Surveying Students and Alumni for Evaluation of a B.S. Program in Mechanical Engineering

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Abstract: This paper describes a survey of graduating seniors and alumni from the Mechanical Engineering Bachelor of Science Program at the State University of New York at Buffalo. The survey has been developed to guide the direction and continuous improvement of our mechanical engineering program. It attempts to identify the perceived needs of our student customers by asking them to rate the importance of various knowledge and skills areas to their careers as mechanical engineers. The survey then asks for a rating of the importance level given in our program to the various knowledge and skill areas. The results reported here are based on two classes of graduating mechanical engineering students and a recent survey of our alumni of the preceding five years. The current results indicate in a quantitative way that the traditional technical areas of mathematics, sciences and basic engineering topics are well covered. Our coverage of applied areas and "softer" topics is less satisfactory. Areas such as product design, manufacturing and computer-aided-design tools clearly need more attention. There is particular interest in communication skills, the ability to work in teams and develop sound engineering judgement as well as professionalism, ethics and experience in engineering practice.

Keywords: survey, quality, curriculum, mechanical engineering

1. Introduction

Surveys in the world of engineering education have been with us for quite some time. An early survey with input from over 7000 engineers was conducted by Mann [1] in 1914 with sponsorship of the Carnegie Foundation. It was directed toward the effectiveness of engineering education and the important factors for success in engineering. Complaints about the communication skills of engineering graduates were common and engineering schools were found to be generally successful only in "imparting technical knowledge". Character, integrity, judgement and common sense were found to be the most important predictors of a successful engineer. Interestingly, a much more recent study involving the Mellon Foundation [2] has also concluded that personal attributes and abilities, rather than college attended, define successful people.

Surveys in engineering education have, of course, continued and are receiving increased attention as quality concepts and continuous improvement ideas come to education, e.g. [3,4]. Certainly there is concern and healthy skepticism about the survey process, e.g. [5], but as the global competition in engineering and business continue [6,7], surveys in the search for enhancing the quality of engineering education are here to stay. The survey described here has the relatively narrow focus of improving the course sequence leading to the Bachelor of Science degree in Mechanical Engineering at the State University of New York at Buffalo. However, the conclusions, which are quite consistent and were not readily anticipated, should be of broad interest.

2. Program Goals

This study began in the best traditions of quality improvement by attempting to define the goals of our mechanical engineering B.S. program. A small item in an alumni newsletter from the University of Wisconsin [8] was considered as we reached this stage. With several additions and modifications it became the basis for our definition of a set of goals which tend to represent the characteristics of graduating mechanical engineers. The goals were initially developed through faculty discussions and the continuing evaluation of the goals themselves has been incorporated into the survey process. The goals are divided into two groups; the "knowledge" goals range across

relatively traditional academic areas but include an experience component. The "skills" goals refer to perhaps more practical factors and abilities. We expect these goals to continue to evolve over time as we obtain feedback from our survey efforts. The goals are stated below in their current form as used for the surveys described herein.

A graduating Mechanical Engineer should have knowledge providing him/her with:

(1) sufficient background in engineering related mathematics (calculus, differential equations, partial differential equations, linear algebra etc.) and sciences (including physics and chemistry) to be able to adapt to a changing engineering environment and facilitate life-long learning,

(2) the fundamentals of mechanics, materials science, thermodynamics, thermal and fluid sciences, and systems sciences as applied to the design, analysis and manufacture of mechanical engineering systems,

(3) understanding of basic analytical, numerical and computational techniques representative of those used in industry and research,

(4) an awareness of the importance of professionalism, ethics, societal and environmental issues as they affect the practice of mechanical engineering,

(5) exposure to engineering practice as appropriate for a new graduate.

The skills of a graduating Mechanical Engineer should allow him/her to:

(1) design engineering products using modern integrated design methodologies and product realization processes to meet defined needs,

(2) construct mathematical models of mechanical engineering systems and use computational/analytical tools and techniques to predict the performance of such systems,

(3) create computer based models of machine components and assemblies using CAD/CAE tools and use them in the product synthesis/analysis process,

(4) use sound engineering judgment when confronted with engineering decision making,

(5) be familiar with the evaluation and choice of suitable materials and manufacturing processes,

(6) communicate effectively and function well in a team-based environment.

3. The Present Program

The current Bachelor of Science program in mechanical engineering at Buffalo requires four years with a mixture of math, science and engineering coursework that has been relatively traditional in the U.S. It is summarized below:

Basic Mathematics - four courses in calculus and differential equations (16 credits)
Basic Sciences - one chemistry course and two physics courses plus one science elective (16 credits)
Engineering Fundamentals - engineering solutions, engineering drawing, introductory programming, thermodynamics, statics, dynamics, solid mechanics, electrical engineering concepts (23 credits)
Mechanical Engineering - instrumentation, systems analysis, fluid mechanics, heat transfer, machine elements, mechanisms, materials, materials processing, thermodynamics II (26 credits)
Design - design processes, capstone design project (6 credits)
Laboratories - instrumentation, materials, fluids/heat transfer, systems, materials processing (5 credits)
Electives - three technical, two applied mathematics, one free choice (18 credits)
General Education - nominally two english courses, six social science courses (24 credits)

Our technical elective program contains a wide variety of course offerings including CAD oriented courses and several courses dual listed with our graduate coursework. Students also have available a summer internship

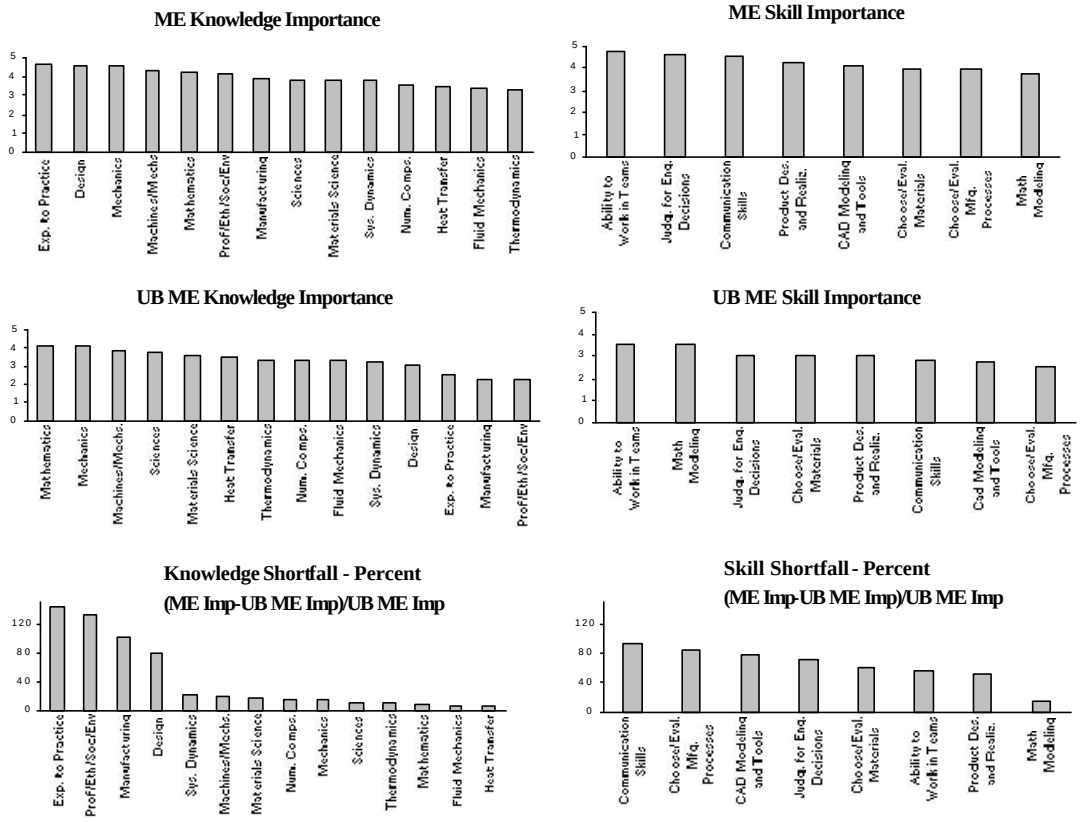

Fig. 1. Survey Results for Graduating Seniors (Classes of 1999 and 2000)

program with many local and state-wide companies and there is a growing co-op program for fourth year students.

4. The Survey

In our surveys of graduating students and alumni, there have been two components. One component requests broad information on the quality and usefulness of their university and engineering educational experience. The other component focuses on the knowledge and skills goals described above. The goals are presented in a brief narrative form and participants are invited to comment on the current goals and suggest items that are missing. We expect that study of these comments will be helpful in our efforts to tune our program goals on a continuing basis.

The focus of this paper is on the quantitative section of our goals survey. In this section, specific phrases of two to four words are used to summarize the various knowledge and skill statements. Respondents are then asked to provide their viewpoint (on a scale of one to five) of the importance of each of the knowledge and skill items to their career. They are also asked to rate the importance that they believe we have placed on each of these items within our B.S. program. This quantitative data identifies the natural importance of the knowledge and skill goals from the viewpoint of the students. It also shows the importance that they see us placing on each item within our program. But, perhaps most significantly, the difference in importance levels can provide the key to improving our program in the eyes of our student customers.

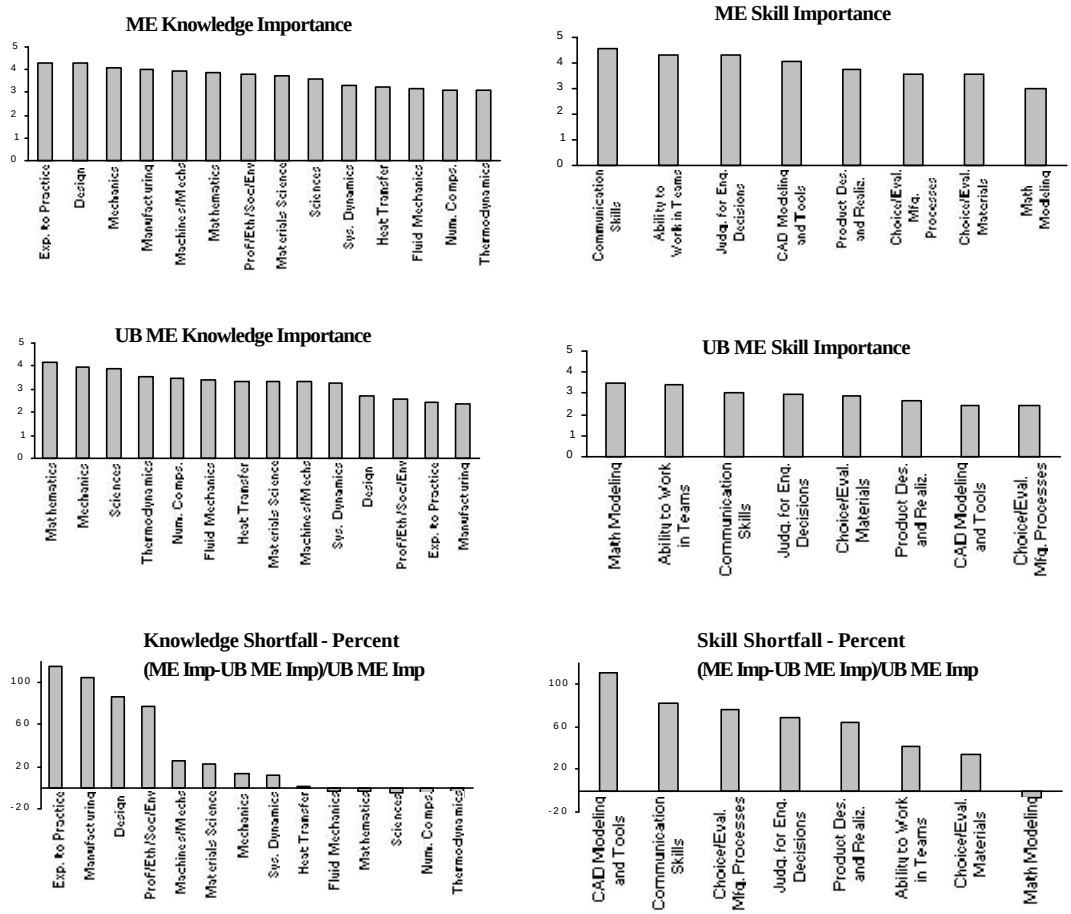

Fig. 2. Survey Results for Alumni (Classes of 1994-1998)

5. Results and Conclusions

Nearly two hundred graduating seniors and alumni have responded to our survey. The more important quantitative results are summarized in Figs. 1, 2 and 3. Fig. 1 presents the results for graduating seniors. The knowledge importance graph on the upper left shows "exposure to practice" as the most valuable item to students (4.7) followed by design (4.6) and continuing on down to thermodynamics (3.4). The next knowledge graph shows the perceived UB importance level led by mathematics (4.1), closely followed by mechanics, and continuing down to professionalism, ethics, society and environment (2.3). The knowledge shortfall graph is expressed in percent and presumably shows the appropriate importance increases needed by our program. Exposure to practice, professionalism, manufacturing and design stand out as needing enhancement. The traditional subject areas of mechanical engineering seem to be appropriately covered. The skill results to the right in Fig. 1 show that our graduating seniors value team work and also see that teamwork is an important part of our program (perhaps as a result of working in laboratory groups). Graduating seniors see our largest skill shortfall in communications, with manufacturing processes and CAD also as concerns. In their view, math modeling clearly needs the least attention.

Fig. 2 shows the results obtained from our alumni respondents in the same format with knowledge items to the left and skill items to the right. The alumni are in considerable agreement with the graduating seniors. Exposure to experience is again heavily valued and we are not emphasizing it sufficiently. In terms of importance shortfall, manufacturing and design have become more noticeable issues. Most of the traditional subjects in mechanical engineering are again well covered with some negative shortfall numbers resulting, particularly for thermodynamics. On the skills side, CAD shows up with the greatest deficit for alumni but the shortfall pattern is much the same as in Fig. 1. Communication needs improvement and, again, math modeling apparently receives more than enough attention. Fig. 3 provides some samples of the distributions of our survey responses as obtained from our alumni data. The histograms shown are for the difference between ME importance and UB ME importance. It is especially clear that the sentiment for more exposure to practice is widely felt as well as the need for more CAD experience.

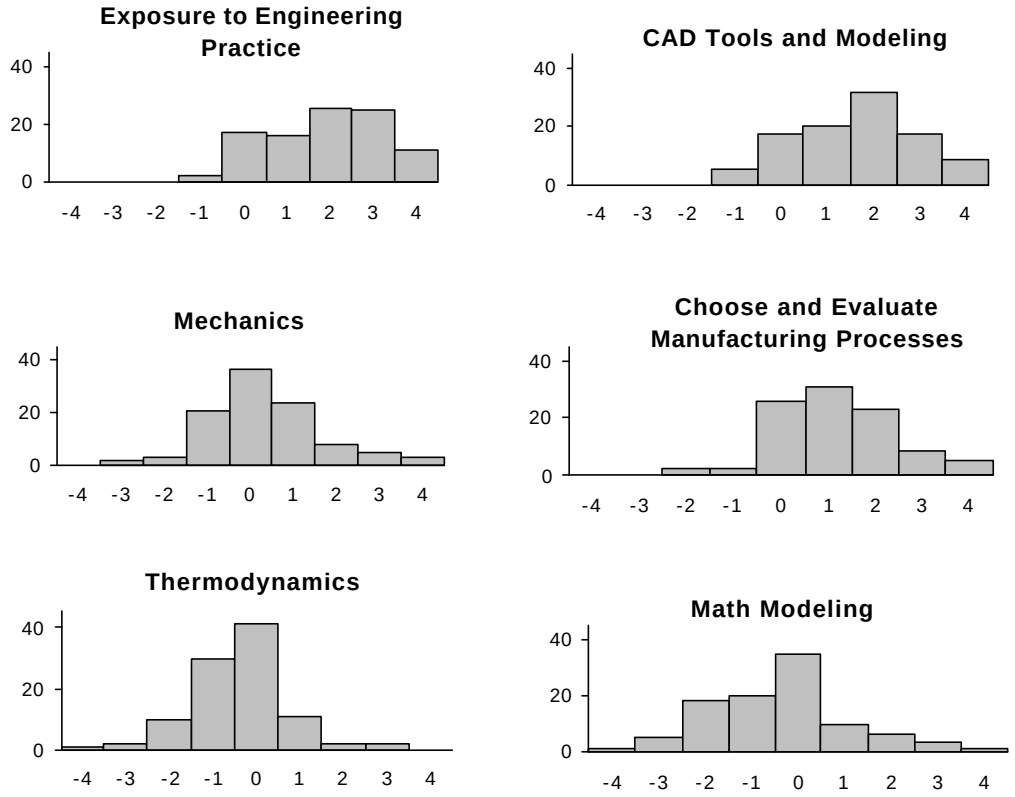

Fig. 3. Typical Shortfall Histograms - Alumni Survey Results
(Shortfall = ME Importance - UB ME Importance) Vertical axes are in percent.

Our present survey data tend to show that our student customers would like more coverage of many topics but do find that the more traditional sciences and technical areas are best covered. Our coverage of applied areas is less satisfactory with areas such as manufacturing, product design and computer-aided-design tools clearly needing more attention. One of the more interesting developments is that students particularly appreciate the importance of some of the "softer" areas. The ability to work in teams, communication skills, professionalism and ethics are student concerns. Students would also like more exposure to engineering practice and the development of engineering judgement. Interestingly, conversations with student focus groups indicate that better integration of practice and judgement issues into coursework may be more important than additional major projects or internship experiences.

6. References

[1]. Mann, C. R., "The Professional Demand", English and Engineering, Edited by Aydelotte, F., pp. 131-139, McGraw-Hill, New York, 1917.

[2]. "Briefings – America's Best Colleges", ASEE Prism, p. 10, February 2000.

[3]. Wallace, J.B., "The Case for Student as Customer", Quality Progress, pp. 47-51, February 1999.

[4]. Johnson, V.R., "Ask and Ye Can Assess", ASEE Prism, pp. 25-28, October 1998.

[5]. Hazelrigg, G., "Should We Question Questionnaires", ASEE Prism, pp. 14-15, February 1999.

[6] Grose, T.K., "Survival of the Fittest", ASEE Prism, pp. 13-16, May 1999.

[7]. Grose, T.K., "Re-engineering in Germany", ASEE Prism, pp. 28-30, March 2000.

[8]. Ragland, K., "A Message From the Chair", Mechanical Engineering Department Newsletter, University of Wisconsin – Madison, November 1997.