission requirement include enrolment in doctoral program
University of Texas	Cockrell School of Engineering	• 16 credits • Core courses on pedagogy: some undergraduate • One elective course in education of engineering education • Teaching Practicum course (6 credits) and Teaching Portfolio Prep course (1 credit)	• Graduate Certificate in Engineering Education • Certificate credits may also be counted toward a degree
University of St. Thomas	Center for Engineering Education	• 12 graduate credits • 3 core graduate courses including Engineering Design • 1 elective course	• STEM Graduate Certificate in Engineering Education • Designed for in-service P-12 educators
Wichita State	College of Education & College of Engineering	• 12 graduate credits • 3 core graduate courses on pedagogy • Internship course	• Graduate Certificate in Engineering Education • Admission limited to Engineering graduate students

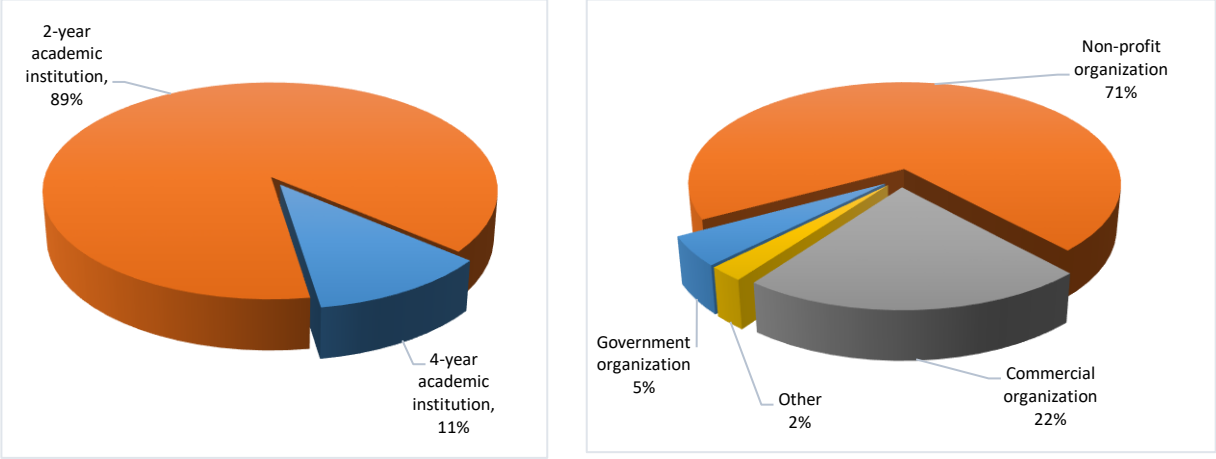
The search of institutional documents available online provided information regarding certificate programs dedicated to engineering education offered by academic institutions, specifically by four-year institutions across the United States. The search did not include industry programs. Findings revealed that few institutions provide education certification program exclusively in engineering education. Of those that offer such programs, Purdue[3] includes only core classes (mainly on pedagogy), whereas University of St. Thomas[4] and Tufts University[5] do not have a teaching internship or practicum. On the other hand, most of the certificate programs, such as at Virginia Tech[6], Clemson University[7], University of Texas at Austin[8], and Wichita University[9], include teaching internship or practicum.

Tufts University[5] offers the only graduate certificate program fully online. However, it is a program that is specifically intended for current K-12 teachers.

Needs Assessment

To determine a need or desire for an engineering education professional development program, a survey was conducted with participants from industry and from 2-year and 4-year colleges (see Figure 1 for breakdown of participants' organization types) from across the country.

The survey was sent to human resource representatives of industry and community colleges, who were asked to forward the link to the survey to their engineering professionals and training educators. Invitations to participate in the survey were sent to 164 community colleges and 684 companies. In most cases, ultiple invitations were sent to several employees (in total, 1541 e-mail invitations were sent to community colleges and 1096 to industry). There were 191 responses to the survey: 105 from community colleges and 86 from industry (see Figure 1 for breakdown of participants' organization types). Most responses (85%) were received from the West/Mid-West region of the United States, and the results presented in this work reflects these findings. The answers were considered as those from potential participants indicating their personal preferences on different aspects of the program. In this survey, participants were asked several questions relating to professional development for engineering educators in college and industry.



(a) Community Colleges (b) Industry

Figure 1: Organization Types, Number of Participants and Survey Participants

The survey included questions about preferred professional development program type, preferred length for each program type, preferred delivery method for the professional development program, and preferences of the content of the professional development program.

Concerning the preferred program type of the participants in the survey, Figure 2 shows the results for both industry and community college participants. For the industry participants, a certificate program was the most preferred program type (28 participants) with a Master's Degree program in a close second (23 participants). For the community college participants, a certificate program was also the most preferred program type (33 participants) with a Doctorate Program in close second (28 participants).

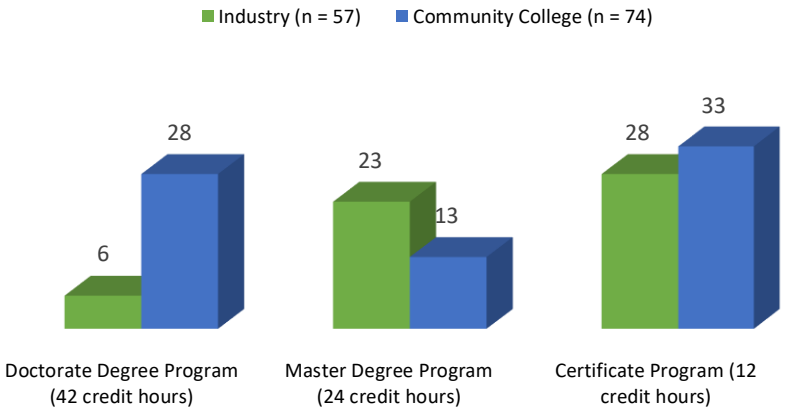


Figure 2: Preferred Professional Development Program Type

Since the certificate program was the preferred program type for both industry and community college participants, only the preferred length of the certificate program has been included below as Figure 3. Both industry and community college participants prefer a short certificate program of up to 12 months.

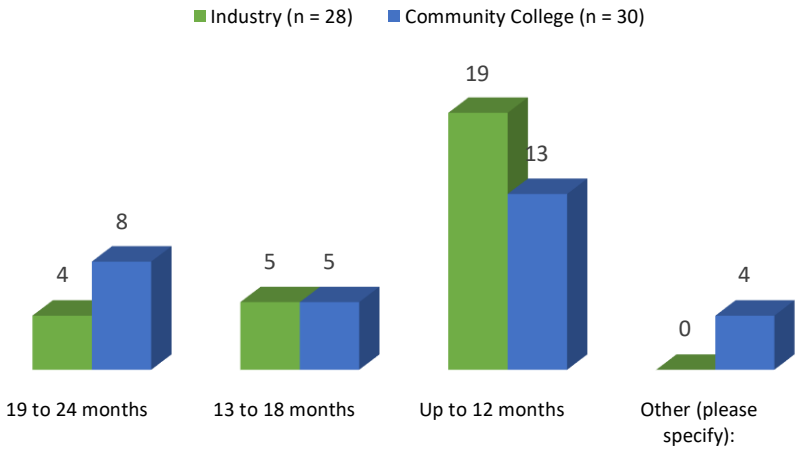


Figure 3: Preferred Length for Professional Development Certificate Program

The survey also asked the participants which delivery method would be preferred for the planned engineering education professional development program. Figure 4 shows the results of this question. The preferred method for both industry and community college participants was Online Option B: A Combination of Asynchronous and Synchronous. Face-to-face was in a close second, in both industry and community college, but this delivery method limits the instruction to those in close proximity to the campus. Between the online options, both industry and community college participants clearly preferred a combination of synchronous and asynchronous instruction.

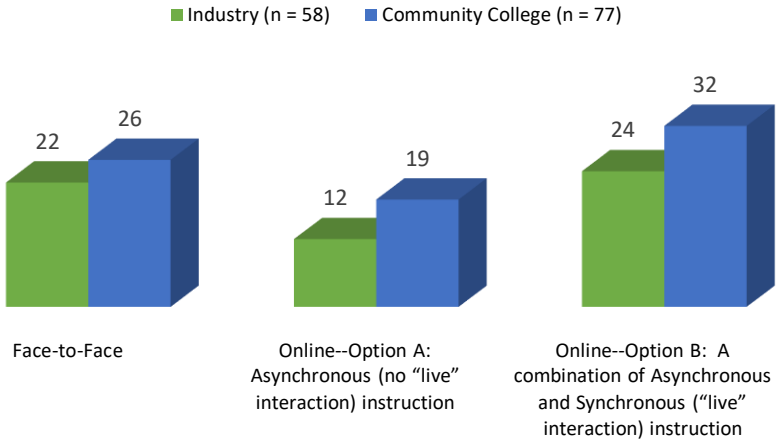


Figure 4: Preferred Delivery Method for Engineering Education Professional Development Program

The survey also asked the participants to rank the importance of four different subject areas for inclusion in an engineering education professional development program: Curriculum Design, Evaluation and Assessment, Principles of Teaching and Learning, and E-learning Course and Training Development. For each rank, a weight was assigned. This weight was then multiplied by the frequency for each topic at each ranking. This weighted score was then totaled for each subject area and divided by the total weighted score for each rank to obtain the weighted ranking that is shown in Figure 5.

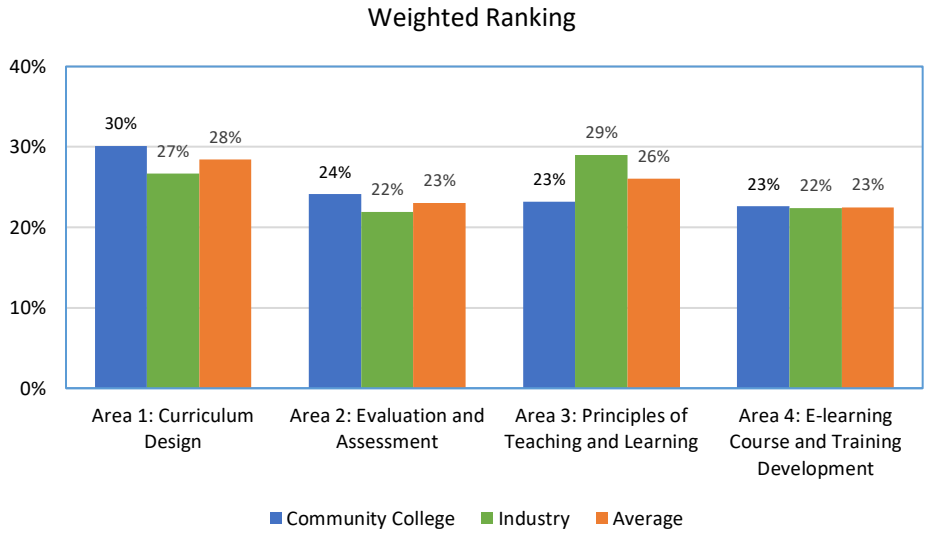


Figure 5: Weighted Ranking of Preferred Topics Covered in Engineering Education Professional Development Program

The weighted ranking for each subject area was approximately 25% (+/- 5%), meaning that each topic has a similar amount of importance to the participants.

Program Overview

Based on the results of the needs assessment survey, a Graduate Certificate Program in Engineering Education was designed and is in the process of being implemented. This program includes four core courses that cover the four topics included in the survey:

- Curriculum Design,
- Evaluation and Assessment,
- Principles of Teaching and Learning, and
- E-learning Course and Training Development.

The program is intended to be delivered purely online with a combination of synchronous and asynchronous instruction and will take approximately one calendar year to complete.

Though it was not included in the survey, the program will also include a Teaching Internship course that includes the application of concepts and skills learned from the core courses into teaching, self-reflection on teaching, and the preparation of a teaching portfolio.

Online Delivery Method

From the survey, it was clear that the preferred delivery method for the Graduate Engineering Education Certificate was a mixture of synchronous and asynchronous online delivery. Besides the results of the survey, there are significant advantages to the online delivery method. Violante and Vezzetti[10] stated some of these advantages: "It is easier for a large number of participants to successfully and more completely acquire instructional content [and] decreased expenses and waste of time of the students for traveling to the class venue"[10]. Besides these advantages, it is

predicted that a fully online certificate program would be advantageous in order to reach a much wider audience than would be available with a face-to-face program.

Although using an online delivery method significantly increases the reach of the program, the fully online aspect of the program does introduce some challenges. For example, the wide reach introduces time zone differences, which could complicate the synchronous aspects of the courses. With any program intended to improve teaching skills, it is important to introduce a type of teaching practice to show that the students in the program have gained the necessary skills. Because of the online delivery method, it would be difficult to place the students in the certificate program into a teaching practice and to directly observe any teaching that would take place. To overcome these difficulties a Teaching Internship Course was developed to accomplish the same goals as an in-person teaching practicum.

Teaching Internship Course

Since the online delivery method makes direct observation of teaching more difficult, a Teaching Internship Course was designed as an essential part of the program. The course is intended to enable students participating in the program to have some sort of teaching responsibility in engineering.

This teaching internship course is a capstone activity that gives the participants the opportunity to demonstrate the skills taught in the four core courses in the program. The teaching internship course includes the compilation of a teaching portfolio and a series of reflections by the participants on their own teaching.

The objectives of the teaching internship course are:

- to contrast critically student's teaching experience with theoretical knowledge gained in courses of the program,
- to learn from teaching experiences, using their own reflections, as well as feedback from students and faculty,
- to present teaching credentials by demonstrating teaching methods and approaches, and by analyzing evidence of student learning,
- to be able to justify the choices of teaching methods and activities,
- to document professional development and to identify areas for improvement,
- to assemble a teaching portfolio that highlights the quality and scholarship of one's own teaching in a presentable form, also for hiring purposes.

Teaching Portfolio

Rather than focusing on specific deliverables, the participants in the teaching internship course will be required to submit a teaching portfolio. The teaching portfolio is to be a collection of good teaching practices[11]. It should also provide information on teaching goals, with reference to the participants' teaching philosophy. The teaching portfolio is an important element of collecting evidence of the participants' teaching experience and effectiveness, especially in the case where direct observation is not possible.

Based on the reading material and their own experiences and thoughts the students the portfolio will be space for the students to:

- present a teaching philosophy,
- present teaching methods and approaches,
- prove achievement of teaching skills,
- document professional development
- identify areas of improvement.

Portfolio should provide materials (videos, written papers, and other documentation) that show competence in a set of skills based on the content of each of the core course in the curriculum. Some of these materials are included as assessments elements in the courses and will only need to be submitted again as a part of the portfolio.

Teaching Reflections

In order for the participants in the program to think about their own teaching, the teaching internship course will require to submit a biweekly reflection on their own teaching. The reflections are important tool in improving students' awareness and capability to monitor their own thinking, understanding, and knowledge about their teaching[12]. The ability to reflect on their own teaching helps participants to identify a situation and issue, with doubting how to proceed in teaching practice.

The self-reflections on teaching experiences will be shared online with the other participants in the program. Participants will also be required to comment on each other's reflections. Teaching reflections should encourage the students to think about their own teaching. That should include collecting, recording, and analyzing what happened during their teaching, so they can make improvements to their teaching strategies. Teaching reflections, through comments from other students, will also create an online learning community that will allow the participants in the certificate program to share in each other's teaching experiences and insights.

Conclusions & Future Work

This work in progress describes the initial stages of the development of an online graduate Engineering Education Certificate program. The program intends to be accessible worldwide, giving more engineering educators an opportunity to broadly apply evidence-based practices into their workplace or learning environments. The program targets current and future engineering educators and trainers, both in academia (community colleges and universities) and industry. Potential candidates should have an undergraduate degree in any engineering discipline. The goal is to improve the quality of the teaching and training in engineering by empowering students to become better and more knowledgeable engineering instructors through their understanding of educational theories and their applications.

The proposed certificate program includes four online courses: *Engineering Course Design, Assessment of Learning and Teaching in Engineering, Principles of Engineering Teaching and Learning, and E-learning and Training Development in Engineering*. The status of the program is that all core courses have been developed at the level of their descriptions, objectives, course content and requirements, and the recommended reading material.

A Teaching Internship course, which is the novel component of the program, and which intends to be a capstone activity for students pursuing the certificate, is still in the process of

development. The objectives of the course, its content and requirements have been developed, similarly to other core courses.

The future work on the program is to prepare core courses in fully online mode, using a designed template. Also, the Teaching Internship course must be fully developed beyond the concept level.

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