

The International Journal of Engineering Education

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- Clive L. Dym** 3–5 Social Dimensions of Engineering Design . . . An Engineer's Perspective
- This paper summarizes the opening remarks made by the engineering co-chair of a workshop on the social dimensions of engineering design and design education that was held at Harvey Mudd College in May 2001. Supported by the National Science Foundation, The Boeing Company, The GE Fund, Hughes Electronics, and Harvey Mudd College, Mudd Design Workshop III brought together engineers and social scientists—in their roles as educators, researchers, and practitioners with design interests—to articulate social and societal issues in and for engineering design. The remarks detailed herein were intended to set the stage and suggest a tone for the presentations and discussions that comprised the workshop. The papers that follow in this Special Issue of the International Journal of Engineering Education include the opening remarks of the Workshop's co-chair, Langdon Winner, and revised and extended versions of the papers presented at the workshop.*
- Langdon Winner** 6–8 Design as an Arena of Choice
- Research and teaching in two distinct professions—engineering and social science—have much to offer both students and the general public as they ponder what are actually important choices about the shaping of new technologies and social patterns. But seldom do these professions find ways to share the perspectives, experiences and strategies that inform their work. Especially interesting are choices that involve the introduction of information technology to existing patterns of work, transportation, housing, community life, and their relationship to the natural environs.*
- Social Issues and Themes in Design*
- Todd Cherkasky** 9–15 Designing Experience
- This paper describes the emerging field of 'experience design' and offers an approach to critical examination of engineering design in an effort to improve the experience of both users and those who design for them. Design is described as comprised of three 'threads' (social, symbolic, and material) that can be teased apart for design analysis, opening up assumptions embedded within design practice. The paper suggests how engineering as a profession, and engineers as responsible designers, can develop not only traditional technical skills, but also the critical inquiry skills to improve the experience of design.*
- T. Govindaraj** 16–24 Social and environmental perspectives in the design of engineering and service systems
- The globalization of most industrial operations has led to a high degree of disconnect between the consumers and the goods and services they consume. The connections between the manufactured products and the culture and place from which they originate and their place of consumption are often lost. This leads to accelerating environmental degradation and decreased quality of life for many people. The engineering community is partly responsible for this situation, due to their lack of consideration of the ecological and social consequences of design in a comprehensive manner by taking into account the rich contexts in which goods and services are produced and consumed. Adaptation and incorporation of ideas from ecological design and the development of appropriate curricula have the potential to change this situation significantly. In this paper, I describe an approach to accomplish these objectives.*
- T. L. Taylor** 25–34 Intentional Bodies: Virtual Environments and the Designers Who Shape Them
- This article examines the ways virtual environment software is explicitly designed with particular visions of identity, communication, and community in mind. This social context of software is considered with a particular focus on the ways various forms of embodiment are encoded in systems. Rather than simply framing software as a primarily technical product, this article analyzes the way software engineers and designers shape architectures and systems as conduits for social values and norms. Considerations of responsibility, identity, legitimacy, and sociability emerge as central factors in design practice.*
- William H. Wood** 35–40 Integrating Social Issues into Design Theory
- A reductionist approach to inquiry in the field of design theory and methodology leads naturally to examination of the lone designer and is the foundation for the development of theories for design. Even in this simplified setting, the two 'heads' of design research emerge: describing what effective designers actually do vs. prescribing what they should do. Without partnership between the two sides there is little hope that developed theories will be applied. Another bifurcation in design occurs between the two primary cognitive activities: generating design options vs. selecting among them. These activities are interleaved; theories that isolate one from the other cannot grasp the real nature of design. This paper examines existing paths toward building design theories that extend beyond the lone designer into groups of interacting designers and further into design situated in a social environment. This analysis points to the need to develop tools that anchor successful real-world design strategies into more formal foundations, helping design teams interact in ways that are both effective and natural.*
- Collaboration in Design*
- Bruce Corson** 41–52 Leadership by Design and Design by Collaboration: Process for Illuminating 'The Box'
- Effective problem solutions depend on the effective naming of problems. Effective problem naming is rarely accomplished within the limited perspective of a single individual. Unfortunately, it also is rarely accomplished by most technically deterministic problem-solving collaborations—whose internal dynamics tend toward converging rather than diverging perspectives. This paper is an exploration of the design of design environments—both social and cerebral—to maximize the elegance and effectiveness of both problem namings and the consequent problem solutions in a universal design process.*

This paper presents an ongoing study focused on the relationship between culture and multi-modal communication in the context of a cross-disciplinary geographically distributed teamwork course organized by the PBL Lab at Stanford. The study focuses on cultural dimensions that characterize distributed Architecture, Engineering, Construction (A/E/C) global teamwork, i.e., language, information flow, context, power distance, and time value. The paper presents a framework and methodology for data collection and analysis of multi-cultural dimensions and initial observations made during the first phase of this study.

Judith Gregory

62–74 Scandinavian Approaches to Participatory Design

What is distinctive about Scandinavian participatory design approaches? What can we learn from Scandinavian participatory design approaches that we can take into our own design practices, collaborations in design, and design pedagogy? The discussion argues that three principles distinguish Scandinavian approaches to participatory design: striving for democracy and democratisation; explicit discussions of values in design and imagined futures; and ways that conflicts and contradictions are regarded as resources in design. The author draws on recent experiences in Norway, in multi-disciplinary and international collaborations in health informatics. Background on Scandinavian approaches to participatory design is provided to give a sense of their distinctive history and critiques reflecting on problems and limits encountered. An instance of information systems interface design is presented in order to talk concretely about Scandinavian participatory design principles in contrast to mainstream systems design traditions in the United States.

Eswaran Subrahmanian, Arthur Westerberg, Sarosh Talukdar, James Garrett, Annette Jacobson, Chris Paredis, Cristina Amon, Paulien Herder and Adam Turk

75–80 Integrating Social Aspects and Group Work Aspects in Engineering Design Education

This paper describes two design project courses we teach at CMU, both emphasizing the importance of the social aspects of design. The first, taught collaboratively with Delft University, asks students to formulate, but never solve, a series of design problems. Students move from individually solving a series of simple problems to solving or interpreting larger problems as cross-Atlantic teams. A second product design projects course is available to all CMU students, with projects supported both technically and financially by industrial sponsors. Students learn the value of multidisciplinary teaming and of having real problems on which to work. We place emphasis on the teams discovering the 'right' problem on which to work. Projects span two terms, with the second term team members learning first hand about the difficulties of project hand-off. In both courses, students learn from each other through weekly project presentations. Also, in both courses, everyone—faculty, industrial partners and students—places, organizes and shares all information electronically within LIRE, our web-based document management system. Finally, for the first course, almost all CMU lectures and student presentations for the past two years are available as web-available streaming video movies.

The Many Meanings of Design

Richard Evans

81–93 Design Design: A Theory of Design

The focus of design design, as a theory of design with associated tenets, is that design, a human activity, is discovery; it is discovery of existing but as yet undiscovered ideas; and ideas are only possessed by individuals. Design is also decisions—decisions in the context of uncertainty—decisions among alternatives based on human preferences and human expectations of the future. Design Design: a Theory of Design, addresses both designing design as well as the design of design.

Charles C. Gordon

94–98 A Selection of Sociologies: *The Sociology of Work*

This paper will examine the role of the social in design practice. In aid of understanding and enacting that role, it will examine the kinds of sociology that could be involved in design practice and education. Topics considered include the fundamentally social and cultural nature of design, and the of design to the sociologies of work, science and technology, organisations, education, and culture.

Jesse S. Tatum

99–102 Junk, Pretty Junk, and 'Other Directed Design'

Often touted as a modern marvel, the increasingly rapid pace of technological innovation in our day might alternatively be interpreted as a sign of imminent crisis. The urgent need for attention to 'design' (to use the current term), however, remains. Sustainability, satisfying work, preservation of the rudiments of human community—even concern with a basic sense of meaning and engagement with the world—all present urgent calls for redesign, not just at the level of individual devices, but at the level of systems and interrelated and mutually dependent ensembles of technology. 'Other directed design' will then be in order. Profit and efficiency will not vanish, but they will need to serve rather than lead or dictate.

Engineering Design Education

P. Hirsch, B. Shwom, J. Anderson, J. E. Colgate, S. Jacobson, D. Kelso, J. Lake and C. Yarnoff

103–109 Collaborating with Design Professionals and Industry to Build a Design Course for Freshmen

A two-quarter course in Engineering Design and Communication offers one answer to an old challenge: how industry and the academy can work together to improve the teaching of design. This article describes a successful collaboration between faculty in a freshman design course and professional industrial designers. Designers take on four key roles in the course: client, consultant, guest lecturer, and section instructor. The model results in a cutting edge course for freshman that yields benefits for all parties.

Barry Hyman

110–117 Public Policy and Engineering Design Education

Both the ABET 'Conventional Criteria' and 'Engineering Criteria-2000' require engineering design education to include considerations such as the environmental, health, safety, ethical, social, and political impact of engineering design. This paper focuses on public policy as a proposed umbrella framework for consideration of these issues, and advances three propositions. First, that the public policy process has a lot in common with the engineering design process; second, that engineering design activities are becoming increasingly entwined with public policy considerations; and third, there are a wide variety of practical approaches to incorporating public policy considerations into engineering design education. The paper begins with well-known models of the engineering design process and the public policy process to establish the similarities between the two. In addition, several popular myths regarding the relationship between these two processes and their practitioners are explored. Next, the paper enumerates different classes of public policy activities engaged in by federal, state, and municipal governments that have implications for engineering design decisions. Included are generic issues such as: environmental, health, and safety regulations; professional licensing and registration; government support for basic and applied research, development, and exploration; defense weapons and other government procurement activities; patent and other policies to support technological development; and government collection, analysis, and dissemination of technical information and data. The third (and primary) part of the paper describes many ways in which public policy issues can be introduced as an integral and logical part of design education, rather than being perceived by either the students or teachers as diversions. This includes lecture and classroom discussion topics and activities, case studies, homework assignments, in-class and take-home quizzes and exams, mini-design projects that extend from one class-session to several weeks in length, and capstone design projects. Also, web-based and other resources on public policy for design instructors and students are described.

Modern engineers must perform a wide variety of tasks. Much of the modern engineering curricula prepares students for these tasks by focusing on individual topics such as thermodynamics or stress analysis. Design courses, by their very nature, must integrate a wide variety of areas. These areas include topics that are traditionally part of the engineering curriculum as well as those traditionally considered outside of the curriculum. This paper focuses on the technical contents of a second year design course. However, the course also attempts to integrate other 'non-technical' issues such as communication, teaming and ethics.

E. J. Woodhouse 124–131 Overconsumption and Engineering Education: Confronting Endless Variety and Unlimited Quantity

Excessive consumption in affluent societies is the taproot of many environmental and social problems. Because engineers play crucial roles in design, production, and distribution of the goods and services that arguably add up to too much for too many, questions arise concerning how engineering educators might address the problem. Section I briefly summarizes some of the defining characteristics of overconsumption. Section II discusses engineers' participation in the phenomenon. Section III considers barriers and prospects for bringing greater concern with the issue into engineering classrooms.

Product and Process Design

Shervin Ghaemmaghami and Larry Bucciarelli 132–141 Structured Methods in Product Development

We adopt the perspective that product design is a social activity: the outcome of an organized human effort to transform a set of requirements into a reality. It requires the collaboration of a wide range of individuals and stakeholders, each with different competencies, knowledge, responsibility and interests. Our focus is on the structured methods developed within the engineering design community to manage the product design and development process. Empirical observations of the product development process within a design consultancy show how they are used, patterned and shaped by participants in many different ways, with an array of intangible as well as tangible benefits.

Özgür Eris and Larry Leifer 142–152 Facilitating Product Development Knowledge Acquisition: Interaction between the Expert and the Team

Product development knowledge cannot be embodied in a specific individual, a specific group of individuals, or a formal process. Those elements can only embody aspects of product development knowledge. Interaction of those elements is what assigns meaning to the aspects of knowledge and allows for their synthesis. Therefore, it can be said that product development knowledge emerges out of the combined interaction of the involved people and resources.

Joseph A. Shaeiwitz and Richard Turton 153–157 Educating Chemical Engineers in Product Design

Historically, chemical engineers have worked on continuous chemical processes that run 24 hours per day for most of the year, characterized by large units such as distillation columns and reactors. The capstone design class has traditionally involved design and economic analysis of such a process. However, the future of chemical engineering may not be in the traditional, large, continuously operating chemical plant. Rather, the future may be in the development and design of what can be termed chemical products. To introduce students to this new paradigm, a capstone experience involving chemical product design was implemented on an experimental basis. The results were three designs, involving either application of chemical engineering principles to a new technology or the design of a device using chemical engineering principles. Assessment results suggest that this experiment was successful and that students appreciated the unique design experience.

Robert M. Counce, John M. Holmes, Ronald A. Reimer, Rita A. Heckrotte and Beth W. Alderson 158–162 Sustainable Development in Future Process Design and Analysis Education

A key role of engineers in the transition to more sustainable activities is likely to remain that of seeking to achieve pollution prevention and energy efficiency in manufacturing/production activities. A fundamental concept that has proven useful in teaching pollution prevention is that of 'intrinsic' vs. 'extrinsic' wastes. The same concept may be amenable to promotion of energy efficiency.

Institutional Issues

Joseph R. Herkert 163–167 Professional Societies, Microethics, and Macroethics: Product Liability as an Ethical Issue in Engineering Design

Professional engineering societies impact the process of engineering design through their role in promoting engineering ethics (among other activities); professional societies also participate in debates over public policy issues regarding the development and use of technology, such as the ongoing debate over product liability reform. Product liability, a key concern to engineering designers, professional societies, and policy makers alike, is an important case study of whether professional engineering societies are successful in bridging microethical and macroethical concerns. Ethical issues include the role of product liability litigation in creating an environment wherein managers take seriously the views of engineers with safety concerns, and the relative standard of care expected of designers and users of products. While professional engineering societies favor substantial changes in the product liability system, there is little evidence that they have considered the effect that decreasing the impact of product liability would have on engineering ethics. The apparent disconnect between the posture of the professional engineering societies on product liability and their concern for protection of public health, safety, and welfare as stated in their codes of ethics undercuts the ability of the professional engineering societies to constructively contribute to a discussion of the social and ethical dimensions of engineering design.

Gary Downey and Juan Lucena 168–176 When Students Resist: Ethnography of a Senior Design Experience in Engineering Education

This ethnographic study explores how engineering students in a traditional senior design course interpreted design assignments in terms of the engineering sciences. These students, who had been taught to value the distinction between 'science' and 'design,' tended to resist design education. They had learned to think about design as a trivial extension of mathematical problem solving. This predisposition made it difficult for activist faculty to convince students that design introduces entirely new learning issues. Although limited in scope, this study suggests that for reform in engineering education to be successful, it may need to go beyond engineering design to rework teaching in the engineering sciences as well.

Poul Kyvsgaard Hansen 177–182 Does Productivity Apply to PBL Methods in Engineering Education?

The dominating trend in most educational programs today is converting traditional classroom teaching to variants of Problem or Project Based Learning (PBL) methods. In most programs the general experience is increased motivation among students as well as teachers. However, most programs do at the same time experience problems regarding productivity in terms of the applied teaching resources. Consequently, many programs limit the PBL elements to the senior courses and keep the freshmen courses as traditional classroom teaching. One can ask whether it is possible to run a PBL program that is competitive in terms of both quality and spending of teaching resources. Can PBL programs be competitive throughout the whole program? This paper presents experiences from initiating and driving such continuous improvement efforts in a PBL program at Aalborg University in Denmark.

Successful competition in the global economy is increasingly dependent on new products and services that reveal new business and infrastructure possibilities. New products and services must be regarded not only as commodities in a marketplace, but as social actors constraining or enabling the quality of our life. In recognition of these two perspectives, Product Design and Innovation (PDI) is a three-year old undergraduate dual degree program educating students for new product invention and development. PDI satisfies the requirements for the Bachelor of Science programs in Architecture and Science, Technology and Society (STS); or Mechanical Engineering and STS. Design programs played a lead role as the PDI curricular model for integrated and studio teaching, linking all three dimensions of the program—the technical, the aesthetic, and the social—with an emphasis on creativity, the imaginative application of new technologies and materials, and the social and political dimensions through design.

Design in and for a Complex World

G. Wackers and J. Kørte

192–205 Drift and Vulnerability in a Complex Technical System: Reliability of Condition Monitoring Systems in North Sea Offshore Helicopter Transport

In the early 1990s vibration-based condition monitoring systems called Health and Usage Monitoring Systems (HUMS) were introduced into the helicopter industry servicing offshore operations in the North Sea. These monitoring systems were specifically designed to improve the helicopters' safety, reliability and availability by providing in-flight, early warning diagnostics; they were reliability technologies that would simultaneously reduce maintenance costs. On September 8, 1997, LN-OPG, a Super Puma helicopter operated by the Norwegian helicopter operating company Helikopter Service AS, was involved in a fatal accident due to a mechanical failure in the engine and gearbox driving shafts. The helicopter was equipped with a HUMS-system that should have detected the impending failure, but failed to do so. This paper tries to understand why HUMS failed in its early warning capability in LN-OPG. It raises practical issues to adopt in one's own working environment in realising system designs that will anticipate, cope with, resist, and recover from vulnerability and failure caused by component or procedural drift over time.

S. J. Lukasiak

206–212 Vulnerabilities and Failures of Complex Systems

The generic product of engineering is a system. Systems interact with each other as a result of the choices of their designers, owners, and users. These complex systems of systems fail in unanticipated ways. The impacts of those system failures are amplified by the often unplanned and unappreciated interdependencies among systems. The result is an increasing frequency and magnitude of system failures that have major impacts on regional economies and on the physical well-being of the populations they serve. Compounding this concern is the emergence of malevolent acts resulting from irresponsibility, disaffected employees and users, criminal motives, terrorism, and state-supported strategic attack. This paper first examines some vulnerabilities encountered in the 'federation' of systems through the widespread application of information technology. It proposes a defensive design paradigm that recognizes the unavoidable occurrence of failures resulting from complexity and from malice. Finally, the implications for engineering design are examined and proposals are made for ways to introduce such an approach to design into curricula.

Michael Black

213–226 Can We Design Ecosystems? Lessons from the California Rivers

For over a century, the US Fish and Wildlife Service and its predecessors have run the Coleman National Fish Hatchery on northern California's Battle Creek. Until recently, however, those overseeing the world's largest salmon hatchery have sought to restrict the upstream passage of indigenous, and, in some cases, 'endangered' stocks of chinook salmon. Today the Service's managerial, infrastructural and scientific priorities appear to be on a collision course with legislatively-mandated, natural restoration priorities. Technological mitigations like hatcheries and other 'serialistic policies' stand in the way of habitat restoration and designing with nature. Natural resource agencies remain wedded to ratcheting up ameliorative technological fixes within riverine systems too battered any longer to support wild fish. Today's 'fish salvage' assumptions are identical to rationale formulated, institutionalized, and subsequently abandoned as unworkable over a century ago.

What have We Learned? What do We Recommend?

John W. Wesner

227–232 Key Learnings and Commitments from Mudd Design Workshop III

As the final two steps of Mudd Design Workshop III, a wrap-up session collected what participants believed to be the key learnings from the Workshop, and personal commitments were made, to take action based upon the things participants had learned during the Workshop. These commitments will be reviewed at the next Mudd Design Workshop.