

## Outcomes of a Biomedical Engineering Design Education Workshop

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**Abstract:** A full day biomedical engineering design education workshop was held on October 22, 2002 in conjunction with the joint IEEE-EMBS/BMES conference in Houston. Attendees were from both University and Industry backgrounds. Eight subject areas relating to the teaching and conduct of design courses were discussed. These topics included placement of the courses in the curriculum, course objectives, solicitation and management of projects, possible sponsored national or international design contests, and industry sponsorship of project groups.

Extensive notes and concept maps were generated for each of the topics discussed as the group met as a “committee of the whole.” The essence of the discussions provided a good general overview of the need by design instructors for mutual sharing of resources and of industry input to design courses, both in lecture content and in sponsorship of relevant design challenges. The group considers that there are several action items that will need to be addressed as time allows, such as: 1. the development of a communication medium, such as a design oriented section (page) of the IEEE-EMBS magazine, 2. the continued development of design overview web sites, 3. the sharing of design lecture and source material, and 4. the development and sponsorship of a national design competition.

**Introduction:** The above mentioned workshop took place involving most of a full day of meetings and discussion. The following text will cover the topics discussed in four consecutive sessions, and will conclude with the group’s recommendations.

**Session 1:** How and when should design be taught? (Gassert) and What outcomes should be expected from a design course? (Goldberg)

Examples may be found in the literature for design courses aimed at the freshman through senior years. It was strongly recommended that design be a consideration in teaching throughout a four year education, but it was noted that few universities actually give credit for consecutive design courses through a four year education. Whatever the placement of the course (most are senior two semester courses) the consensus was that one needs to cover hard skills (project management, resource mining, and constraints), soft skills (technical communication, and team dynamics) and concept coverage (ethics, safety, intellectual property.) Design should provide the integration of theory and practice, provide skills for employment, and be done in such a manner as to over satisfy ABET minimum requirements. The design experience must

include assessment, evaluation, and motivation by the instructor; it must include teamwork in project development and presentation, and must include real projects.

**Session 2:** What structures are used to teach design? (Goldberg) and What are the expectations for graduate design courses? (King)

The actual structure used to teach design seems to vary, from heavily emphasis on simple projects (generally at the freshman level), to a combination of project work and affiliated lectures on the design process and interactions necessary to permit generation of a paper design or prototype design. Projects depend on available resources (faculty, industry, private initiatives), as do the evaluations of the projects (faculty, industry panels, combinations.) Most structures involve various levels of homework and class participation, with a major emphasis on the performance of and reporting of a single design project. The production of a prototype is generally preferred over a feasibility design. Expectations are dependent on the level of the student, thus a masters level design project would be expected to involve a higher degree of technical sophistication and completion.

**Session 3:** How are projects solicited, managed, staffed, - what works? (Goldberg) and How can we better involve industry and obtain real-world problems? (Fries)

Ultimately, the responsibility for the majority of design course project solicitation will fall to the designated design instructor. This instructor will then solicit, hopefully with the assistance of fellow faculty the following sources of projects:

1. Fellow faculty who need a design, rather than a research assistant
2. Industry affiliates, through fellow faculty or one's own contacts
3. Retired engineers (who might also co-advise)
4. Program alumni
5. Local or affiliated hospitals and clinics
6. Service organizations (Cerebral Palsy Foundation, etc.)
7. Past project sponsors
8. Entrepreneurial groups (campus or local)
9. etc.

Some experience was related regarding solicitation of project using brochures distributed via mail or at a conference such as Medical Design and Manufacturing, but no success stories were forthcoming. Persons who do have projects should be invited to propose them in class, such that the interaction with the class becomes an active learning experience. No single source of funding was evident from the discussions, with a mixture of departmental, school, and industry support being evidenced.

**Session 4:** What design tools are needed for university and industrial design? (King) and How can we best sponsor a mutually beneficial yearly design competition? (Yock)

The discussion of tools and resources needed for a good design course could be very extensive, a partial listing of the items discussed were:

1. Useful textbooks for reference
2. Shared teaching materials (case studies, lecture notes, etc.)
3. Hardware supplies for fabrication
4. Prototyping facilities
5. Reasonable financial support and expectations from the department
6. Shared listings of proposed projects and sponsors
7. Proper faculty offset and credit for this activity
8. Computer and design shop support
9. Software support, for example the purchase of:
  - a. Designsafe 2.0
  - b. Inventor 5.0
  - c. Total Quality Software
  - d. MATLAB 6.1
  - e. Microsoft Office with Project and Visio and FrontPage
  - f. National Instruments Software suite, including LabVIEW
  - g. iGrafx Process 2003 (Corel Corp.)
  - h. Concept Mapping Software (Institute for Human and Machine Cognition, Univ. of West Florida)
  - i. Innovation Workbench with E-learning and TRIZ basics (Ideation International, Detroit MI.)
  - j. Thomas Regional Industrial Buyers Guide

Other curricula maintain national design competitions. Civil engineers, for example, hold a national concrete canoe competition. Mechanical engineers have several car competitions. Chemical engineers work a common design project. It was felt that a similar competition could be of value to our profession and to our students by providing a common theme on which to compete, and understand what to improve upon if necessary in future competitions. It could provide good publicity, and generate an *esprit des corps* amongst our students.

**Recommendations:** As a result of this meeting, and the discussions held, it was felt that the following items should be addressed:

1. We should consider archiving instructional materials and case studies and create a shared educational infrastructure in a central location (web or otherwise).
2. We should communicate with each other about design via the EMBS magazine.
3. We should follow-up on considering a design competition.
4. We should develop and distribute a survey on design course structure.
5. We should set up an industrial advisory committee, perhaps through one of the national BME societies.

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## **Biographical Information:**

Paul H. King, Ph.D., P.E. is Associate Professor of Biomedical and Mechanical Engineering at Vanderbilt University. He is a licensed Professional Engineer in Tennessee. He is one of the founding members of the Biomedical Engineering department at Vanderbilt. He initiated and has taught the required senior year “Design of Biomedical Engineering Devices and Systems” course for eleven years.

Joan M. T. Walker is a Doctoral Candidate in Developmental Psychology at Vanderbilt University. Upon completing her Ph.D. in May 2003, she will work as a post-doctoral research associate in the Department of Engineering at Vanderbilt. In addition to her master’s degree in Developmental Psychology, Joan holds bachelor and master of music education degrees. Her research interests include self-regulated learning and the role of creativity in design.

Sean P. Brophy received his B.S. degree in Mechanical Engineering from the University of Michigan, an MS in Computer Science from DePaul University, and a PhD in Education and Human Development from Vanderbilt University. Dr. Brophy works with the Learning Technology Center at Vanderbilt to apply current theories of Learning Sciences to improve instruction at various educational levels.

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John Gassert, Ph.D., P.E., is currently a Professor and Vice Chairman of the Electrical Engineering and Computer Science Department at Milwaukee School of Engineering. Prior to arriving at MSOE, Gassert spent seventeen years in industry in positions as a design engineer, a clinical engineer and a consultant.

Paul Yock, M.D., is the Martha Meier Weiland Professor of Cardiovascular Medicine and, by courtesy, Mechanical Engineering at Stanford University. He is Director of the Program in Biodesign, a university-wide research and educational program that focuses on the invention and implementation of new technologies for health. Dr. Yock has also recently been selected as Co-Chair of Stanford’s new Department of Bioengineering.