

The International Journal of Engineering Education

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Part I

Special Issue on Assessment (1)

Guest Editor: Gloria Rogers

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| M. Liu, P-F. Chang, A. M. Wo,
J-Y. Yen, Y-B. Yang and C-H. Wei | 854–863 | Quality Assurance of Engineering Education through Accreditation of Programs in Taiwan |

The number of universities in Taiwan has increased enormously over the last ten years; this has raised concerns over the quality of the engineering programs. In 2003 the Institute of Engineering Education Taiwan (IEET) was established, to ensure quality control of the programs via outcomes-based accreditation. This paper describes key elements of IEET, a provisional signatory to the Washington Accord, and the lessons learned in the application of the scheme. Currently, nearly a quarter of all four-year engineering programs have participated in accreditation. Work in progress includes the fine-tuning of the accreditation process and accreditation of master's degree programs beginning in 2007. The work of IEET should help other economies that are in the process of establishing their own accreditation systems.

Keywords: accreditation; quality assurance; evaluation; Taiwan

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| A. C. Estes, R. W. Welch and S. J. Ressler | 864–876 | Program Assessment: A Structured, Systematic, Sustainable Example for Civil Engineers |
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As the outcomes-based accreditation process has continued to evolve since its implementation six years ago, the standards for program assessment and continuous improvement are progressively being raised and many schools struggle with what is required. This paper offers an example of a structured, systematic, sustainable assessment program implemented by the civil engineering program at the United States Military Academy. The process is compatible with the university assessment process and has eight years of documented results. The assessment includes fast loop and slow loop cycles that accomplish very different things. Other features include standardized course assessments, embedded indicators, performance measures for all outcomes and objectives, advisory boards, feedback from all constituencies, faculty involvement, and closing of the feedback loop.

Keywords: course assessments; embedded indicators; performance measures; outcomes; objectives; advisory boards; constituencies; feedback loop

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| Z. A. Yamayee and R. J. Albright | 877–883 | Direct and Indirect Assessment Methods: Key Ingredients for Continuous Quality Improvement and ABET Accreditation |
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The new accreditation criteria, better known as ABET EC 2000, require that each program 'must have an assessment process with documented results.' Furthermore, a white paper by the Engineering Accreditation Commission's Executive Committee states, 'The assessment process should include direct and indirect measures and does not rely only on self-report surveys and evidence that the material is 'covered' in the curriculum.' This paper presents: (a) an overview of an assessment process to make engineering programs ABET accreditation compliant; (b) assessment methods that are used to collect data, interpret them, and utilize the results to improve engineering programs; (c) a process to choose the appropriate mix of direct and indirect assessment methods/instruments, and (d) implementation of assessment methods to an electrical engineering program. As an example, the paper presents a sample of recent changes that have led to improvements based on program assessment of the University of Portland School of Engineering electrical engineering program.

Keywords: accreditation; direct assessment; indirect assessment; outcomes assessment; continuous quality improvement (CQI); performance rubrics or criteria.

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| L. A. Shay, K. L. Huggins, J. R. S. Blair
and B. L. Shoop | 884–892 | Approaches to Increasing the Efficiency of an Effective Outcome Assessment Process |
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We use the framework of the Electrical Engineering Program and the Computer Science Program within the Department of Electrical Engineering and Computer Science at the U.S. Military Academy at West Point to describe a systematic process to increase efficiency in assessing program outcomes while maintaining effectiveness of the assessment results. We describe two systems used in the Electrical Engineering and Computer Science Programs to reduce the number of embedded indicators and therefore the time required by faculty to accomplish program outcome assessment. We then propose an extension of the Computer Science system to formalize faculty communications to ensure the student learning model facilitates program outcome achievement. Finally, we propose a cross-correlation matrix used by both programs that eliminates redundancy of assessing a program multiple times for different accreditation sources. These approaches not only effectively monitor graduate abilities, but also provide mechanisms to monitor individual course contribution and serve as troubleshooting instruments for deficient outcome results. This process can also be extended to satisfy other institutional assessment requirements and encourages increased faculty interaction which results in improved course linkages.

Keywords: ABET accreditation; outcome assessment

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| K. J. Reid and E. M. Cooney | 893–900 | Implementing Rubrics as Part of an Assessment Plan |
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Student assessment of technical skills in engineering and engineering technology is relatively straightforward. Problems typically have right or wrong answers, and assessing students' ability to effectively solve problems, design systems and evaluate designs can be quantitatively measured. Assessing non-technical skills (sometimes called 'soft skills') such as the ability to function in teams, communicate effectively or understand ethical responsibilities [1] can be a challenge for faculty in engineering or engineering technology as these more qualitative characteristics don't necessarily involve right and wrong answers. These characteristics have traditionally been measured by engineering technology faculty the same way they are evaluated in the workplace: 'I know it when I see

it'. While this method may lead to a letter grade ('That presentation was pretty good—I'll give it a B'), this is not truly assessing the student, the presentation or the degree program. Meaningful assessment of the student or of the presentation should include constructive feedback, and assessment of the degree program should include qualitative measurement of the necessary characteristics of a good presentation. Good assessment practices also recommend that data be 'triangulated', or measured in more than one way. The assessment plan for the Electrical and Computer Engineering Technology programs at IUPUI include the development and use of rubrics for assessment of student performance and to supply meaningful and consistent feedback to students.

Keywords: ABET, assessment, assessment plan, engineering technology, rubrics

T. Flateby and R. Fehr

901–905 Assessing and Improving Writing in the Engineering Curriculum

Two essential higher education outcomes, the ability to write effectively and the development of the reasoning skills necessary for effective writing, are both specifically addressed by ABET and highly sought by employers. Since writing is typically taught in courses outside the engineering college, students often lack the ability to write and reason effectively within the discipline. An innovative system is described to close the loop on writing improvement by comprehensively assessing writing effectiveness and providing a means of strengthening the weak areas.

Keywords: CLAQWA; cognitive skills; critical thinking; peer review; writing improvement

D. Riley and L. Claris

906–916 Developing and Assessing Students' Ability to Engage in Lifelong Learning

Many modes and definitions of learning ensure that learning will not be lifelong, cultivating a dependence on the expertise of a faculty member who 'downloads' knowledge to students without much interaction or negotiation in the learning process. By fundamentally altering the way we understand learning from something that is to be remembered to something that is to be engaged with, empowering students to be responsible, self-directed and intentional learners and creating a new, question-centered process, we can open up new possibilities for lifelong learning in which assessment becomes integrated as an inherent part of the learning process and not simply something that comes at the end to measure learning.

Keywords: lifelong learning; blogs; reflection; relational learning; self and integrated assessment; liberative pedagogies

W. Lefevre, J. W. Steadman, J. S. Tietjen, K. R. White and D. L. Whitman 917–925 Objective and Quantitative Outcomes Assessment Using the Fundamentals of Engineering (FE) Examination

Over more than a decade, the authors have developed considerable experience in using the Fundamentals of Engineering (FE) Examination for objective and quantitative outcomes assessment. Results from the FE Examination are now sent directly from the National Council of Examiners for Engineering and Surveying (NCEES) to the institution and a variety of methods have been developed to analyze this data on a subject-by-subject basis. Three specific approaches to data analysis are presented: the percentage-correct method, the ratio method, and the scaled-score method. Each has its own pros and cons with regard to its use. Institutions can set student performance standards for individual topic areas, select one or more of the methods to graphically analyze the data, and then make decisions regarding instructional effectiveness in each topic area.

Keywords: assessment; outcomes; Fundamentals of Engineering exam

J. A. Marin-Garcia, C. Miralles and M-P. Marin

926–935 Oral Presentation and Assessment Skills in Engineering Education

This study examines the possibilities of including students in the assessment process and the conclusions drawn from the experiences of the academic year 2004–05. The fieldwork focuses on examining the reliability of the marks given by students in relation to those given by the lecturer. Similarly, the marks given by the subject lecturer are examined with those assigned by four external markers. In each presentation the assessment of several markers is also studied, whether they are students or lecturers. The results obtained seem to indicate that students can be adequate markers for their peers' oral presentations. Also in their assessments, few significant differences are seen from those suggested by the subject lecturer.

Keywords: oral presentations; agreement among markers; peer assessment; reliability of the assessment

Part II

Contributions in: Engineering Education Research, Computer Studies, Industrial and Systems Engineering, Bioengineering, Biomedical Engineering, Manufacturing Engineering, Electrical and Electronic Engineering

K. W. Jabllokow

936–954 Developing Problem Solving Leadership: A Cognitive Approach

The difficulty and complexity of today's problems, in their catalytic progression, mandate the need for engineers who are both advanced problem solvers and leaders within their profession. Their knowledge and skill must extend beyond the traditional technical subjects to an understanding of problem solvers themselves, alone and in teams, and to the facilitation of those teams—a task that demands even more insight and practical expertise. This paper describes a cognitive framework for problem solving (founded on Kirton's Adaption–Innovation theory) that supports this view, and the new curriculum based upon that framework that was initiated and developed at Penn State University to help address these needs. The curriculum is composed of a core module of three courses that focus on fundamental concepts and principles of problem solving, progressing from the individual problem solver to problem solving teams and culminating in problem solving leadership. Several supporting courses are also offered or are under development (including courses on invention and problem solving ethics), and additional enhancements (including on-line delivery) are underway. The design, implementation, and evaluation of this program are discussed here, as well as our exploration and testing of the underlying theory based on the assessment of students' problem solving styles.

Keywords: problem solving; leadership; creativity; diversity; cognitive style; engineering education

R. Parkhurst, B. M. Moskal, J. Lucena, G. L. Downey, T. Bigley and S. Elber

955–964 Engineering Cultures: Comparing Student Learning in Online and Classroom Based Implementations

Engineering Cultures is a course that was developed primarily to prepare United States' engineering students to effectively collaborate and communicate with engineers from other countries. In order to reach a broad audience, two versions of this course have been developed and offered: an online and an in-class version. The schools participating are Virginia Polytechnic Institute (VT) and the Colorado School of Mines (CSM). In this article, the results of an investigation that compares the learning outcomes and student perceived usefulness of the two designs are reported. The assessment instruments used in this investigation were multiple-choice content pre and post tests, essay pre and post tests, and a self-report end of semester survey. Differences in learning between the two courses were not detected on the pre to post multiple-choice content test; however, differences were detected, with in-class students displaying

greater increases, between the pre and post essay exam. This indicates that the learning outcomes measured through the essay exam, which included analysis and synthesis, were better supported through classroom based instruction than the online instruction.

Keywords: assessment; global engineering; on-line learning

W. E. Eder

965–979 Self-Starting Graduates—An Impression of Industry’s Needs

Industry has some perceived needs with respect to graduates. Here, the scope of Design Engineering is outlined, and compared with the more artistic and management aspects. Engineering designers follow some principles in their work, and display expertise and competence when trying to solve design problems. Formalizing methods should prove useful from a safety/rational operating approach. These methods are best derived from Engineering Design Science, using the model of a general transformation system as the basis. Engineering students should learn such rational operation and the theory on which the methods are based.

Keywords: design engineering; engineering design science; education

A. Zeid and S. Kamarthi

980–989 Best Teaching Practices in Database Courses for Engineering Students

The National Academy of Sciences recommends adapting engineering education to the new century. One of its recommendations is that engineering schools introduce interdisciplinary learning at the undergraduate level. An area that lends itself well to interdisciplinary learning is information technology (IT). Sample IT courses are Computers and Information Systems and Databases. Teaching IT courses to engineering students is more challenging than traditional engineering. Here we focus on teaching a database course in a mechanical and industrial engineering curriculum, and on the best practices to teach such a course. We make a threefold contribution. First, we discuss the obstacles to teaching IT courses in engineering. Second, we provide a model to teach database courses to engineering students. Third, we offer a blueprint to engineering educators who are interested in or thinking about introducing such courses in their curricula.

Keywords: Engineering education; IT; databases; productive pedagogy; globalization

Z. O. Abu-Faraj

990–1011 Bioengineering/Biomedical Engineering Education and Career Development: Literature Review, Definitions, and Constructive Recommendations

Bioengineering/Biomedical engineering education has evolved since the late 1950s and is progressing in leading academic institutions around the world. Today, bioengineering/biomedical engineering is considered to be one of the most reputable fields within the global arena, and will probably be the primer for any future breakthroughs in medicine and biology. This paper is intended to provide a detailed study of career development in Bioengineering/Biomedical Engineering, together with a set of strategies and recommendations to be pursued by individuals and/or entities seeking to plan and design careers and/or curricula in this field. The paper aims to address the international student who is considering bioengineering/biomedical engineering as a career, with an underlying emphasis on students from developing and transitional countries where career guidance is lacking. The paper is also addressed to academic institutions of higher education, ministries of higher education, and other governmental agencies, mainly within such countries, who intend to launch or reform their bioengineering/biomedical engineering curricula. A comprehensive undergraduate curriculum that has been recently implemented at the American University of Science and Technology, Beirut, Lebanon, is presented here as a prototype of a modern well-developed curriculum in Biomedical Engineering. This program is considered to be one of the regional premier curricula in Bioengineering/Biomedical Engineering. The paper also provides a thorough review of the literature followed by a comprehensive definition of the field and its subdivisions.

Keywords: biomedical engineering; bioengineering; education; career development; curriculum

A. L. Carrano, M. E. Kuhl and M. M. Marshall

1012–1017 Integration of an Experiential Assembly System Engineering Laboratory Module

Curriculum integration and multidisciplinary studies have become key issues in improving engineering education. This paper presents the design and implementation of laboratory material, based on active and collaborative learning, which integrates three traditionally independent courses in the industrial engineering curriculum: Manufacturing Engineering, Ergonomics, and Simulation, utilizing an experiential assembly system. This collaborative project incorporates a team-based learn-by-doing approach to the theoretical knowledge in these subject areas. These components are implemented in a dynamic and reconfigurable environment in which the students are given the opportunity to contrast their design against the working reality. The preliminary results of this project are discussed along with the impact on the curriculum.

Keywords: active learning; collaborative learning; assembly laboratory

E. Gómez, J. Caja, C. Barajas, P. Maresca and M. Berzal

1018–1030 Development and Application of a New Interactive Model for the Teaching of Manufacturing Engineering Technology

The object of this paper is to outline the interactive teaching model developed by the education innovation group ‘New Teaching Methodologies in Mechanical and Manufacturing Engineering Technology’ of the Polytechnic University of Madrid. The aim of the model is to teach the subject of Manufacturing Engineering Technology for the Mechanical Technical Engineering degree course. It is based on a new face-to-face methodology that we have called DE-learning (driven electronic learning) in which theoretical teaching and laboratory teaching are combined in a collaborative environment, managed through the developed software that combines: theoretical lessons, solved practical examples, exercises, bibliographical references, Webpage links and self-assessment tests. [Here the term ‘collaborative’ is used to describe the teaching methodology whereby student-to-student and student-to-teacher relationships take place in the learning process and not exclusively through a one way teacher-to-student relationship.] The teaching of this new model is ‘driven’ under the guidance and supervision of a professor, in an educational environment with no formally taught classes. Students themselves can decide on the pace at which they learn, the resources used, the definition and carrying out of practical exercises and whether they wish to form collaborations among themselves during study time. The fundamental advantage of this model is its efficiency in optimising learning time, given that: (a) all the necessary resources are accessible to the student through electronic teaching support, (b) the laboratory practical classes take place in the same environment, as they are combined and connected to the theoretical concepts without any break in continuity, and (c) students’ problems can be resolved in a personal and immediate way by the professor. In addition to this, other advantages have emerged that are equally relevant in the engineering training of the students: the development of better communication skills as well as their skills and abilities, motivation, creativity and increase in confidence and confidence in their decisions. The efficacy of this new teaching model has been confirmed through the academic results attained by the students during the 2006/07 academic year, which are presented in this paper.

Keywords: driven electronic learning; manufacturing engineering; games; learning styles

R. García-Gil, J. M. Espí and J. Castelló 1031–1039 Computer Simulation of Power Factor Corrected Circuits

An efficient method for simulating three-phase power factor corrected (PFC) converters, using MATLAB/SIMULINK[®], is applied for the education and training of undergraduate students in power electronics. This simulation method requires a previous mathematical analysis of the proposed converter to obtain the SIMULINK commutation model, which allows students to acquire a better knowledge of the circuit. Two PFC rectifiers, i.e. voltage source (VSR) and current source (CSR) rectifiers, are analysed and simulated. Two different PFC controllers are considered: a sinusoidal-PWM (SPWM) controller for the VSR and the space vector modulation (SVM) technique for the CSR. With these SIMULINK models, students can carry design the controller and validate whether or not their closed loop system meets the prescribed performance requirements.

Keywords: electrical engineering education; space vector modulation; power factor correction; voltage source rectifier; current source converters

J. Dudrik and P. Bauer

1040–1048 New Methods in Teaching of Power Electronics Converters and Devices

In this paper traditional and state-of-the-art educational methods and experience in teaching power electronic converters and power electronic devices to undergraduate students are described. The main focus is on ways of improving study using e-learning methods. Interactive screens with animations created for illustrating the features of power converters and devices are presented.

Keywords: E-Learning; power electronics converter; power semiconductor devices