

The International Journal of Engineering Education

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- C. L. Dym 422–428 Engineering Design: So Much to Learn

This paper recaptures remarks made at the opening of a workshop on learning and engineering design by the workshop's organizing committee's chair. Held at Harvey Mudd College in May 2005, and supported by Mudd's Center for Design Education, Mudd Design Workshop V brought together engineers and social scientists—in their roles as educators, researchers, and practitioners interested in learning and in design—to identify and articulate important issues about learning in engineering design. The remarks detailed below are intended to provide a context for the presentations and discussions that comprised the workshop by exploring some of the many difficulties attendant to teaching design. While this address may have been preaching to the choir, it is nonetheless somewhat unsettling to list the myriad of skills associated with good design. In addition, the point is made that while the difficulties of teaching design may still be underappreciated by the (much) larger analysis community, the benefits associated with teaching design are increasingly seen as the primary goals of engineering education—which suggests that in the long run, design and synthesis will at least draw equal to, if not prevail over analysis and reductionism as the prime movers in engineering education.

- S. Sheppard, A. Colby, K. Macatangay 429–438 What is Engineering Practice?
and W. Sullivan

In this paper we develop a description of engineering practice. This description is based on published research on engineering work and on interview data from the engineering faculty. It was undertaken as part of a larger study that is underway at the Carnegie Foundation for the Advancement of Teaching. The study is looking at the relationship between how engineering is taught and how it is practiced.

Keywords: engineering practice, engineering work, work practices, design, problem solving, analysis.

- D. C. Davis, S. W. Beyerlein 439–446 Deriving Design Course Learning Outcomes from a Professional Profile
and I. T. Davis

National calls for enhanced preparation of engineering graduates have spawned and elevated efforts toward assessment-driven improvement of engineering education. Adoption of outcomes-based accreditation criteria by the Accreditation Board for Engineering and Technology (ABET) provided incentive for this change. A necessary first step is embedding attributes of engineering professionals in the program and course objectives of specific baccalaureate degrees. This paper presents a 'profile of an engineer' that encapsulates important roles performed by engineers and key observable behaviors associated with effective performance of these roles. The profile is then utilized to derive sample learning outcomes for a client-driven capstone design course. This involves identifying key roles in support of the course as well as the type of learning outcome best aligned with each of these roles. Outcomes derived in this manner provide rich definitions of desired student achievement that will aid in engineering design education and assessment.

Keywords: engineering design; learning outcomes; professional profile.

- J. H. McMasters 447–459 Influencing Student Learning: An Industry Perspective

Much has been written over the past several decades about the need for reform in engineering education and the elements of what such reform might encompass (e.g. enhanced curricula with a stronger emphasis on design, improved pedagogical methods). Most of this literature has been written from an academic rather than industry or employer perspective, with a focus on faculty and curricular issues. Relatively little has been presented from a student perspective. The issue of what factors influence students in their choice of pursuing a career in engineering or how they might be educated and retained in engineering education programs has not been adequately addressed. The purpose of this paper is to discuss some of the steps we within the broader technical community (in industry, government and academe) can and should take to assure an adequate future supply of well prepared engineering graduates for the full range of employers who have need for such talent. Although much has been accomplished in the past decade to enhance engineering education, we, as both educators and practitioners, have much to do to cooperatively create a strong and vivid vision of our future, and ensure the proper development of a future generation of engineers with the skills and motivation to meet society's needs in our ever-evolving enterprise.

Keywords: engineering manpower; engineering career, professional skills; industry perspective.

- L. R. Lattuca, L. C. Strauss 460–469 Getting in Sync: Faculty and Employer Perceptions from the National
and J. F. Volkwein Study of EC2000

This study compares the changes in programs and courses reported by Chairs and faculty with the assessments of new engineering hires reported by employers in a national study of engineering accreditation. Employers report that new engineers demonstrate adequate competency in foundational science, math, and technical skills—and program Chairs and faculty report little change in their courses and program curricula in these areas. In the areas where employers perceive the need for more attention to skill building, such as communication, teamwork, and use of modern engineering tools, faculty and Chairs report the greatest increases in curricular emphasis.

Keywords: accreditation; student assessment; competencies.

- M. Contero, F. Naya, P. Company 470–477 Learning Support Tools for Developing Spatial Abilities in
and J. L. Saorin Engineering Design

This paper presents some learning support tools for developing spatial abilities in engineering design students. They are based on the previous authors' experience in teaching traditional Engineering Graphics and uses both on-line and batch computer-aided generation of 3D models from 2D freehand sketches. Although these applications can be used with standards PCs, they are intended to be used on Tablet-PCs to provide an experience similar to sketching on real paper. The objectives of these applications are to develop three important elements for the future engineer: spatial visualization, freehand sketching and normalized view generation. The authors present the results of a pilot study that has been realized in some Spanish universities. Two well-known tests for evaluating spatial

abilities: *Mental Rotation Test (MRT) and the Differential Aptitude Test— Spatial Relations subset (DAT-SR)*, have been used to validate the pilot study.

Keywords: spatial abilities; visualization; freehand sketching; 3D reconstruction.

C. L. Magee and D. D. Frey

478–488 Experimentation and its Role in Engineering Design: Linking a Student Design Exercise to New Results from Cognitive Psychology

This paper advances the hypothesis that engineering design is most effective when heuristics are used in many aspects of the design process, particularly in structuring sequences of experiments and adapting the design based on data. These heuristics appear to be natural behavior in the sense that engineers will use them when no training or external incentives are offered to encourage alternative approaches. Our observations of seven repetitions of a student design exercise with a total of over 300 students are consistent with our hypothesis. The approaches used by students appear to be economical and highly effective even though they are not consistent with theoretically optimal experimentation techniques. Our observations are related to recent research in cognitive psychology, especially the work of the Adaptive Behavior and Cognition group regarding 'fast and frugal heuristics' and also the observations of some researchers in Design of Experiments. The implications for design practice and education are considered.

Keywords: heuristics; disciplined design; design education.

Y. Reich, E. Kolberg and I. Levin

489–495 Designing Contexts for Learning Design

Any learning activity including learning to design takes place in a particular context. Given the goals of the learning activity, this context could be designed, in a way that other products are designed, to satisfy its goals. In a reflective consistent discipline, such as design research could be, design researchers that develop design tools, use these tools to design their research. We present a case study in which a mechatronics design course for high school students was designed using design tools. The course design included teaching design tools. A controlled study showed that the design of the course led to outstanding results. Students engaged in the course, compared to students who studied fewer design tools, won an international robotics competition, improved their science grades, displayed superior design skills, and improved their technology perception. These results demonstrated that by careful design, successful contexts for learning design could be created. In addition, they demonstrated that being reflectively consistent in design research is rewarding. In summary, we also present ideas for further improving the design of the design course.

Keywords: design education; reflective consistency; mechatronics; robotics contest; controlled study; high-school.

G. E. Okudan and S. Mohammed

496–502 Facilitating Design Learning in a Cooperative Environment: Findings on Team Functioning

Design learning is generally done collectively, but more needs to be known about how students can work better in teams. This paper presented the results of a study measuring student perceptions of team functioning and the changes that occurred over the course of the semester as students transitioned from an initial, guided project to an open-ended, industry-sponsored project. Students generally had positive perceptions of team functioning, including relatively high levels of conflict resolution, collective efficacy, and teamwork behaviors. As compared with the first project, team members reported more time spent together outside of class, greater conflict resolution behaviors, and higher individual growth for the second project.

Keywords: design teams; collective learning; design tasks.

T. Meijknecht and H. Van Drongelen

503–507 The Five Saints of Electrical Engineering

Spirituality is essential in the training of engineers. Engineers have always had a religious calling—it was their task to save the world from downfall—and they still have this feeling. But it is a feeling that is hard to express. Articulating it is not an integral part of the training. High time for a coming out!

Keywords: Revealing the professional tradition of an engineer as a tradition of compassion.

R. Bailey and Z. Szabo

508–518 Assessing Engineering Design Process Knowledge

Rigorously assessing students' design process knowledge is essential for understanding how to best create learning environments to facilitate the development of such knowledge. Such assessment is also quite difficult and hence there is a lack of assessment tools capable of measuring design process knowledge of every student in a large college. Faculty from both the Colleges of Engineering and Education at the University of Arizona are developing such a tool. The approach being developed aims at assessing if students can explain and analyze an engineering design process by having them critique a proposed process. Two versions have been developed so as to provide a pre- and post-test. An analytic scoring rubric is used to assess the design knowledge embodied by the student responses. Results from the 2003–4 academic year indicate that one of the two tests has sufficient validity and that the scoring rubric is too detailed for the nature of the tests. Hence, in the second phase of this work, a new test will replace the invalid one and a simpler rubric will be implemented.

Keywords: design process; assessment; Bloom's taxonomy.

M. Mehalik and C. Schunn

519–532 What Constitutes Good Design? A Review of Empirical Studies of Design Processes

The authors conducted a meta-analysis in which they sampled over 40 journal articles of empirical studies of the design process. The articles were selected from several journals that are indexed in PsychInfo. They were reviewed and indexed according to whether or not those articles mentioned and/or focused one or several of 15 common design process elements. These elements consist of a bootstrapped framework that the authors constructed from past experience in studying the design process and from validation from literature. The coding was conducted by an additional expert in design, and the results were shown to have reliability greater than 80%. The results show which elements of the design process have been studied most frequently, and of those studied, which were documented to contribute to an effective design outcome. Both the framework and the coding outcomes contribute to a stronger understanding of the overall design process that relies upon existing, more fine-grained empirical studies of design.

Keywords: design processes; meta-analysis; design outcomes.

D. K. Sobek, II

533–539 System-Level Design: A Missing Link?

System-level design is proposed as the set of activities that aid design engineers in transitioning from highly abstract conceptual ideas to detailed designs. It is characterized by exploration of and decisions about the arrangement of components and subsystems, and design of interfaces. While these activities are sometimes included in engineering design frameworks, it has not been well studied. And yet, the results from three analyses of empirical data derived from mechanical engineering student design projects suggests that such activities seem to have a significant impact on independently assessed outcome measures, even though they comprise a small percentage of student effort. This further suggests that system-level design may be a high leverage activity worthy of further investigation. This paper defines system-level design, summarizes the research methods used and analyses of the empirical data, and presents a tool to aid in the system-level design phase.

Keywords: design subsystems; design frameworks; design decisions.

This paper explores the question of whether designing software is different from designing other things (we believe it is). We discuss several key distinctions that are largely missing from the discourse on software design yet which are vital to the success of software designs. These distinctions are increasingly important as software becomes prevalent in the design tools and products of other engineering disciplines. By considering what is similar and what is different we help reveal how the lessons of software design may help other disciplines, and vice versa. This in turn illuminates a core meta-question of how educators in academia and industry can help evolve our understanding of what we do so that we can be more effective at software design. But first, we need to understand what is different, and what is not different, about this discipline called software design.

Keywords: software design; architecture; complex adaptive systems; design; design process; digital artifacts; organizational design; organizational intervention; pattern language; test-driven development.

O. Eris 551–559 **Insisting on Truth at the Expense of Conceptualization: Can Engineering Portfolios Help?**

Teaching and promoting conceptual thinking in engineering education is challenging. Two recently introduced design thinking models are compared in order to explore the reasons behind this challenge. The comparison results in key distinctions between divergent and convergent thinking, and between concept and knowledge domains. The differentiating principle is shown to be a common principle of the two models, truth-value, or logical status, of the propositions that engineers make. Building on this insight, divergent thinking by inquiry is identified as a mechanism for promoting conceptual thinking, and a specific implementation of engineering portfolios is proposed as a pedagogical tool.

Keywords: conceptual thinking; divergent inquiry; engineering portfolios.

K. J. Obarski and S. W. Soled 560–565 **Engineers as Inquiry Practitioners**

The goal of this paper will be to describe Project STEP, the importance of using inquiry-based learning methods to enhance student learning, especially when teaching urban high-school students, and the training involved in teaching engineers to teach using these techniques in under-resourced classrooms. Special attention is given to describing the impact on engineers who were transformed through teaching and learning education coursework and their experiences in these classrooms.

Keywords: inquiry-based learning; inquiry practitioners; transformative education.

M. Ogot and G. E. Okudan 566–576 **Systematic Creativity Methods in Engineering Education: A Learning Styles Perspective**

The traditional approach to creativity (using methods such as brainstorming, C-sketch, morphological charts, scamper, etc.) calls upon the designer to look inward for inspiration. TRIZ, on other hand, invites the designer to use a ready pool of knowledge for inspiration. TRIZ does not discount the use of the traditional approaches. On the contrary, TRIZ ensures that design teams use these traditional methods in a systematically directed manner by carrying out intelligent idea generation in areas where other people have solved a similar general design problem. The main focus of this paper is to look at systematic creativity methods, such as TRIZ, from a learning styles perspective. Three learning styles dominant in the engineering education literature are explored: MBTI, Kolb and Felder-Silverman. For each it was found that the tasks required of each of the TRIZ steps matches a broader range of engineering student learning styles, than the sole use of brainstorming.

Keywords: creativity; learning styles; TRIZ to the paper.

M. W. Ohland and J. D. Summers 577–583 **Teaching Design Using Multiple Hierarchical Engineering Education Models**

This work seeks to add to the theoretical underpinnings of design education through the use of hierarchical educational models by Haile and Egan, building on a foundation laid by Vygotsky. We fit commonly used techniques of design education into Haile's hierarchical model to ensure that a proper foundation is laid before the next level of the structure is built. Relating Haile's hierarchy of technical understanding to Egan's general hierarchy of understanding helps anchor the study of technical understanding in the more general context provided by the cognitive sciences. Using this perspective, we gain access to examples of design education from other fields such as music, writing, and art. These examples improve the understanding of design by strengthening the pattern of what design is and by clarifying how engineering design is different from these other examples. Vygotsky divides the reorganization of knowledge into four steps: (1) conceptualization, (2) transference, (3) generalization, and (4) extension. The use of this model of reorganization helps guarantee that learning will proceed from concrete situation to abstraction and then, by extension, can be applied to different concrete situations. Vygotsky's framework is particularly useful in integrating the perspective of three schools of thought regarding design education identified in previous work by Dym.

Keywords: design education; Vygotsky; cognition.

T. Healy 584–590 **Restructuring an Engineering Core Course to Prepare Students for Design Experiences**

This paper describes the restructuring of a core electrical engineering course in electromagnetics to better prepare students to do engineering design. Traditionally the course was taught in a linear mode, one step following the other. There was also little attention to practical applications, or to the relation of the material to other courses in the core. The paper begins with a review of some of the current literature on teaching and learning, particularly as it relates to the restructuring. This includes a discussion of student intellectual development, the reality of uncertainty in the world and student reaction to it, some assumptions that instructors need to take into the classroom, and finally some thoughts about the possible relation of child development to student development. The restructured course is then described. The linear approach to teaching is abandoned. Students are asked to face the reality of uncertainty, as well as its implications for engineering design. A daily handout sheet is designed to facilitate student integration of ideas across classes and courses. A design project is introduced. The response of students to the course is briefly discussed. The paper closes with a set of questions designed to guide continuing restructuring of the course.

Keywords: electrical engineering; core courses.

C. Lewis, S. Magleby and R. Todd 591–597 **Learning to Design Products in Environments with Limited Design Traditions**

Many researchers agree that 'today's engineer must design under—and so understand at a deep level—constraints that include global, cultural, and business contexts'. In an increasingly global economy, the demand for engineers and technical personnel is increasing in every country. Developing countries which have few internal design traditions are struggling to find a place in the ever growing, ever increasing competitive global marketplace. Even developed countries like the United States are finding increasing challenges to their technological dominance. The ability to design and manufacture timely, needed, and inexpensive products for a large variety of consumers is becoming the great differentiator in controlling the global marketplace. Better design and engineering curriculum is needed in developing countries to improve their ability to compete in a global marketplace and find ways to open their own untapped and waiting markets. The objective of this paper is to provide an overview of our approach to develop more flexible design structures and processes that could be adaptable to environments where there is a limited design tradition. It is anticipated that through the use of appropriate processes, designers in developing countries will be able to effectively learn to design products that have value both inside and outside of their community. We also anticipate that these flexible design structures and processes can be integrated into a formal

design curriculum customized to meet specific needs. There are six major topics that are relevant to our research. They are design curriculum outcomes, design processes, design curriculum, learning activities and tools, appropriate assessment techniques, and research in developing countries. Our paradigm is based on the premise that project-based learning is one of the most appropriate and effective means of teaching engineering design principles to students. Furthermore, the authors feel that it is crucial to involve industry with academia. Industry involvement in engineering education improves the relevance of education, better prepares students for employment, provides industry with a better qualified workforce, and creates synergy between industry and academia.

Keywords: engineering design; developing countries; education; design capacity.

J. Turns, M. Cardella, C. J. Atman, 598–608 Tackling the Research-to-Teaching Challenge in Engineering Design
J. Martin, J. Newman and R. S. Adams Education: Making the Invisible Visible

Translating research results into everyday teaching practice is notoriously difficult. In this paper, we focus on the growing body of research on design knowing and learning, and examine and make visible opportunities for getting this research to positively impact teaching in engineering design education. Core to the paper is the position that successful efforts to get research to impact teaching will involve an emphasis on educators and their teaching practice. In this paper, we situate our position in scholarly thinking concerning the research-to-teaching challenge, present results of an empirical analysis of current teaching practice in design education, and describe an on-going approach for supporting research into teaching that follows from the empirical results. We close with the observation that information on the decision making strategies of engineering design educators could be particularly helpful for getting research to affect teaching practice in engineering design education.

Keywords: engineering design; research impact.

J. P. Terpenney, R. M. Goff, M. R. Vernon 609–616 Utilizing Assistive Technology Design Projects and Interdisciplinary Teams
and W. R. Green to Foster Inquiry and Learning in Engineering Design

In industry, successful products and systems usually require a collaborative design process with a multitude of participating stakeholders (customers, sales/marketing, industrial designers, engineering designers from various engineering disciplines, manufacturing, distribution, etc.). Addressing this future work environment, interdisciplinary teaming has become an important element of student design projects. For the last several years at Virginia Tech, interdisciplinary design projects have been created with teams of students from the first year Exploration of Engineering Design course in the College of Engineering and students from the second year Industrial Design Program in the College of Architecture and Urban Studies. While students and faculty alike have appeared to enjoy the exchange of different perspectives and insights that interdisciplinary collaboration appears to offer, there has heretofore been no effort to assess the effectiveness of this experience. This paper describes the experiment currently in progress that investigates student learning with interdisciplinary teams taking on assistive technology (AT) design projects. Two of the three major milestones of the project have occurred thus far, and the leap from the conceptual presentations to the first working prototypes has been surprisingly astute and successful. To date, observations and analysis of assessment data indicate there is a discernable difference between the quality of the projects of interdisciplinary teams of engineering and industrial design students and engineering only teams. Data also indicate that interdisciplinary teams value and are more amenable to projects that are more complex due to being open ended, human centered, and collaborative more than engineering only teams.

Keywords: assistive; design; interdisciplinary; teams.

A. Agogino, S. Song and J. Hey 617–625 Triangulation of Indicators of Successful Student Design Teams

This paper reports on research conducted on design teams at UC Berkeley over several years at the undergraduate and graduate levels. The paper provides a triangulation of indicators of successful design teams drawn from different research methods. The research sources include questionnaires, team documents, email communication, individual design journals, faculty evaluations, and ratings from external design judges. Computational linguistic algorithms are used to analyze the text documents with a focus on latent semantic analysis and semantic coherence. Sketches are analyzed using a comprehensive list of metrics, including Shah's 'variety' measure for quantifying the breadth of the solution space explored during the generation process. A synthesis of the results provides interesting and counterintuitive indicators for predicting the success of student design teams. This analysis, in turn, provides insight into learning how the student design teams negotiate and learn the design process and can assist educators in improving the teaching of design.

Keywords: design teams; shared understanding; semantic coherence; latent semantic analysis; sketching.

E. Cuddihy and J. Turns 626–636 Assessing One Aspect of Design Learning: Qualitative Analysis of Students' Design Rationales

This paper explores the ability of undergraduate engineering students to write effective design rationales that describe the reasoning driving their decisions as they create solutions for open-ended design problems. This study sought to uncover the ability that students have to write design rationales that effectively capture their justifications for key design decisions, identify the strengths and weaknesses found in the design rationales prepared by the students, and determine if the quality of the students' design rationales improved with practice over the course of a 10-week academic quarter. While the students' attitudes toward activities associated with design rationale were generally more negative than their attitudes toward the rest of the class activities, their written design rationales indicated improvement over the quarter in their ability to provide concise, discipline-specific justification for their design decisions. This paper presents findings that include students' initial perceptions of their ability to justify design, their attitudes toward design rationale, the strategies that students used to justify key design decisions, and students' ability to write design rationales based on principles from their academic discipline.

Keywords: design decisions; design rationales; student's design concept.

S. Finger, D. Gelman, A. Fay 637–644 Assessing Collaborative Learning in Engineering Design
and M. Szczerban

Through an iterative, user-centered design process, we are designing and building computer-based tools to support students learning through collaboration. We have been conducting empirical studies to evaluate the usability of the tools and how they contribute to student learning. Our goal was to design tools that would support the processes of knowledge co-construction and reflection. Co-construction is the successful activity of knowledge building and problem solving between individuals. Reflection and discussion promote critical thinking. This paper reviews the iterative design and development process of these tools.

Keywords: design; collaboration; groupware.

J. M. T. Walker, D. S. Cordray, 645–651 Design Scenarios as an Assessment of Adaptive Expertise
P. H. King and S. P. Brophy

The ability to adapt to new challenges is critical to success in rapidly advancing fields. However, educators and researchers struggle with how to measure and teach for adaptive expertise. This study used a design scenario to assess how undergraduates approach novel design challenges. A scenario presents individual students with a short realistic description of a complex, open-ended design problem. In this study, we developed a scenario from a cardiologist's concerns about the design of an implantable defibrillator. Participants included 63 senior design students and 37 freshmen enrolled in a signal analysis course. After reading the scenario, students responded to three questions: What do you need to do to test the doctor's hypothesis? What questions do you have for the doctor? and, How confident are you in your response? The first question tapped students' efficiency or their ability to devise an appropriate response. The second tapped students' innovation or their ability to consider important facets of the problem. The third question estimated students' confidence/cautiousness. Data were collected at the beginning and end of one semester. Analysis showed that seniors consistently devised more

efficient and innovative solutions than did freshmen. Seniors were also more confident in their problem-solving abilities. Over time, all students became more innovative and more confident. Findings are discussed in terms of what they suggest about undergraduates' intellectual development at entry to and exit from a standard four-year curriculum and how adaptive expertise might be assessed within the context of students' regular academic coursework.

Keywords: adaptive expertise; efficiency; innovation; design.

J. S. Lamancusa

652–658 Design as the Bridge Between Theory and Practice

It has taken over a year to get to this point. Our Mechanical Engineering Department was attempting its first major curriculum change in over 20 years. Under discussion was a proposal to eliminate Thermodynamics II and the Kinematics course, and to institute a design course in the junior year, while reducing total credits by 6. Still to come was the even more controversial issue of integrating active learning into our lecture-dominated courses without increasing the teaching load or spending more money. It had been a year of contentious meetings, followed by passionate e-mail salvos with “bold highlights” for emphasis. Mirroring the recent presidential election, there were three camps: two with unshakeable beliefs on either side of the theory/practice divide, and a third group who just wanted the other two to go away so they could get back to their research. When it was time for the final vote on the “Midstone” design course, comments included: How can you teach design if students don’t know the fundamentals of xxx . . . ? Design is too touchy-feely. This course is not worth 3 credits; can’t we do it in one or two? Not technical enough, too much business stuff, you can’t teach common sense, we are watering down the curriculum, etc.

This paper presents the things I wish I had been quick enough to think of and say at that faculty meeting. The outcome of our curriculum improvement process is presented, including the new Midstone design course. Finally, the following long-term goals for engineering education are sought:

1. Formal training in education pedagogy, with periodic re-certification, for all college instructors.
2. Recruitment and retention of “Professors of Practice”—practitioners from industry.
3. A new “Goals for Engineering Education” by ASEE, to guide engineering education in the 21st century. ASEE’s previous report is now 50 years old.

Keywords: design; active learning; curriculum change.

L. C. Schmidt

659–664 Engineering Teams: Individual or Group Sport?

This paper describes a study undertaken to explore the functional roles that engineering students take on project teams as they progress through the Mechanical Engineering program at the University of Maryland. The data gathered from the study exposed the pervasiveness of functional role specialization in project teams. Specialization may be turning engineering project teams into collections of individuals learning different topics.

Keywords: team; team notes; specialization; project teams

D. Ollis and J. Krupczak

665–670 Teaching Technology Literacy: An Opportunity for Design Faculty?

The National Academy of Engineering, the National Science Foundation, and various prominent engineering faculty and administrators have pleaded over the last decade that technological literacy for non-technical majors is a topic which engineering faculty ought to provide. This paper explores the notion that design faculty are well qualified, perhaps uniquely so, to teach such courses for non-technical majors, i.e., to represent engineering and technology to the non-technical campus population. Previously we reviewed the attributes of the various groups promoting technological literacy. We showed that engineering, with its balance between theory and practice, has a distinct and highly effective perspective on technology, making engineers uniquely qualified to explain technology to the non-engineer. Here we focus on engineering design faculty as those engineers most qualified to carry out this effort. Inasmuch as design instruction is universally present on the more than 300 campuses boasting an engineering school, and each engineering department has at least one design instructor, a potential teaching faculty in excess of 1000 is identified from which to recruit future technology literacy instructors. We make the case for this novel activity as a logical component of design instruction, and argue further that such novel participation will accomplish a second goal, long sought by design instructors, namely that their profession will have an increased, and more public, visibility and appreciation. Thus, creating a cadre of design instructors as teachers of technology literacy will assist a national need and at the same time will satisfy a professional goal.

Keywords: technology literacy; design faculty.

**A. F. McKenna, J. E. Colgate,
S. H. Carr and G. B. Olson**

671–678 IDEA: Formalizing the Foundation for an Engineering Design Education

At Northwestern University we have recently created the Institute for Design Engineering and Applications (IDEA) within the McCormick School of Engineering. Through IDEA students can obtain a certificate in engineering design alongside their bachelor’s degree in their engineering discipline. IDEA was formed with the goal of integrating interdisciplinary design throughout the engineering curriculum, and creating a design community to support innovation. In this paper we discuss the design principles, community-based practices, and central education components of the IDEA certificate program. In addition, we discuss our process for monitoring students’ design understanding and performance and how we continue to evolve our design courses based on this data, as well as ongoing feedback from members of the IDEA community.

Keywords: design education; interdisciplinary design; experiential learning.

**P. K. Hansen, J. O. Riis, F. Gertsen
and P. Israelsen**

679–684 Learning for Life—PBL in Continuing Education

This paper describes a Master’s Program on Management of Technology (MMT) at Aalborg University. The program is a post-experience education focusing mainly on engineers with more than three years of practical experience. The idea underlying the division of the MMT program into four terms is primarily to create an understanding of strategy and strategic challenges (first term) and to relate these to organizational options and challenges (second term). Subsequently, the program strives to ensure a basis for holistic planning of corporate development. During the third term, focus is on planning of corporate development, and during the fourth term managerial aspects in connection with implementation are addressed. As a part of the curriculum at Aalborg University the program is designed as a problem-based and project-based learning initiative.

Keywords: problem based learning; management.

J. W. Wesner

685–688 What We Have Learned in Mudd Design Workshop V: Learning and Engineering Design

This contribution summarises the main points discussed at the Workshop on Designing Engineering Education which took place at Harvey Mudd college 19–21 May 2005. The points raised are the meaning of the profession of engineering, the definition of design knowledge, design, inquiry and learning, learning in design and in engineering design, inspiring learning in design courses, assessing learning in design courses, programmatic and related issues in design, and apparent paradoxes. Future steps are also discussed.

Keywords: engineering profession; design knowledge; design learning assessment.