AC 2012-5553: QUO VADIS, ENGINEERING ECONOMICS

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Quo Vadis, Engineering Economics?

This paper examines a process for answering two fundamental questions:

- Which engineering topics most enhance a student's ability to contribute to society as measured by employer needs?
- What is the effectiveness of current educational practices, such as computer-aided-instruction?

It uses a well-recognized engineering discipline, engineering economics, to illustrate this process.

A fundamental issue in any educational endeavor is determining the relevancy of specific topics and how much resources should be devoted to them. The American Society for Engineering Education (ASEE) and its divisions, such as the Engineering Economics Division (EED), can serve a useful function in that process. These organizations can help to obtain and organize information at a national level that is not routinely available to academic decision makers, specifically industrial needs and how academic practices address those needs. This paper examines each of these subjects in the following sections, and then discusses implementation strategies.

Relevancy

Is engineering economics, or any other specific topic, relevant and how important is it? Traditionally, science has sought to provide knowledge, and engineers put that knowledge to a practical use. This would seem to make engineering economics relevant because two of the primary criteria of the utility of an engineering project are:

- Does it work?
- Does it provide a return on its investment?

Nonetheless, if the National Council of Examiners for Engineering and Surveying (NCEES) had not increased the weight assigned to engineering economics on its Fundamentals of Engineering Examination (FEE), partially in response to the EED, then it is possible that inclusion of engineering economics in engineering curricula would have continued to decline.

Many colleges are under pressure to reduce the number of hours required for graduation, and a natural inclination is for professors to de-emphasize courses such as engineering economics or other courses that are not offered within their major. The same thing happens at a departmental level within all disciplines. Professors seek to promote courses that they like to teach or that are important to their research agenda. A more rational procedure is needed to determine which topics need to be included within a curriculum.

Role of the ASEE and Its Divisions

The NCEES is the *de facto* arbiter of the relevance of fundamental engineering topics by virtue of the FEE. Similarly, the Accreditation Board for Engineering and Technology (ABET) has historically influenced determination of the relevancy of engineering topics. The ASEE and its

divisions serve as a forum in which engineering educators interact, and it has provided input to the NCESS and ABET, but more can be done.

The ASEE is ideally situated to serve as a clearinghouse for the needs of engineering employers and the response of engineering educators to those needs. Individual members of the ASEE and other engineering organizations occasionally perform surveys or studies of needs versus educational practices, but there is no systematic collection and dissemination of information.

Industrial Information Needs

What information is needed to continually improve engineering education? The first step in planning is to determine needs. Educators currently conjecture on the needs of employers or use a small sample of opinions provided by an advisory board. Some possible needs of employers of concern to the ASEE include:

- engineers who understand technical issues, communicate them effectively, and work in a team environment,
- new hires who can maintain and improve profits without a long delay,
- individuals who can continue learning and adapt to changes, and
- technically competent persons who can progress into management.

Employers sometimes focus on one of these needs more than another, depending upon their current problems, but the foregoing issues seem to be recurrent themes. However, the relative importance of these and other needs is not documented on a systematic basis. How can this be done?

The ASEE includes industrial members and also can interface with other organizations to obtain this information at a level suitable for academic planning. One alternative is to perform a periodic survey. This would allow needs to be tracked over time with continual improvement of the survey as educators become familiar with it as a planning tool. The EED and other divisions can operate within this framework and add detail to the survey instrument as necessary. For example, information that might be useful to the EED could include topics such as:

- employer satisfaction versus academic preparation in economic analysis,
- the stage of design at which economic considerations are recognized,
- which economic criteria are measured,
- clarity of reporting economic analyses,
- the extent to which are spreadsheets used,
- the need for computationally efficient techniques, such as factors,
- how capital budgeting is implemented,
- the need for an increased understanding of taxes,
- techniques of cost estimation and their adequacy versus stage of design,
- relevancy of currently popular research topics, and
- other educational areas that need to be addressed.

It is probable that many educators can guess some of the outcomes of such a survey, but it is nonetheless extremely important to have firm, reliable information that can be used in designing

curricula, developing research programs, designing instructional software, and exploring alternative instructional tactics. This knowledge also would be extremely useful to agencies such as NCEES and ABET, as well as providing a basis for funding agencies to award grants.

Academic Information Needs

The ASEE and its divisions are also uniquely positioned to survey members to determine current educational practices and contrast them with industrial needs. The ASEE's Engineering Deans Council provides a constituency that can supply information about broader issues in engineering education, such as the policies of different colleges in administering the balance between research and teaching, the role industrial or public service programs, the use of non-engineering classes to improve communication skills, accreditation status, success rate on the FEE by area, and so forth.

Individual divisions can solicit information from their members to ascertain the degree to which specific industrial needs are being addressed by educators. For example, input potentially useful to EED members might include:

- which colleges offer engineering economics,
- which departments within those colleges require engineering economics,
- whether instruction is in a stand-alone course or a component of another course,
- number of credit hours,
- which topics (including specific industrial needs) are taught and hours on each topic,
- number of sections and average students per section,
- use of recitation sections,
- teaching techniques, such as lecture, discussion, or web-based,
- educational innovations
- internal metrics used to measure effectiveness of techniques and innovations,
- use of projects,
- grade distribution,
- performance of students in engineering economics on FEE,
- unsponsored and sponsored research areas, and
- publication topics and frequency.

The foregoing data can provide feedback regarding how well industrial needs are being met, the relevancy of research, and the effectiveness of different instructional techniques.

Implementation and Institutional Considerations

Surveys can be used to collect the type of assessment information described above, but there are other alternatives, such as regular meetings in which participants are polled. Implementation strategies for surveys are considered below, and they can provide advocates of other methods with a basis for comparison.

The first point that must be recognized is that surveys require effort to design, complete, analyze, and report. As a consequence, many surveys are one-time efforts. If the knowledge offered by

such surveys is important, then its structure must be institutionalized so that it can be maintained and improved over time. Simply assigning this responsibility to an ASEE or divisional officer will not work, because of the level of work and the fact that each new officer will have to reinvent the wheel. This suggests the establishment of an Assessment Committee with staggered terms.

It is reasonable to develop a prototype within one or two divisions, and thereby facilitate implementation elsewhere. A committee with as few as three members can develop a survey instrument using readily available and well-known software such as Excel. A spreadsheet is easy to transmit either via email or as a web download, and it captures data in a digital form. Once individual responses are collected, they can be manually copied or extracted via VBA into a single large spreadsheet and thereafter easily analyzed. Once familiarity is gained with this process, then more advanced options can be considered if desired or necessary, such as a Web interface to a database. Starting with an advanced system can establish too much of an initial hurdle for volunteers, followed by a lack of participation, and then failure.

Potential industrial and academic respondents can be identified using three primary sources, all available within the ASEE databases:

- The database of divisional members can produce a list of professors and industrialists with interests in a specific area, such as engineering economics.
- The foregoing list will not cover all colleges, so it can be supplemented with the database of ASEE college representatives who can either respond to the survey or identify respondents.
- Finally, the database of deans can be used to obtain information at a college level. Further, deans, with the consent of their advisory boards, can supplement the list of industrialists.

The institutional structure must be designed so that the survey instrument can be allowed to evolve. Initial efforts might be fairly limited, and at the other extreme surveys cannot be allowed to grow until they become a burden to respondents. One approach is an iterative three-step process: (1) The assessment committee conducts a survey, (2) survey users and respondents provide suggestions for modifications, and (3) the committee decides which changes to implement. The committee must be empowered so that it can make decisions without routinely requiring an unwieldy vote of the entire membership, and its membership should minimally include persons who can provide input regarding the teaching and research components of academia, industrial needs, and computer applications.

Quo Vadis

Determining goals and objectives in engineering education requires that educators know what is needed and what is currently being provided. The ASEE and its divisions are uniquely positioned to provide that information on a consistent and documentable basis. This provides a framework for a continuing, meaningful improvement of engineering education:

- Professors focusing on teaching know which areas need further development, and they can examine the effectiveness of different teaching strategies.

- Academicians conducting non-educational research or serving in editorial positions can obtain feedback about what is important to end users, the employers of our students.
- Administrators have an objective basis for allocating resources.
- Agencies such as NCEES and ABET have guidance on what they need to be evaluating.

Is it not likely that a large organization like the ASEE will make a commitment to conducting surveys or providing other services unless there is evidence that they can provide useful results. This leaves the task to a division, and the EED is a good candidate to recognize the need for such information due to the problems that it encountered when many engineering colleges did not recognize its relevancy. Quo vadis, EED?