AC 2007-344: ENABLING THE U.S. ENGINEERING WORKFORCE FOR TECHNOLOGICAL INNOVATION: THE ROLE OF COMPETENCY-BASED LEARNING FOR PROFESSIONALS

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Enabling the U.S. Engineering Workforce for Technological Innovation: The Role of Competency Based Learning for Professionals

1. Introduction

This is the third of four invited papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform to enable a strong U.S. engineering workforce for competitiveness and national security. As Fred Gary, former vice president of General Electric pointed out: Companies can no longer afford to have their products produced at B or C level. Nor can they afford to have their engineers, who conceive these products, to be educated at B or C level of competence. The importance for the nation to more fully develop its creative engineering capital in industry for professional competency and responsible positions of engineering leadership of continuous technology development and innovation is no longer in doubt. But the new challenge in professional graduate education for engineers requires a change in educational process that is not new. What were once the dreams of forward thinking educators to remove the constraints of time and place from the educational process for competency-based learning can now become reality. We now have the capability of making "learning the constant for professional competency" and "time the variable" in professional engineering graduate education. This paper presents the issues involved and recommends changes required in implementing high-quality competency-based learning into first rate professional educational programs for working professionals.

2. Competency-Based Education for Engineering Professionals

The National Collaborative is effecting a dramatic change in the professional education of practicing engineers. This is being done with full recognition of the way in which practicing engineers grow professionally throughout their careers. This is, in many ways, a new paradigm based on the understanding that receipt of a baccalaureate represents for the engineer entering the profession a challenge to continue the educational process. At the same time, it is an old paradigm based on an understanding of the educational process in general.

Practicing engineers perform at the highest levels of creativity. Consequently, professional education for practicing professional engineers must be focused on the highest categories of the cognitive domain in the taxonomy of educational objectives as shown in Figure 1.[1,2,4] In addition; it must include important areas such as ethics, team building, and effective management of professionals that clearly fall within affective domain in the taxonomy of educational objectives. Further, because technologies change so rapidly, the educational process must enable the practicing engineer to develop facility with the new tools and technologies at his disposal. Such activities are within the psychomotor domain in the taxonomy of educational objectives. Hence, the professional education of practicing engineers is quite naturally competency based.

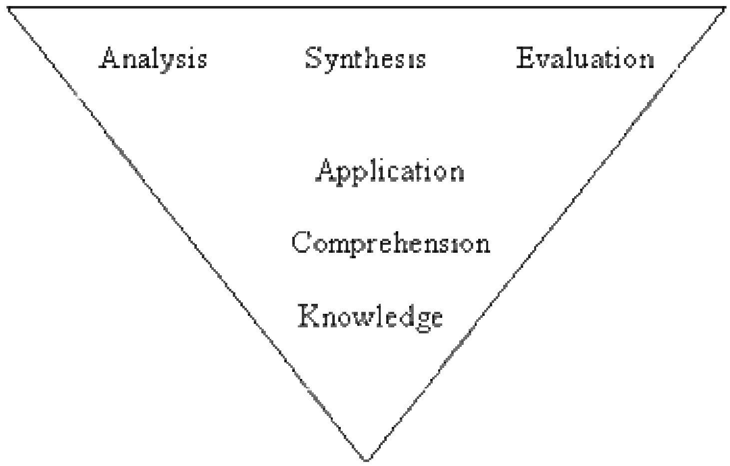

Figure 1: Categories in the Cognitive Domain of Bloom's Taxonomy

3. Curriculum Development – Establishing Objectives

The program of advanced professional education for practicing engineers has as its basis recognition of the way that engineers grow professionally throughout their careers. The National Collaborative has identified nine levels of growth that are recognized throughout the engineering community.[5] We have identified significant milestones associated with advancement through these levels. These are: entry level (the baccalaureate), Master of Engineering, and Doctor of Engineering. In addition, there is a level beyond the Doctor of Engineering, which we tentatively call the Engineering Fellow (or Chief Engineer) that recognizes the substantial professional growth that occurs beyond the Doctorate. These levels serve as "recognition points" in the program of advanced professional education for the practicing engineer.

The National Collaborative has identified the skill sets that are associated with each level of progression through the program: Master of Engineering, Doctor of Engineering, and Engineering Fellow. These skill sets form the basis for the curriculum at each level. It is expected that the full resources of associated universities will be available so that many existing courses (and adjunct faculty) can be used to meet the program objectives.

Some portions of the program objectives will not be satisfied by existing course offerings. New courses will be developed using best practices from competency bases education theory to meet this need. It is expected that the National Collaborative will make a substantial contribution to the advanced professional education of engineers as a result of such new course development.

4. Curriculum Development – Establishing Outcomes

The formalism for developing meaningful competency-based educational program outcomes is not only well established but also widely adopted. Bloom's work serves as the basis for this activity.[3,6,7] This formalism is well suited to this program as well.

Bloom established six categories in the cognitive domain of his taxonomy.[1,2,3] These are shown in Figure 1 Learning outcomes are developed around these catagories.[7] Recognizing that this unique program cannot rely on traditional course delivery methodology, the establishment of course/unit objectives attains critical importance. Keeping in mind the objectives of the program, learning outcomes should

- Define the expected type and depth of learning
- Provide objective benchmarks for learning assessment
- Clearly communicate expectations to participating students
- Clearly communicate to stakeholders / employers the skills gained by participating students
- Define coherent units of learning in keeping with the overall program objectives

It is important that all courses in the program adhere to the highest standards whether they are developed specifically for the program or are adopted from an established graduate program. This will require that all courses in the curriculum be developed on a foundation of well planned learning objectives.

5. Curriculum Development – Assessment

A key aspect of strong competency-based education programs is assessment of student performance. The participants in the program are practicing professional engineers. They are not in a traditional academic program and they are motivated differently than traditional students. Consequently, the traditional A, B, C grading scale should not be uniformly adopted for assessment of their educational accomplishments. On the other hand, performance evaluation without meaningful assessment is unsatisfactory as well. Keeping this in mind, each course in the curriculum must be considered separately and the most appropriate assessment method chosen in accordance with the high academic standards of the program. This is a matter that requires careful deliberation. The program goals and learning objectives must be met, of course. But these must be considered in the context of the overall academic institution as it is viewed from within and without. Assessment methods appropriate for competency-based education programs have been implemented successfully in other professional education programs such as medicine, law, nursing, and the military. Best practices from these professional education programs will be adopted in an evolutionary manner to ensure that the highest standards are maintained in this program.

Conclusions

Competency-based education is an appropriate methodology to adopt for the professional education of practicing engineers. Practicing engineers are creative professionals who grow professionally throughout their careers, generally outside a traditional academic setting. Hence, the educational process must be centered on the skill sets associated with levels of growth that are part of the profession. Engineering is a creative profession. Consequently, the educational process must be focused on the highest categories in the cognitive domain of Bloom's taxonomy of educational objectives. Once these key aspects of the program are established, program objectives and program outcomes can be developed using widely adopted standard practices.

The assessment methodology for this program must be developed carefully using best practices adopted from competency-based education programs in other professions. Assessment methods for the program will evolve in order to ensure that the highest standards are maintained in this program while recognizing the program participants and their motivation, the stakeholder / employer and their assessment of the benefit derived from the program, and the overall academic setting in which the program is offered.

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