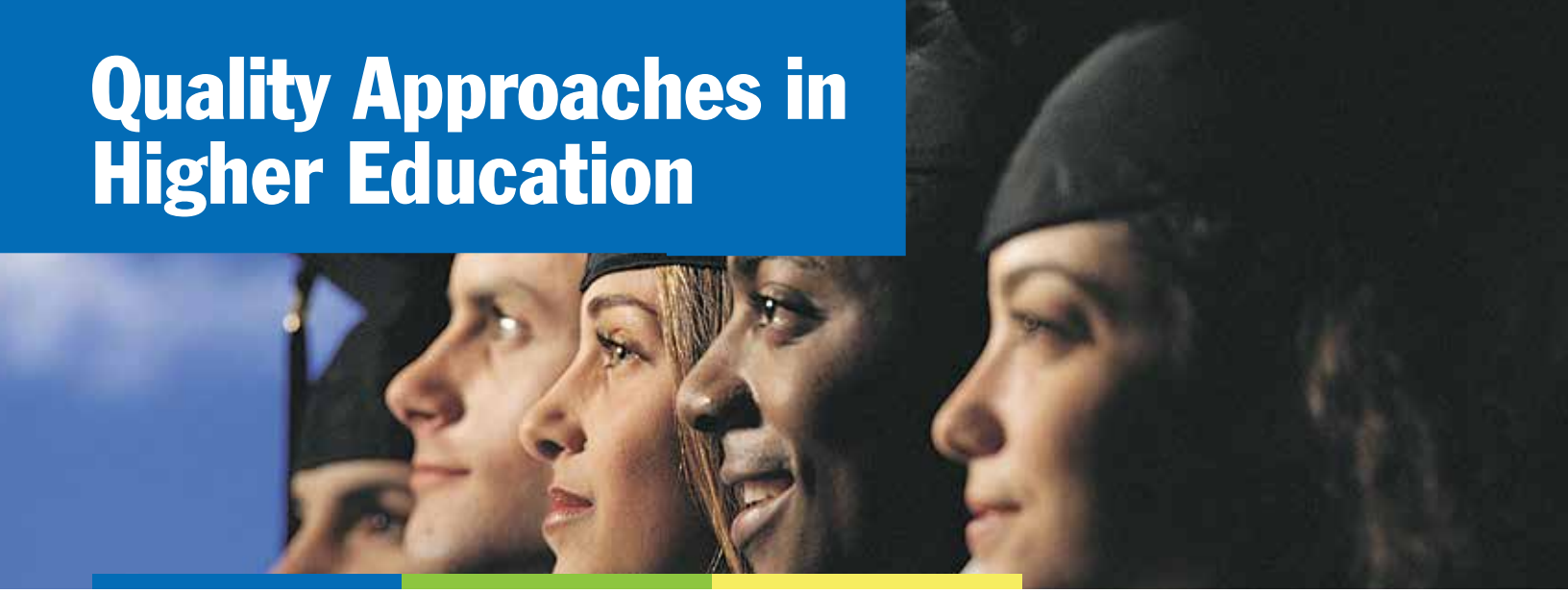
Quality Approaches in Higher Education



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IN THIS ISSUE:

Editor's note: This issue of *Quality Approaches in Higher Education* is focused on STEM education and partnerships among universities, industry, and government that enhance and provide experiential learning to STEM and engineering majors. This issue celebrates the ideas and planning behind the upcoming ASQ Education Division's Advancing the STEM Agenda Conference, co-sponsored with Grand Valley State University's Seymour and Esther Padnos College of Engineering and Computing on June 3-4. Significantly, the theme of the conference is "Collaboration with Industry on STEM Education." We asked Dean Paul Plotkowski to introduce this issue with a commentary on the engineering program at Grand Valley State University and the collaboration it has with industry. We further highlight advances in STEM learning, education, leadership, and collaboration with articles from NASA's Langley Research Center, The Ohio State University, and Southern Illinois University Carbondale. Together, these articles represent different and critical perspectives on how the STEM agenda is impacting STEM programs to develop better prepared professionals.

—Cindy P. Veenstra, special issue editor

The Journal That Connects Quality and Higher Education

Quality Approaches in Higher Education (ISSN 2161-265X) is a peer-reviewed publication that is published by ASQ's Education Division, the Global Voice of Quality, and networks on quality in education. The purpose of the journal is to engage the higher education community in a discussion of topics related to improving quality and identifying best practices in higher education, and to expand the literature specific to quality in higher education topics.

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GUEST COMMENTARY

Real-World Engineering Education: The Role of Continuous Improvement

Paul D. Plotkowski

Recently, the National Academy of Engineering (NAE) recognized 29 undergraduate engineering programs in the United States as "Exemplars of Real-World Engineering Education." This recognition was the result of a project addressing classic concerns about engineering education. Mark Papermaster, senior vice president and chief technology officer, AMD and one of the leaders of this project, explained the need for "real-world experience" in the engineering workplace as part of an engineer's education:

> "Historically, engineers have received excellent technical education, but have generally lacked formal training in the additional skills required to succeed in today's globally connected, rapidly evolving workplace. Young engineers need to be taught how to think independently, communicate clearly and adapt to change to become leaders in the global marketplace." (NRC, 2012, p. 3)

In recognizing the engineering education exemplars, the NAE report, *Infusing Real-World Experiences into Engineering Education,* explains the aim of the report and exemplar recognition:

> "The aim of this report is to encourage enhanced richness and relevance of the undergraduate engineering education experience, and thus produce better-prepared and more globally competitive graduates, by providing practical guidance for incorporating real world experience in US engineering programs." (NRC, 2012, p. 2)

This is further summarized by Charles Vest, president, National Academy of Engineering, as:

> "The basic idea is to create an engineer who has deep, strong, up-to-date technical education and the experiences that wrap around that to enable him or her to work in industry, to work across geographical boundaries, to work with people from totally different professional fields." (NRC, 2012, p. 4)

I am proud to report that the engineering program at Grand Valley State University (GVSU) was named as one of the NAE Exemplars in recognition of our approach to undergraduate engineering education. This approach includes an interdisciplinary foundation, highly integrated cooperative education, extensive use of design and build-oriented courses with extensive laboratory components, and a highly successful industry-based, interdisciplinary capstone project experience. Of equal significance is the fact that the engineering program at GVSU was first established and continues to be guided by the principles of continuous improvement.

GVSU is located in the greater Grand Rapids area of West Michigan. This is a community with an extensive and very diverse industrial base. The top 20 employers in this region are in 19 different industry sectors.

In the early 1980s, GVSU was approached by a substantial group of industry leaders with the request to introduce an engineering program. They recognized that the area was underserved in the number of engineering graduates, and that the graduates available did not have many of the essential skills and abilities expected of entry-level engineers in our contemporary regional industries.

The leadership of GVSU agreed to take on this task via an approach that was typical of industry, but very rare in education. The university established a project team of faculty

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and practicing engineers to define the requirements of local industry and to draft a proposal for an academic program that would address those requirements and ensure that the program maintain currency and relevancy.

The results of that effort provided the foundation for the engineering programs that GVSU offers today. The fundamental principles upon which these programs are based include:

- Engineering graduates cannot be prepared in only the theoretical elements of engineering.
- Contemporary engineers require a strong interdisciplinary background as an "engineering generalist" as well as depth in their engineering specialty area.
- A contemporary engineering education must integrate strong design and technical content with an equally strong liberal arts and sciences foundation.
- Prior to graduation, engineering students must have substantial "hands-on" experience in designing and fabricating their designs.
- Prior to graduation, engineering students need to develop the skills to be effective in an organization, in communication, and in dealing in team environments.

It was quickly realized that:

- It is not possible for any academic institution to provide this type of education in isolation.
- Program evolution and then maintaining currency (continuous improvement) would require frequent and regular communication and feedback between the university, employers, and alumni.
- This approach could only be accomplished through a true and sustainable collaboration between the university, our industrial partners, and our alumni.

The program that was developed, and is still the foundation of our current programs, included several key elements:

- Highly integrated cooperative education for all engineering students that provides a full year of industry experience prior to graduation.
- A highly common first two years that integrate engineering design and science topics throughout and provide a broad foundation across engineering disciplines and preparation for the co-op program.
- Extensive use of laboratory experiences, with more than two thirds of the engineering courses having formal labs.
- A common, interdisciplinary capstone senior project.

GVSU's continuous improvement efforts are well supported by a unique approach to cooperative education that includes:

- A preparation course that involves not only instructors from the engineering faculty and our career services office, but also makes extensive use of industry representatives and alumni (drawn from the advisory board that has evolved from our original planning working committee).
- During the co-op semesters of full-time work experience, students have academic as well as work assignments and a faculty supervisor as well as the industrial work supervisor. The faculty supervisor meets with the industry supervisor and the student each semester.
- Assessments are completed by the industry supervisor, the student, and the faculty supervisor each semester. These assessments speak directly to the student's preparation and performance as well as the quality and contribution of the work experience.

This approach has established one of the foundational pillars of our continuous improvement process (nearly two decades before either ABET or the regional accreditation associations implemented similar expectations). The "in-process" feedback that is received each semester provides a rich data set for formal assessment of the elements of our curriculum content, lab experiences, design experiences, facilities, etc. and how these match with current industry expectations.

Perhaps more importantly, however, is the relationship element that this approach has produced. The frequent and regular interactions between the faculty, the students during their work semesters, and the industry supervisors has created a unique dynamic. It has become a highly productive ongoing dialog that has generated true ownership of the programs and the continuous improvement process by the faculty, students, employers, and alumni.

A few of the improvements that have resulted from this very interactive relationship include:

- Frequent curriculum review and revision to remain responsive to the needs of industry and the students.
- A vastly expanded use of project-based learning in a wide variety of engineering courses (frequently projects from industry).
- Regular review and updating of the hardware and software tools utilized at the university to reflect (to the extent possible with such a broad industry base) industry practices.
- The addition of online instruction modules during co-op semesters that address topics such as project planning, engineering economics, and professional ethics.
- Use of industry-based and funded senior capstone projects.
- The creation of the Sebastian Endowed Chair in Engineering Cooperative Education. The duties of this position include leading our assessment efforts.

- The introduction of additional engineering programs that are in high demand by local employers, including emerging areas such as biomedical engineering, alternative and renewable energy, nanotechnology, product design and manufacturing engineering, and computer engineering that complements traditional strengths in electrical engineering and mechanical engineering.

The industry-based senior project program is a major hallmark of the GVSU engineering education program. These are highly interdisciplinary in content and team make up and provide an additional eight months of industry-based experience for the students. Each of these projects has an industry sponsor who is asked to treat the team as they would a custom engineering design house. As such, the process includes industry standard design proposals, design reviews, sign-off procedures, etc. Again, just as in the co-op program, there is systematic assessment by the faculty supervisors, the industry sponsors, and the students themselves. This provides significant and invaluable "end-of-process" feedback to our continuous improvement process. The technical content of these projects includes designing, building, testing, and delivery of working products, automation systems, testing systems, etc.

Employers need professionals with strong technical, critical thinking, interpersonal, and communications skills. Feedback from employers and alumni alike lead us to believe that the university-industry partnership approach, embedded in a strong liberal education foundation that is utilized by GVSU, is very successful in producing such engineering graduates. This is consistent with the stated GVSU mission of *"Educating students to shape their lives, their professions, and their societies."*

Reference:

National Research Council (NRC). (2012). *Infusing real world experiences into engineering education.* Washington, DC: The National Academies Press.

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