Preparing Engineers for the 21st Century: How to Teach Engineering Students Process Skills

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ABSTRACT

Process skills (problem-solving, lifelong learning, critical thinking, communication and collaboration, self-assessment, change management, etc.) have always been important in any education and work setting. However, new challenges presented by a new, globalized economy, have put a new focus on these skills in the engineering workplace. Process skills present a great challenge for educators and practicing engineers alike because they are hard to define explicitly, hard to teach, and even harder to develop as a student. They depend on attitudes and values as much as they depend on content knowledge. For educators the challenge is three-fold: how to clearly define these skills, how to assess them, and how to effectively teach them to their students. The paper discusses a course design process that facilitates the development of these skills to help prepare engineering and technology students for the challenges of the 21st century workplace.

Keywords: 21st Century Skills, Course Assessment, Course Design, Engineering Education, Process Skills

INTRODUCTION

An essential task of our profession as engineering educators is to design new courses or re-design old ones that meet certain educational goals. This task has become more challenging in the past few decades due to several factors, as outlined in the following:

A. New requirements imposed by globalization and the demands of the 21st century workplace:
The modern engineering workplace involves much more complex tasks than ever before. Engineering projects tend to be multi / interdisciplinary, which require integration of new knowledge and ever-changing technologies. Engineers need to be technically savvy but they must also possess lifelong learning skills to help them stay current. In addition, they must be culturally sensitive, with good interpersonal and team skills to interact effectively with colleagues and customers from around the world.

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B. Changing needs of our student populations: The modern engineering classroom has become just as diverse as the 21st century workplace. Engineering students come from all walks of life. Some are youngsters, fresh out of high school. Some are married with children. Some are professionals, already working in industry. Some work odd jobs to support themselves going through engineering school, while others work to support their families. They bring to the classroom their own varied experiences and lots of creativity. They also bring a full spectrum of learning styles along with their individual learning needs, which depend on their educational and cultural background.

C. Lack of formal training in pedagogy among engineering educators: Most engineering faculty, while experts in their field, have little or no training in pedagogy. As a result, many engineering courses are ineffective and do not meet their educational goals. This has been very well documented from results of student performance as well as performance of employed graduates. For example, it is not uncommon for students to demonstrate a lack of prerequisite knowledge while taking advanced courses, even though they have completed the prerequisite courses with high grades. Neither is it uncommon for employers to complain about a lack of skill among newly hires. In fact, complaints of this nature played a significant role in the revamping of the US accreditation criteria in 2000 (ABET, 2016-2017).

The purpose of this paper is to provide a pedagogically sound process for engineering course design, which would significantly increase our effectiveness in teaching students process skills and preparing them for the 21st century workplace. This methodology is similar to the iterative process used for the design of an engineering product.

THE PROCESS OF COURSE DESIGN

Traditionally, engineering educators begin their planning for a new course with a search for an appropriate textbook on the subject. Assuming they are able to find such a book, the next step is usually to browse through the chapters and decide how much can be “covered” in the course of the term. If a textbook is not available, educators often get to work producing their own course readers with the material they see fit to include. The bulk of the work for putting together this new course, eventually evolves, as it should, around preparing lectures, homework assignments, laboratory experiments, and tests. In this process, there is often little or no thought given to the end product, namely the skills students are supposed to acquire in relationship to the course content. This traditional process of putting together a course is known as “teach, test, and hope for the best”. Needless to say, such a process cannot be relied upon to ensure that engineering students learn the very complex process skills we expect them to learn.

When engineers design a product, on the other hand, they start with an end in mind. For example, when aerospace engineers design an airplane, they begin with a set of very specific mission requirements, which describe what the airplane is supposed to do. These typically include the number of passengers to be carried, the distance (range) these passengers will travel, the cruise speed and altitude of the flight, and the minimum runway length necessary for takeoff and landing. The aircraft manufacturer typically works in close collaboration with customers (e.g. airlines) to define the mission requirements for a new airplane, using extensive market analysis. For example, an airline may need a new airplane to transport 550 passengers and their luggage 5,000 nautical miles, at a speed of 650 miles per hour, at an altitude of 37,000 ft. The airplane should be able to take off and land from existing 12,000-foot international runways. The Aerospace engineers who design this airplane must meet all of these requirements if the airline is
A Holistic Approach to Software Engineering Education
www.igi-global.com/chapter/holistic-approach-software-engineering-education/54974?camid=4v1a

Proposing a Feedback System to Enhance Learning Based on Key Performance Indicators
www.igi-global.com/article/proposing-a-feedback-system-to-enhance-learning-based-on-key-performance-indicators/104665?camid=4v1a