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Contents

M. S. Wald 767 Editorial

Engineering Education Policy and Research

P. David Fisher, James S. Fairweather and Marilyn J. Amey 768–776 Systemic Reform in Undergraduate Engineering Education: The Role of Collective Responsibility

The aggregate of individual faculty member accomplishments—however well done or prolific—seldom fulfills all collective curricular and instructional obligations of an academic program or department. The purpose of this paper is to help those attempting reforms in undergraduate engineering education to better understand the array of systemic factors likely to affect the long-term success of their efforts. We identify the reasons underlying the difficulty in achieving the necessary level of collective responsibility, describe the tensions within academe that affect an individual faculty member's contributions to collective responsibilities and discuss strategies that can be used to meet these collective obligations.

Whitey Brewer and Mel I. Mendelson 777–787 Methodology and Metrics for Assessing Team Effectiveness

This paper describes a new systematic methodology and measurements for assessing the effectiveness of engineering/business student teams. This new methodology is unique because it predicts team effectiveness. Our approach replaces the traditional methods of indirect surveying and interviewing with direct surveys and systematic exercises designed to measure team effectiveness. Effectiveness was defined and evaluated using three outcomes: creativity, collaboration and productivity. These three outcomes were measured using applied psychology metrics. By quantifying creativity, collaboration and productivity, this new assessment methodology provided a more objective way of measuring effectiveness. The outcomes were equally weighted to calculate an effectiveness rating. The teams that were faculty-selected and properly coached were confirmed to be at least twice as effective as those that were student-selected and received little coaching.

Roxanne Zolin, Renate Fruchter and Raymond E. Levitt 788–798 Realism and Control: Problem-Based Learning Programs as a Data Source for Work-Related Research

Problem-based learning (PBL) is a pedagogical methodology that presents the learner with a problem to be solved to stimulate and situate learning. This paper presents key characteristics of a problem-based learning environment that determines its suitability as a data source for work-related research studies. To date, little has been written about the availability and validity of PBL environments as a data source and its suitability for work-related research. We describe problem-based learning and use a research project case study to illustrate the challenges associated with industry work samples. We then describe the PBL course used in our research case study and use this example to illustrate the key attributes of problem-based learning environments and show how the chosen PBL environment met the work-related research requirements of the research case study. We propose that the more realistic the PBL work context and work group composition, the better the PBL environment as a data source for a work-related research. The work context is more realistic when relevant and complex project-based problems are tackled in industry-like work conditions over longer time frames. Work group composition is more realistic when participants with industry-level education and experience enact specialized roles in different disciplines within a professional community.

Vladimir Hubka and W. Ernst Eder 799–809 Pedagogics of Design Education

Pedagogics, a theory and strategy for teaching, is an essential background which can lead to learning. Difficulties of design engineering, and therefore of learning to design in engineering are outlined. Engineering design education aims to bring students to various competencies. The parameters for engineering design education are related to the teaching system. They are outlined with reference to several important questions, which refer to the learners (students) and to the complete teaching situation, including the teachers (and their knowledge and competencies), teaching materials (e.g. books, computers), information on teaching/learning, organization, and environment.

Shari J. Kimmel, Howard S. Kimmel and Fadi P. Deek 810–817 The Common Skills of Problem Solving: From Program Development to Engineering Design

The introduction of engineering design in the first year of the curriculum has become commonplace in order to provide students with early experiences in engineering principles and exposure to real-world applications. Many different approaches to the development and implementation of these courses are used but regardless of the method or specific emphasis, students enrolled in engineering design classes are expected to be problem solvers and to communicate effectively, both verbal and written. We have adapted and integrated a problem-solving and program development methodology originally used in a computer science environment to an introductory engineering design class which helps beginning engineering students develop these important skills. We have also conducted a base-line study in this engineering design course to evaluate this methodology and its impact on students' problem-solving abilities, skills, knowledge, and attitudes in a first-year course on engineering design.

Andreas P. Christoforou, Ahmet S. Yigit, Mohammad D. Al-Ansary, Faridah Ali, Haitham Lababidi, Ibrahim S. Nashawi, Aziz Tayfun and Mohamed Zribi 818–827 Improving Engineering Education at Kuwait University through Continuous Assessment

The initial stages of development and implementation of assessment plans for the engineering programs at Kuwait University are presented. The plans are based upon an integrated set of strategies aimed at: establishing and maintaining a structured process that translates educational objectives into measurable outcomes and specifies feedback channels for corrective action; providing necessary assessment training; creating an assessment toolbox, and identifying and reviewing key institutional practices to ensure that they are aligned with the assessment process. Preliminary results from pilot implementations are also presented. Improvements are already evident in the areas of teaching effectiveness, assessment of student learning, and involvement of all the constituents.

Larry L. Howell, Gregory M. Roach, D. Cecil Clark and Jordan J. Cox 828–835 Use of Explicit Instructional Objectives to Achieve Program Outcomes and Facilitate Assessment: A Case Study

This paper describes an approach, based on common practices, for explicitly defining instructional objectives for university courses, mapping educational activities to those objectives, and using assessment tools that measure student proficiency in attaining the objectives. The advantages of implementing the approach are enhanced quality of instruction, increased student learning, and improved assessment. A case study in engineering demonstrates that data from the assessment can be used in several ways, including improvement of course instruction, supporting changes to educational activities, and supporting program objectives and accreditation. Student evaluation data for two instructors over several terms demonstrates that student perception of the course improved after implementing explicitly defined objectives.

Krista Donaldson and Sheri Sheppard 836–846 E-pals to Enhance Mechanics Learning

The E-pal Program linked undergraduate Kenyan students with practicing engineers, researchers, and other technical North American professionals in an e-mail 'pen pal' dialogue for the duration of an introductory fluid mechanics course. The Program aimed to counteract the dearth of resources at the Kenyan university by utilizing the Internet to facilitate the central three goals of the program: (1) to demonstrate to students applications of taught concepts and material, (2) to expose students to the range of sub-disciplines, careers, and engineering problems within fluid mechanics, and (3) to promote the use by students of the Internet in an environment where its value had not previously been demonstrated. The Program was found to be popular with student and practicing engineer participants and highly successful in achieving its goals. This paper gives an overview of the Program and its context within the Kenyan academic environment, delineates its successes and lessons learned, and discusses pedagogical value and applicability to other courses and situations with recommendations for implementation.

D. Vassalos, B. S. Lee and P. G. Sayer 847–854 A Rational Method of Project Selection by Post-Graduate Students

A critical part, and sometimes the whole, of any postgraduate programme is the undertaking by the students of a project. One of the most crucial phases in this undertaking is the project selection. It is also this phase where students, invariably, receive no formal training and this could delay the whole undertaking substantially; in some cases leading to premature abandonment of the project or the degree programme altogether. This paper attempts to fill this gap by providing a framework and a methodology that would enable the student to develop a greater comprehension of the problem and to make a rational choice. The framework is based on decision analysis and comprises a two-stage procedure: (a) technical uncertainty and dominance screening and (b) the application of SMART (Simple Multi-Attribute Rating Technique). A hypothetical case is considered to illustrate the methodology and the results are discussed.

Kin Wai Michael Siu 855–861 Cultural Studies in the Engineering Curriculum

Several studies concerning industrial design, technology and engineering learning have been conducted on students in Hong Kong. The findings indicate that the students are weak in problem finding (that is, the identification of needs or problems). The absence of cultural studies was found to be one of the main factors limiting the development of the level of insight and understanding needed to identify problems. All of this further limits the ability of students to exercise critical judgement in other learning activities. By reviewing the findings of the case studies in Hong Kong, this paper tries to point out that cultural studies should serve as one of the key foundations for engineering students to make critical judgements in their future educational endeavours and careers. This paper then discusses the importance of incorporating cultural studies in the engineering curriculum in a more organised and regular way instead of only as optional activities, and identifies key activities, contents and elements of cultural studies in the curriculum. In the last section, discussing Kissock's ten-stage decision-making model, this paper suggests how a more flexible and dynamic teaching and learning arrangement can be developed for cultural studies in the curriculum.

Mechanical Engineering

Timothy A. Philpot, Nancy Hubing, Ralph E. Flori, Richard H. Hall, David B. Oglesby and Vikas Yellamraju 862–873 Computer-Based Instructional Media for Mechanics of Materials

Computer-based instructional materials offer great potential for engineering education. Using readily available development software, sophisticated graphics and animations can be created to present engineering topics in ways that are not possible within the confines of the traditional textbook and lecture format. This paper presents examples of instructional media developed for the Mechanics of Materials course. These examples include lecture supplements, animated example problems, interactive example problems, interactive instructional learning tools, and games. Using animations, graphics, and interactivity, the instructional media is designed to engage and stimulate students, to effectively explain and illustrate course topics, and to build student problem-solving skills.

Dan Jensen, John Wood and Kristin Wood 874–884 Hands-on Activities, Interactive Multimedia and Improved Team Dynamics for Enhancing Mechanical Engineering Curricula

The focus in engineering education is moving from an emphasis on theory to a balance between concrete experiences and analysis. This paper reports on such initiatives made to the Mechanical Engineering curricula at the US Air Force Academy and at the University of Texas, Austin. In particular, these two institutions have been collaborating for the last four years to improve ME courses through new initiatives in three areas: 1) use of hands-on activities, 2) incorporation of interactive multimedia, and 3) new tools to improve team dynamics. The development, implementation and assessment for this project are described below, along with extensive references describing the details of each individual improvement. For example, we have quantitatively measured significant improvements in team performance for our design courses. We have also seen dramatic increases in student interest level in the machine design courses. Based on these results, specific suggestions on how these educational enhancements might be implemented at other institutions are given.

Tarsicio Beléndez, Cristian Neipp and Augusto Beléndez 885–892 Numerical and Experimental Analysis of a Cantilever Beam: a Laboratory Project to Introduce Geometric Nonlinearity in Mechanics of Materials

The classical problem of deflection of a cantilever beam of linear elastic material, under the action of a uniformly distributed load along its length (its own weight) and an external vertical concentrated load at the free end, is experimentally and numerically analysed. We present the differential equation governing the behaviour of this system and show that this equation, although straightforward in appearance, is in fact rather difficult to solve due to the presence of a nonlinear term. The experiment described in this paper is an easy way to introduce students to the concept of geometric nonlinearity in mechanics of materials. The ANSYS program is used to numerically evaluate the system and calculate Young's modulus of the beam material. Finally, we compare the numerical results with the experimental ones obtained in the laboratory.

Chemical Engineering

Adélio Mendes, Fernão D. Magalhães and Luis M. Madeira 893–901 Sucrose Inversion: An Experiment on Heterogeneous Catalysis

Illustration of heterogeneous catalysis concepts in laboratory courses is not usually simple or economical. For our undergraduate senior lab course we have developed an environmentally friendly experiment dealing with several aspects of heterogeneous catalysis, having in mind the use of readily available and relatively inexpensive equipment and chemicals on a compact setup, which students can safely

operate. The experiment deals with the acid-catalyzed sucrose inversion, performed in packed bed chemical reactors, where the catalyst is a cation-exchange resin in the H^+ form. An additional reactor is included for illustrating an enzyme-catalyzed system. The conversion achieved is determined using the Flow Injection Analysis technique.

Manufacturing Engineering

Anthony J. Vizzini

902-909 Design and Manufacture of Composite Prototypes

This paper details the development and implementation of a course on the design and manufacture of composite prototypes. The course is taught as a design elective resulting in student groups designing and demonstrating a manufacturing process to fabricate an actual composite prototype. The students are responsible for determining their own metrics in evaluating their manufacturing process. The paper identifies key learning points, and the course syllabus demonstrates the implementation of the learning kernels. Projects from the past seven years are itemized, and lessons learned are drawn from the cumulative experience. The course was developed at the University of Maryland to instruct undergraduate students about the manufacturing of composite structures by providing a hands-on design experience of a real-life composite prototype. The students are formed into teams and are responsible for developing a manufacturing process to produce a composite component. The students demonstrate the feasibility of their process by producing a prototype. The students conduct a preliminary marketing analysis and must conclude whether or not further pursuit of their manufacturing process is warranted. The course enhances the undergraduate design experience while training students in the science of composite manufacturing.