

Introduction and Overview

THE PAPERS in this special issue of the *International Journal of Engineering Education* represent much of the proceedings of Mudd Design Workshop II, 'Designing Design Education for the 21st Century', which was held on the campus of Harvey Mudd College in Claremont, California, on 19–21 May 1999. The papers have been revised and updated for journal publication. Supported by the GE Fund, Hughes Electronics and Harvey Mudd College, this workshop brought together design educators, researchers, and practitioners to focus on future directions for engineering design education. Participants spent two and one-half days discussing the design of engineering design education, in order to identify and propose key methods to improve engineering design education.

The workshop sessions were constructed to give *everyone* a chance to participate, to be heard as well as to listen. Workshop sessions were typically scheduled for two hours, starting with brief presentations by four panelists in each session, and concluding with moderated, open discussion. Panelists were asked to reflect on ideas and attitudes about things to be done in the future, rather than focusing on their own current research. The papers that appear here are (for the most part) the panelists' position. (Further details about the Workshop and its organization appear in Clive L. Dym (Editor), *Mudd Design Workshop II: Designing Design Education for the 21st Century*, Harvey Mudd College, Claremont, CA, 1999.)

The papers in this special issue are organized in themes that emerged as a result of our joint view of the entire corpus of the workshop presentations. Those themes are:

- **Key workshop themes and commitments:** Wesner has identified five key themes that emerged from the Workshop discussions:
 - a focus on *learning*, rather than *teaching*;
 - attention paid to the *humanist engineer*;
 - the importance of *assessment*;
 - a focus on projects and experiential learning;
 - the need to address *grading* in new ways.In addition, Wesner lists commitments made by many participants at the Workshop's final session.
- **'People' issues:** Three authors have put a personal, social face on engineering design. Faste argues that there is an enormous human challenge that engineers must meet as designers. Fonczak observes that engineering design requires knowledge, skill, and attitude, and that providing learning opportunities for all three attributes requires significant investment. Bender describes how German universities and engineering programs weave the social 'intangibles' of leadership, motivation, and communication into their design curricula.
- **Teams and collaboration:** Four papers highlight the importance of teamwork and present ways of improving collaboration and team effectiveness. Hirsch *et al.*, present a course model that integrates design and communication faculty into a single teaching team, while Kuhn discusses the benefits of creating a 'studio environment' for design work in which the critique of work by faculty, peers, and visiting experts is frequent. Taylor *et al.*, discuss the importance of faculty working as coaches to students on design projects and the likely need for faculty to be trained for this role. Finally, Delson describes the characteristics of effective teams.
- **Products and projects:** Eleven papers are presented here that discuss students engaged in projects to produce products. The first two papers set the stage: Harris gives an inspiring argument for projects and hands-on learning, even in theory-based courses, and Doecker overviews the product realization process. The next three papers are about freshman design work: Pionke *et al.*, illustrate how design projects can be integrated with engineering science concepts into the freshman year. Regan *et al.*, discuss freshman engaged in a term-long project that requires hardware creation. Little and King present criteria for selecting successful freshman projects, as well as for capstone course projects. The next four papers describe capstone design experiences that involve clients. Caenepeel and Wyrick discuss high performance teams and the need for coach training. Counce, Holmes, and Reimer give an overview of client-based projects in a chemical engineering course. Magleby *et al.*, present criteria for industrial project selection for their two-term capstone course, while Hyman proposes that the client-based projects worked on in the senior year be documented and integrated into subsequent freshman-senior level courses. The final two papers discuss ways of engaging students in design work in different contexts. Cannon and Leifer present a course model of how creativity and innovation can be learned in cross-cultural contexts, while Apfel and Jeremijenko present a graduate-level course model that integrates product design, business development, and team processes in product creation.

- **Science and systems for the design toolbox:** The nine papers in this section are about improving and expanding the engineer's design toolbox. Kurfess discusses a sophomore-level course that has mechanical engineering students working with electronics, computer software, and mechanical components to create design solutions. Fruchter presents a course model that has graduate students from architecture, engineering, and construction working together to design a building project. Lastly, Olson outlines a design course in material science that is based on a formalized design process. Wood describes the benefit of having students learn about decision theory as part of their design experience in school. He also comments on the trade-off between presenting students with 'realistic toy' projects, as opposed to 'toy real' projects. Lukasik and Erlinger take up this theme in their discussion of how to create opportunities for students to learn to work with complex systems. The papers by Linder and Flowers and by Sheppard discuss the need for engineers to ground design work in analysis, while noting that students are not necessarily facile with analytic modeling. The last two papers in this group describe the use of computer-based tools to assist in design work and learning: Arciszewski and Lakmazaheri discuss the use of tools to assist in structural design, while Briggs notes the integration of commercial CAD and CAE tools into engineering education.
- **Assessment:** These five papers present a top-down view of assessment and its role in the continuous improvement of engineering design curricula, courses, and projects. Yoshino draws an analogy between the design and assessment processes both in their origins and their theories. Phillips and Duron describe the outcome for one engineering department in the first round of assessment-driven accreditation visits by the Accreditation Board for Engineering and Technology (ABET). Shaeiwitz demonstrates another model of using capstone course projects to assess departmental curricula. Doepker draws parallels between departmental accreditation and continuous improvement of both capstone design courses and institutions. Finally, Feland and Leifer propose an assessment instrument that can be used to predict and assess the performance of teams in project-based design courses.

Clearly, this collection of papers represents a rich body of experience and knowledge that, we hope, can be brought to bear in support of design education with the same intelligence and vigor that the participants brought to Mudd Design Workshop II.

Finally, we want to acknowledge again the support of the remaining members of the Workshop's Advisory Committee: Steven J. Fenves, Carnegie Mellon University; Woodie C. Flowers, Massachusetts Institute of Technology; George A. Hazelrigg, National Science Foundation; Patrick Little, Harvey Mudd College; Gregory B. Olson, Northwestern University; John W. Prados, University of Tennessee; Jami Shah, Arizona State University; and John W. Wesner, Lucent Technologies. The Advisory Committee's involvement made Mudd Design Workshop II bigger, more exciting, and more challenging than its founding (1997) predecessor.

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