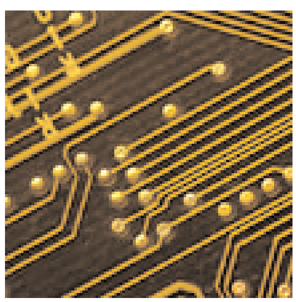
Improving the Technological Literacy of Undergraduates Identifying the Research Issues

A workshop sponsored by The National Science Foundation



Held at the National Academy of Engineering
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Improving the Technological Literacy of Undergraduates
Identifying the Research Issues

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EXECUTIVE SUMMARY AND RECOMMENDATIONS

A workshop on the technological literacy of undergraduates was sponsored by the National Science Foundation (NSF) under grant number DUE-0444677 and convened at the National Academy of Engineering (NAE) on April 18-19, 2005. This workshop sought to identify and define the current research issues regarding the broad understanding of technology by all undergraduates. The workshop format consisted of a dozen presentations by faculty having individually implemented technological literacy courses, followed by group discussions centered around the following focus topics:

- Obstacles to courses on technology.
- Learning objectives and student outcomes.
- Relevant assessment tools and techniques.
- Strategies for developing a scholarly community.
- Potential means of stimulating growth of interest in the topic.
- Implementation in different types of institutions including community colleges.
- Perspectives and issues concerning women, minorities.
- Considerations regarding inclusion of the physically challenged individuals.

Workshop participants included technological literacy instructors from engineering and physics, representatives of other academic areas such as Science Technology and Society (STS), history of technology, education, and the humanities, and representatives from the National Science Foundation and the National Academy of Engineering.

The technological literacy courses presented establish that the subject can be implemented successfully across a wide range of undergraduate institutions. The modest number of campuses offering such courses, estimated at perhaps two dozen, indicates opportunity and need for expansion in order to increase the technological literacy of US undergraduates as both NAE and NSF have recommended.

Among the current courses, several have been taught for more than ten years, others are as recent as one year. Class size varied from ten to several hundred, according to campus. The highest enrollment examples were found at campuses where the technological literacy course fulfilled a technical or science distribution requirement for non-engineering students. Thus the design of technological literacy courses to meet local distribution and curricular needs appears important for gaining course permanence, and in aiding the spread of technological literacy instruction.

WORKSHOP RECOMMENDATIONS

Definitions and dimensions of technological literacy.

Create a Different Terminology for Technological Literacy
The term "technological literacy" has a negative, remedial connotation. A definition is required in language that is broad enough to resonate with a multiplicity of expert, undergraduate, and lay audiences is needed.

Develop an Underlying Theory
Develop a theoretical core or theory-base for technological literacy.

Emphasize Engineering Design as a Creative Process
Creativity and design are themes found in many disciplines and could form the basis of collaborations between engineering and other disciplines for teaching technological literacy.

Teach Engineering Thinking as a Fundamental Outcome
This can occur through any of several contexts such as understanding how things work, analyzing history of technological developments, or study of contemporary issues.

Connect Technological Literacy to Humanities and Social Sciences and to STS
The history of technology and historical context of technological developments are important elements in understanding technology. These topics are not exclusively the domain of any college or discipline; cross-college collaborations are needed.

Develop Links to Other Competency Criteria
Concepts of technological literacy should be linked to the U.S. Department of Labor SCANS Commission on Workplace Skills, and may be link to competencies sought by employers.

Obstacles to initiating and continuing courses on technology.

Lack of peer and administrative support were the most frequently cited resistances. Additional "top down" interest from college and university administrations is needed.

Learning objectives and student outcomes.

The diversity of student learning objectives in existing technological literacy courses reflects the diversity in local definitions of technological literacy. Refining the definition of technological literacy must precede development of consensus learning objectives and student outcomes.

Relevant assessment tools and techniques.

Technological literacy may be defined as appropriate knowledge, skills and attitudes. Assessment possibilities for these attributes need development and testing.

Specific Assessment Needs

Develop a rubric for evaluating socio-technical design projects which involve both social and technical innovation. Develop a reliable method for assessing the ability to make sense of unfamiliar problems. Identify and measure the factors that influence someone to become, or want to become, technologically literate. Develop a way of measuring a decrease in fear of science and technology

Strategies for developing a scholarly community.

Use Existing Organizations

A firm consensus emerged to use existing organizations and groups to develop a scholarly community. Such a community should provide a locus for supporting faculty who teach technological literacy, an acceptable place to publish work, and mechanisms for drawing in other interested groups and institutions such as International Technology Education Association (ITEA). In response to this recommendation, The American Society for Engineering Educations (ASEE) created in June of 2005 a Technological Literacy Constitutive Committee whose first program will occur at the 2006 Annual Meeting.

Assess Faculty Crossing Boundaries and Cross-College Efforts

Develop protocols for assessing scholarly contributions of faculty who cross disciplinary boundaries in research, teaching, or scholarly activities. This would include faculty who are teaching with non-engineering faculty or teaching non-engineering students.

Potential means of stimulating growth of interest in the topic.

A new NSF program to stimulate faculty interest was ranked as the strongest choice, a not unexpected result , given the logic and the NSF workshop sponsorship. There is need for a best practice collection of easily adopted materials, not just a journal devoted to the topic. A loosely organized user affiliation such as a Yahoo group would facilitate communication among peer groups of instructors. Development of textbooks around a well-defined core would facilitate offerings in both four year and community colleges.

Implementation in different types of institutions including community colleges

In many ways, the institutional issues are not unique to technological literacy. Respondents felt that smaller, liberal arts campuses might be easier locations to initiate new courses. Implementation in community colleges must include minimizing the preparation time needed by instructors, especially for laboratory activities.

1. PREFACE: Technological Literacy for Undergraduates

The understanding of technology by American citizens has been described as "woefully inadequate[1]," by William Wulf, President of the National Academy of Engineering. The central nature of technology in our daily lives and our dependence upon technology products and processes is readily apparent. In its recent publication, "*Technically Speaking*[2]," the National Academy of Engineering has established the national importance that all Americans understand and appreciate our technological infrastructure.

This call for technological literacy has resulted in some action; however the national efforts are just beginning and are directed toward the pre-college population. The International Technological Education Association (ITEA) with support from the NSF and NASA has produced a set of standards, directed at K-12 students, which help define the concept of technological literacy[3]. ITEA is also working to develop program and assessment standards and curriculum materials for the K-12 audience[4]. The American Association for the Advancement of Science (AAAS) incorporates technological literacy as part of the standards developed through Project 2061: Science for All Americans.[5,6]

The engineering community has responded enthusiastically to the need to increase the awareness and understanding of engineering as a career by initiating a number of programs aimed at the K-12 audience. A recent example is the American Society for Engineering Education's (ASEE) publication, *Engineering Go For It*[7], and a website[8] aimed at a K-12 audience. Most major engineering societies now have outreach activities for K-12[9-12]. Additionally, commercial interests have identified understanding technology as marketable product. For example, the website "How Stuff Works[13]" is illustrative of some of the new internet-based information resources that are available.

The college-age non-engineering student however, has not received a similar level of attention. If technological literacy is important, it must be included as an aspect of a liberal education at the college level. Efforts at technological literacy cannot stop at the 12th grade. A modern and meaningful presence in the college years must be established.

The last major initiative to address technology literacy among undergraduates was the Sloan Foundation's New Liberal Arts Program[14,15]. It has been nearly two decades since this initiative ended. The New Liberal Arts Program was completed just as the Internet was becoming widespread, the audio compact disk was a novelty, and the vast array of digital devices which now permeate daily life were just appearing in crude form. Rising on the technological horizon today are such opportunities and challenges as revolutionary biomedical engineering, products at the nanometer scale, ever more ubiquitous computers, and a potential transportation revolution via commercially viable hybrid automobiles. Also occurring in the past 20 years are major changes in assessing educational outcomes[16,17], consolidation in understanding how people learn[18], and a revolution in the criteria used by ABET to accredit engineering programs.[19] In addition, expertise and experience in related areas such as educational assessment and web-based dissemination have matured, and is highly relevant to progress in any area of undergraduate education. In light of these substantial developments, it is time to reconsider technological literacy among undergraduates.

Technological literacy should address the needs of the undergraduate population, the majority of which is not intending a career in science or engineering[20]. This group will be consumers and decision makers about technology. Today's undergraduates are just years, or even months, away from being handed full responsibility as participants in the economy and as national and international citizens. In a world with few certainties, one would appear to be that technology is assuming ever more prominence in both daily life and public policy.

Engineers hold one of the central roles in the development of modern technology. The creation of technological products is the primary task of the profession. As such, engineers should take on an equally central role and responsibility in establishing understanding of technology by the public. The academic engineering community has a responsibility to address the needs of all undergraduates.

Technological literacy efforts will lead into unfamiliar territory for everyone. While the understanding of technology by American citizens is "woefully inadequate," engineering departments have displayed comparable inadequacy in finding and fulfilling an educational mission that includes service to all undergraduates. However, just as technological literacy can offer compelling benefits to all Americans, engineering programs taking leadership in this effort may realize substantial benefits in their self interest. Success in helping all students achieve a sense of empowerment rather than aversion to technology will help increase the prominence of the engineering profession in the public eye. Furthermore, technological literacy classes open to all undergraduates have the potential to recruit students of diverse interests and backgrounds into the engineering profession. It may be that this pool of students will prove to be the source of the talents, abilities, and ways of thinking seen as vital to the future of the American engineering profession itself.

The time has arrived to move forward in this area. While activity by engineering educators has not been widespread, a number of individuals have worked steadily on aspects of the topic and have accumulated encouraging results. This workshop brings together individuals who have successfully implemented courses at the undergraduate level and representatives of other disciplines who can offer relevant perspectives and key insights. The purpose of this workshop is to distill the experiences of the group, identify research issues at the undergraduate level, and catalyze progress in this area.

2. WORKSHOP CHARGE

A workshop sponsored by NSF was convened with participants including engineering faculty active in the area of undergraduate technological literacy and other individuals with a range of experience relevant to success in this topic. The group included individuals of diverse perspectives and backgrounds.

The purpose of the workshop was to help identify the research issues and help to frame a national agenda for a new effort to address technological literacy at the undergraduate level.

Topics of discussion included:

- Review of successful implementations.
- Obstacles to courses on technology.
- Learning objectives and student outcomes.
- Relevant assessment tools and techniques.
- Strategies for developing a scholarly community.
- Potential means of stimulating growth of interest in the topic.
- Implementation in different types of institutions including community colleges.
- Perspectives and issues concerning women, minorities.
- Considerations regarding inclusion of the physically challenged individuals.

David Ollis of North Carolina State University and John Krupczak from Hope College were co-investigators. Responsibilities of the investigators included: finalizing a list of potential participants, inviting the participants, preparing the meeting agenda, identifying and compiling a collection of pre-workshop material, and conducting the workshop. At the conclusion of the workshop the investigators prepared this summary.

The workshop was conducted over two days of April 18-19, 2005. The venue was the National Academy of Engineering, Washington, DC.

3. PRECONFERENCE QUESTIONNAIRE SUMMARY

Prior to the Workshop on Technological Literacy, the prospective faculty participants were surveyed to capture their key thoughts with respect to the various issues to be addressed jointly in group discussions within the workshop program. In this manner, the opinions and views of all academic participants could be collated and presented to each working group at the workshop.

All participant responses to the preconference questionnaire appear verbatim in Appendix C. The summary below represents the author/investigators efforts at crystallization of major themes within each area addressed. However, the wide range of thoughtful and diverse insights of the participants is best represented by the verbatim responses in Appendix C.

TOPIC 1: Obstacles to courses on Technology Literacy

Technological literacy courses, like any other undergraduate offering, require commitment of resources for space, instructional salary, and intellectual ownership of the subject mater by instructor and department. A lack of commitment in any area is viewed as an “obstacle.” Faculty were asked to respond to a series of negative statements. Results are summarized in Table 1. A total of 25 people responded. Approximately half of all responders DISAGREED with statements indicating a lack of support from peers, heads, or deans. The level of perceived obstacles decreased in the following order: Faculty take no ownership (43% agree), head takes no ownership (41%), engineering in general takes no ownership (36%), dean takes no ownership (33%), lab space not available (24%), and salary not available (22%). Thus, faculty peers and administrative lack of ownership were perceived to be the greatest challenges. Nonetheless, a full fifty percent or more of all responders felt that these issues were not major obstacles on their campuses.

Table 1: Results from survey question concerning obstacles to courses on Technology Literacy (25 total respondents)**.**

	Question	Agree	Neutral	Disagree
a	The dean takes no responsibility for this topic on his/her campus	35%	13%	52%
b	Department heads take no responsibility for this topic on their campus	41	9	50
c	Faculty take no responsibility for ownership of this topic	43	10	48
d	Laboratory space for demonstrations and devices is not available	24	19	57
e	Funding for instructional salary is not available	22	30	48
f	Engineering in general does not take ownership of this topic	36	14	50

Beyond the obstacles listed on the questionnaire (see Appendix), other obstacles or resistances mentioned were the following (# respondees indicated in parentheses): lack of faculty reward or incentive to teach technological literacy courses (5), lack of intellectual recognition of technological literacy courses (5), lack of non-technical student interest (2), Technological Literacy course does not satisfy STS distribution requirement (2), lack of "service course" tradition within engineering(2), intercollegial resistance (1), cost of labs, devices, materials, etc) (1), insufficient faculty time (1), and teaching materials not readily available (1).

In summary, lack of peer and administrative supports were the most frequently cited obstacles, with other potential obstacles in the 5-25% responses zone.

TOPIC 2: Learning Objectives.

Within the context of engineering education, student learning objectives are important as they provide the basis for outcome-based assessment: did student learning result in achievement of the desired outcomes? Four of the participants submitted student learning objectives which provided a level of detail suitable for assessment and evaluation. These are summarized below. While some commonality exists, the diversity of student learning objectives is appreciable, reflecting lack of an accepted definition for "Technological Literacy."

Student Learning Objectives (four examples)

1. Technology and the Human Built Environment (K. Vedula)

   Students will develop:
   a. an understanding of the nature of technology including relationships among technologies and the connections between technology and other fields.
   b. an understanding of Technology and Society including the cultural, social, economic and political effects of technology; effects of technology on the environment; role of society in the development and use of technology, and influence of technology on history.
   c. abilities to apply the design process, use and maintain technology and assess the impact of products and systems.
   d. an understanding of the design world including selecting and using medical technologies, agricultural and biotechnologies, energy and power technologies, information and communication technologies, transportation technologies, manufacturing technologies and construction technologies.

2. Engineering in the Modern World (M. Littman)

   Students will
   a. develop an understanding of the transformation of the modern world through engineering (e.g., agriculture to industry, isolated to connected, etc.).
   b. define modern engineering through examples of innovations (structures, machines, networks, processes from the start of the industrial revolution to the present); understand the historical context (political, social, economic) for engineering innovation; understand the underlying science; recognize the influence of technology on society as expressed by artists (painters, photographers, writers).
   c. develop an understanding of the key people who were responsible for engineering innovations-what they did, when they did it, and why they were successful.

3. Science and Technology of Everyday Life (J. Krupczak)

Students will:

a. understand the basic principles of electricity, magnetism, light, sound, and mechanics as applied in familiar technology. Know the fundamental scientific and engineering principles applied in familiar technology.
b. understand key technological inventions and innovations and the ideas embodied in these technological devices.
c. develop an ability to find and interpret technical information as it pertains to issues of importance to the non-engineering student. Be able to evaluate and combine technical information from several sources. Demonstrate an ability to build upon a knowledge base developed in the class.
d. be able to transfer knowledge to new contexts beyond the classroom.
e. increase interest, motivation, and self-efficacy for understanding science and technology.

4. Technology Literacy: How Stuff Works (D. Ollis)

Students will:

a. develop a basic vocabulary and conceptual framework for describing the technical and historical origins of modern technological devices.
b. explain the conceptual operating bases of current and prior technologies which address similar societal needs.
c. use and dissect devices to develop understanding of the relationships between technical subsystems of a device (e.g., the optical, electrical, and mechanical subsystems of a facsimile (FAX) machine), and their influence on device design and operation.
d. develop and understanding of the impacts (technical, economic) of a device in a given context, through lecture and individual analytic written papers.

These four examples of learning objectives all relate strongly to Nan Byar's 1998 proposed definition of technology literacy,[27] and her associated expected outcomes:

"Technology Literacy: A Working Definition: The ability to understand, intelligently discus and appropriately use concepts, procedures and terminology fundamental to the work of (and typically taken for granted by) professional engineers, scientists, and technicians; and being able to apply this ability to:

a. critically analyze how technology, culture and environment interact and influence one another.
b. accurately explain (in non-technical terms) scientific and mathematical principles which form the basis for important technologies.
c. describe and, when appropriate, use the design and research methods of engineers and technologies.
d. continue learning about technologies, and meaningfully participate in the evaluation and improvement of existing technologies and the creation of new technologies.[24] "

Teaching materials were an item of concern on several of the questionnaires. The textbooks used in the individual courses are listed below. These again indicate a wide variety of usage, and illustrate the relative lack of central focus among the current technology literacy courses.

Table 2: Sampling of Texts Used Within Conference Courses on "Technology Literacy."

Course	Book
Explore Engineering	(instructor materials)
Technology and Human values	Volti, Society and Technological Change Teich, Technology and the Future
The Hidden World of Engineering	(instructor materials)
Science & Tech of Everyday Life	Macaulay, The New Way Things Work Bloomfield, How Things Work
The Digital Information Age	Kuc, The Digital Information Age
Technology and Western Culture	(multiple sources)
Electrical Fundamentals and Applications	Boyles, Introductory Circuit Analysis Tokheim, Digital Electronics Frenzel, Electronics Communication Systems
Engineering in the Modern World	Billington, Innovators
Technology 21	(multiple)
Women in Mathematics and Science	(instructor materials)
Technology and the Human Built World	Hacker & Berghardt, Technology Education - Learning by Doing Constable and Somerville, A Century of Innovations

TOPIC 3: Assessment Tools and Techniques.

Most presenters used several assessment tools and techniques. The average number of tools and techniques per course was about 6, probably larger than the average number used within a typical engineering course. Shown in Table 3 are the most common along with additional individual approaches indicated in category (i), and including individual or team-written term papers, web-based projects, lab reports, robot simulations, and book analyses.

Table 3: Summary of Assessment Tools and Techniques.

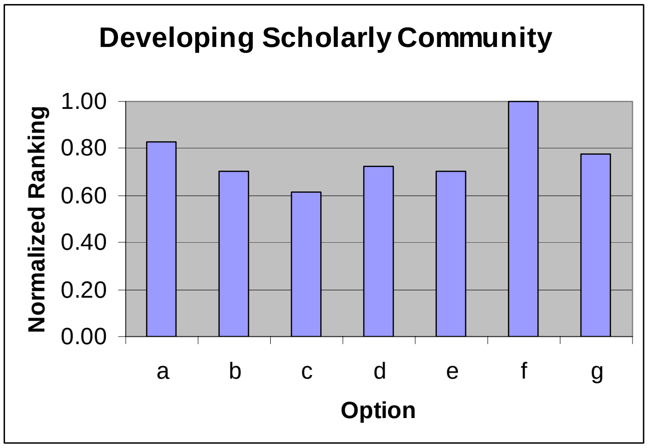
	Method	YES	NO
a.	Pre/post course student survey	5	5
b.	Student interviews	7	2
c.	Formative course assessment	7	4
d.	Summative course assessment	9	3
e.	Written exams	10	2
f.	Oral presentations	8	3
h.	Lab team performance	9	2
i.	Other: individual (1) or team-based (1) term paper Web-based projects (1), lab reports (1) robot simulations(1), book analyses(1)		

The lack of a consensus definition for technological literacy noted earlier makes comparison of evaluations among different courses awkward. Similarly, the relative lack of student learning objectives also diminishes the potential effectiveness of the evaluations for other courses presented, since the student themselves may not have been aware of the instructor expectations in all cases.

TOPIC 4: Strategies for developing a scholarly faculty community in technological literacy.

Among the questionnaire choices for this topic, the creation of a new program at NSF received largest emphasis. Relative to this response, all other possibilities listed in the questionnaire received respectable endorsements as well. Results are summarized in Figure 2. In decreasing frequency of mention, these were: form new ASEE or FIE interest group (80%), form new groups within the professional disciplinary societies of AIChE, ASME, IEEE, ASCE, etc. (70%), publish scholarly papers on technological literacy courses (75%), create new column in periodical (e.g., PRISM) (70%), present talks at annual and deans' conferences (70%) and form new annual conference on this topic (60%).

Question 4 : STRATEGIES FOR DEVELOPING A TECHNOLOGY LITERACY SCHOLARLY (RESEARCH) COMMUNITY OF FACULTY.



Higher number = more promising. Normalized to score of highest ranked option.

Option	Explanation
a	Form new ASEE and/or FIE interest group/division
b	Form new group/division at other professional societies, especially IEEE, ASME, ASCE, Am. Inst. Phys.
c	Form new annual conference on topic
d	Create a new column in periodical, e.g., PRISM
e	Present at annual Engineering and Science Deans' conferences
f	Form new NSF thrust in Technological literacy area
g	Submission of scholarly articles on Technological literacy courses to journals (J.Eng. Ed, Int'l. J. Eng'g. Ed., Physics Today, etc)

Individual participant suggestions included exhortations to use existing organizations and groups to maximum possible extent. It was also suggested that those interested engage general educational forums, not just engineering faculty.

As detailed in a later section of this report, in the April 2005 workshop discussions, the participants voted to encourage ASEE to create a Technological Literacy Constitutive Committee. One participant, Sherra Kerns, President of ASEE, carried this request to the ASEE board, with positive results: a Technological Literacy constitutive group was authorized, and at the June 2005 ASEE annual meeting in Portland OR, the Technological Literacy constitutive group (TLCG) was formed, by-laws established, and officers were elected.

TOPIC 5: How to stimulate faculty interest in teaching TECHNOLOGICAL LITERACY COURSES (TLCs)?

Again, founding of a new NSF program to stimulate faculty interest was ranked strongest. This result was not unexpected, given both the logic itself and the NSF sponsorship of the technological literacy conference. Reasonably strong endorsements were also recorded for the following options, relative to NSF new program formation:

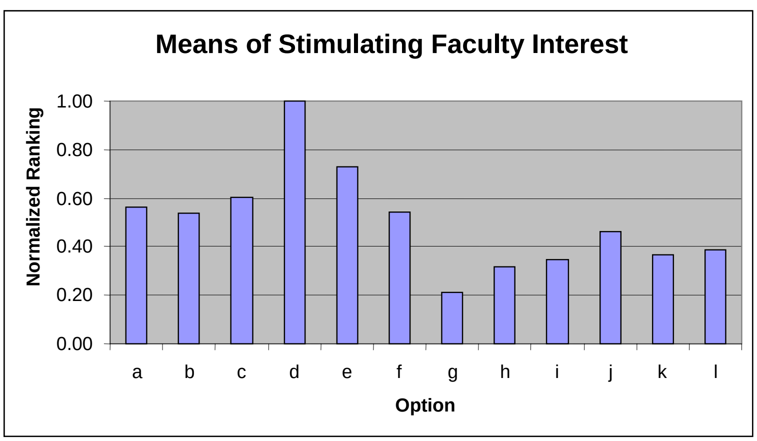
- Create and maintain of TLC website with materials (70%).
- Create of ASEE disciplinary sessions on TLCs (60%).
- Increase professional society presentations (55%).
- Form new ASEE division (55%).
- Disseminate (CDs, videos, etc) of TLC materials to campuses (55%).
- Partner with colleagues in other colleges (on same campus) (50%).

Substantially fewer endorsements were received for:

- Broaden use of TV documentaries, videos, etc on technology (30%).
- Broaden use of existing texts (35%).
- Partner TL instruction with device dissection labs (38%).
- Publish scholarly papers (40%).

The creation of additional funding venues for technological literacy at NSF remains the strongest suggestion, as found for the previous question: "How to stimulate formation of a scholarly community." This outcome also parallels a similar recommendation from the NAE study "Technically Speaking[2]."

Question 5: POTENTIAL MEANS OF STIMULATING GROWTH OF FACULTY INTEREST IN TEACHING TOPIC.



Higher number = more promising. Normalized to score of highest ranked option.

Option	Explanation
a	Professional society presentations
b	ASEE new division formation
c	ASEE disciplinary sessions on technological literacy courses
d	New NSF thrust in Technological literacy area
e	Creation and maintenance of Technological literacy website for teachers (to contain links to all known technological literacy courses/campuses/instructors)
f	Dissemination of materials inventory (websites, books, radio/TV programs and videos/CDs) to campus faculty and administration
g	Broader use of existing radio presentations in undergraduate courses.
h	Broader use of existing TV documentary (PBS videos/CDs, etc) in courses
i	Broader use of existing texts (Bloomfield, Billington, Petroski, Lienhard, Florman, etc) in courses
j	Partner teaching and research with colleagues in other colleges e.g., history (of science/technology), industrial design, technology education, etc.
k	Partner teaching Technological literacy with instructors of "device dissection " labs.
l	Submission of scholarly articles on Technological literacy courses to journals (J.Eng.Ed, J. Int'l. Eng'g., Physics Today, etc)

TOPIC 6: Implementation in different types of institutions including women's colleges, HBCUs, and community colleges.

Respondents felt that smaller, liberal arts campuses might be easier locations to initiate new courses. Technological literacy should be addressed "across the board" at all types of institutions (research, undergraduate, liberal arts, HBCUs, and community colleges) in a manner consistent with the university mission. Being able to satisfy some portion of the general education graduation requirements for non-engineers is seen as critical to technological literacy courses being successful. Getting a new course into the general education curriculum can be difficult in any type of institution and often requires persistence and ingenuity on the part of the faculty desiring to teach such a course.

Individual responses included the following:

- For technological literacy courses on single-sex campuses, women feel freer to contribute to technology. Emphasis of the social and historical context provides an opportunity to highlight contributions by women, minorities, and persons with disabilities.
- For widespread implementation across different types of institutions, technological literacy courses will need to be both standardized and adaptable.
- Such courses must be taught at ALL higher education institutions. Community colleges, all female campuses and HBCUs are particularly critical in order to reach a diversity of student body.
- Have students DO ENGINEERING was important (hands-on, design, possibly test and build). This is critical regardless of the institutional context.

TOPIC 7: Perspectives and issues concerning underrepresented groups.

Respondents noted that technological literacy courses have the potential to serve as a recruitment vehicle for underrepresented groups. Technological literacy course may help make engineering concepts familiar, relevant, and engaging. By incorporating historical perspectives it is possible to demonstrate that minorities and women have always been active in developing technology, although these contributions have not always encouraged or recognized. It was pointed out that the rest of the engineering curriculum may need to be adapted to be similarly engaging otherwise members of under represented groups may be not be retained.

Individual responses included the following:

- To the extent that technological literacy courses emphasize social and historical contexts, they provide an opportunity to highlight contributions by women, minorities, and persons with disabilities and may help recruit and retain members of these groups.
- Technological literacy can be taught at the high school level as illustrated by "The Making of an Engineer" (ASEE).
- Technological literacy courses could make science and technology more socially acceptable. The topic is least popular among males in under-represented groups.
- Use past inventions and injustices to show that minorities have long been active in technology and science.
- Technological literacy courses may have no impact in interesting underrepresented groups in technology. However, courses and summer programs to recruit women into engineering can work if done properly.
- It would help to make science and technology literacy more socially acceptable. The current anti-intellectual climate of society is even worse among the under represented groups (except among women, who are probably less anti-intellectual on average then men).

TOPIC 8: What aspects of humanities and social sciences should be included within Technological Literacy Courses?

Most respondents indicated that understanding something of the history of science and technology and the societal impacts of technology should be included within technological literacy courses. Another major view recommended for inclusion is developing recognition that technology is value laden and must be examined within a specific social and cultural environment. A sampling of verbatim responses is included below:

- History of science and technology. Societal impacts of technology. Ethics in science and technology.

- Technology is inherently value laden, thus cannot be taught outside of societal context.
- Historical context; discussions and structured controversies, local and global impact. Students must see connection to real world.
- History and developments of technology and engineering.
- Connectivity: engineering influences, and is influenced by, politics, economics, and society.
- Need to relate Technological literacy to STS (very relevant).

TOPIC 9: Research Issues Associated with Technological Literacy.

In the pre-conference survey of research questions, participants responses could be roughly grouped into three categories. There were issues related to teaching and pedagogy, issues concerning the theoretical basis for the body of knowledge that defines technological literacy, and questions concerning the significance of being technically literate and the impacts on society of a literate citizenry. A complete list of all responses can be found in the Appendix C. Representative responses are summarized below.

It was also suggested that a helpful perspective on this issue is to consider what can be learned from science literacy efforts.

<u>Teaching and Pedagogy</u>

- How to keep the costs down and teach a good course that is hands-on and experimental?

- Explore student learning styles vs. the various formats for "Technological literacy" instruction present at the workshop.

- Affect of technological literacy courses on engineering enrollments and retention.

- How can technological literacy gain traction in a discipline-driven environment?

- The differences in the pedagogy of teaching technological literacy; in particular, identifying the prior knowledge base and assisting the students in organizing the new knowledge in relation to their prior knowledge.

- Preparing teachers for promoting the importance of technological literacy. Also encouraging their students to seek technological careers.

- Explore how/if material devices and their manipulation enhances learning, and why.

- Study how non-technical people learn about technology and science. What can you expect them to learn, what do they want to learn, and what will they find useful.

- How does an understanding of the dynamics of becoming technologically literate (i.e., learning to be) support engineering/science education?

- How to best improve the skills of non-technical educators so that they are able to teach introductory courses in technology and engineering? How to best improve the skills of technical educators so that they can bring a larger societal perspective to their teaching?

- Are there inherent pedagogic differences in teaching technology literacy versus other curricular content? If so, how do those differences affect instruction? How should instruction be modified to promote effective learning within technological literacy courses?

- Assessment of abilities and skills related to technological literacy. Methodology for teaching technological topics to diverse groups of learners.

Underlying Theoretical Issues

- What constitutes technological literacy? Can we define the body of knowledge or the process of acquiring the knowledge?

- Development of new curricula in engineering stressing the scientific, social, and symbolic aspects of engineering as taught through history, science, and art.

- What fundamental courses are needed to provide a foundation for technology literacy courses in engineering?

- Integration of technological content with social science topics. Finding ways of integrating the technological component of social issues with more standard presentations of material.

- How can the social sciences encompass technology literacy as a fundamental part of a liberal education?

- Must recognize the need to work with engineering faculty to develop the scope of what is technical literacy, and start paying more attention to technical literacy at the university level.

- Explore scientific analysis vs. engineering creativity. What are the missing dimensions of engineering self-representation which could make the field intellectually richer?

Impacts of Technological Literacy

- How is public understanding of engineering affected by various modes of technological literacy instruction? Does early exposure to technological literacy topics affect interest or aptitude in traditional engineering courses?
- How does technology/science literacy affect peoples' lives?
- Focus on outreach and CULTURAL change /perceptions.
- The political impact of technological development in emerging countries.
- Impact of technological literacy on society: benefits in the social, economic and political dimensions.
- Does participation in technological literacy courses affect (increase/decrease) public anxiety about the uses of technology? How does delivering technological literacy courses affect the attitudes and viewpoints of engineering faculty toward communities of non-engineers? Does teaching such courses affect the interactions among engineering faculty?
- In what social contexts can technological literacy be meaningfully used? How does technological literacy relate to the democratic management of technology?
- Examples of engineers and inventors, their upward social movement, and their impact on their society. Successes and failures of engineered systems.

TOPIC 10: Formation of Technological Literacy advocates.

Workshop participants identified a variety of potential advocates including societies, university administrators, faculty, students, and government. No consensus emerged, however, the following response (for all others, see appendix) reflects what became the major post-workshop accomplishment to date: establishment of recognition of Technological Literacy as an interest domain of ASEE:

"Ideally, a (more) broad based group such as the American Society for Engineering Education (ASEE) should be home to the technological literacy effort. Modern technology is created primarily by engineers. Technological literacy work should originate within an engineering society. The ASEE, as an interdisciplinary organization with an educational focus would seem the most appropriate home rather than a specific engineering disciplinary society such as ASME or IEEE. The ASEE also has a history of participation by non-engineering professionals in such divisions as ERM (Educational Research and Methods), LED (Liberal Education Division), and EECC (Engineering Ethics Constituent Committee)."

Other societies which could be approached for collaboration and session development, etc, including the Society for History of Technology, and the American Physical Society. The latter discipline has two advantageous characteristics for the advancement of technological literacy: physics is taught on almost all US campuses, whereas engineering is limited to perhaps 350 sites. The physics text, The Physics of Everyday Life by L. Bloomfield (University of Virginia), is in use at over 200 schools, making it the most widely used text on the technological literacy market, limited as it is. Strategically, the ASEE should build alliances with these groups, as well as the societies representing community colleges and HBCUs. Formation of a freestanding society of technological literacy advocates does not appear promising, as adequate current institutions exist for presentation and dissemination of technology literacy courses, workshops, and materials. The establishment of the fledgling Technological Literacy constitutive interest group appears to be the best test case: if this group can establish division status within three years, it would signal sufficient interest within ASEE to become a permanent activity and area of ASEE influence. If such interest cannot be maintained within this ASEE community then there appears little likelihood of success elsewhere.

4. SUMMARY: TECHNOLOGY LITERACY COURSES

The technological literacy courses presented at the workshop showed substantial variety and focus in subject matter and approach. This character is illustrated best through the simple course summaries presented below (alphabetical by instructor). Table 5 summaries principal components of some technological literacy courses.

Table 5: Technology Literacy Course Summary: Principal Components.

Instructor	Semesters	Units	Lectures/wk	Laboratory	Demos	Co- taught
Baish	one	1	3	no	yes	w/eng'g and liberal arts, sociology
Balmer	one	3	3	some	some	w/liberal arts faculty
Bloomfield	one	3	3	no	yes	no
Hammack	one	3	2	no	no	no
Krupczak	one	4	3	yes	yes	no
Kuc	one	3	2	yes	yes	no
Mechtel	two	4	3	yes	yes	with other engineering
Littman/ Billington	one	3	2	yes	yes	yes
Ollis	one	3	2	yes	yes	no
Rosa	3 quarters	4/q	3	yes	yes	w/other engineering
Shraibati	one	3	3			
Whitman	summer	3	4	yes	yes	yes

The following examples illustrate that technological literacy courses have been successful across a wide range of undergraduate institutions types.

"Designing People," James Baish, Bucknell University [21]

In this foundation seminar, students will explore the design process. They will study the elements of past designs and engage in design themselves. They will work as individual designers and as part of a design team. They will undertake a design project to address an important human need in today's society.

A major segment of the course will focus upon the evolution of the automobile as an example of human design. Questions about the real versus created need will be asked. The interaction of design with economics, social structure, politics and engineering capabilities will be studied. The elements of style and aesthetics will be assessed including the presence of gender differences. Several field trips are planned to museums in order to see and evaluate past designs, and to modern manufacturing facilities to see how design is employed today.

It was found that design projects were technically accessible to all types of students without the need for highly specialized quantitative methods. Rule-of-thumb techniques made the design process accessible to math-averse students. While a challenge, limited mathematics background was not a barrier. The course appealed to a broad range of students. Meeting a university degree requirement was found to be an important element in establishing enrollments.

"Converging Technologies," Robert Balmer, Union College [22, 23]

Converging Technologies are the new and often unforeseen technologies that appear at the boundaries between of traditional fields of study. Starting in 2001, Union College began implementation of a Converging Technologies initiative. Since then approximately 30 new courses have been introduced. In each interdisciplinary area, courses are open to both engineering and liberal arts students. Course topics include: Bioengineering and Computational Biology, Entrepreneurship, Mechatronics, Nanotechnology, Neuroscience, Pervasive Computing, and Science, Medicine and Technology in Culture

The Converging Technologies Program is well integrated into Union College curricula. Notable results include: creation of approximately 30 new courses, creation of one new converging technologies major and four converging technologies minors, integration of converging technologies material into numerous existing courses, appointment of a converging technologies director and designation of a building to be remodeled as a Center for Converging Technologies, establishment of an external converging technologies advisory board. This program has received the support of the college Board of Trustees and is now considered one of the pillars of excellence of Union College.

“How Things Work, Physics 105 and 106,” Louis Bloomfield, University of Virginia [24, 25]

For non-science majors. Introduces physics and science in everyday life, considering objects from our daily environment and focusing on their principles of operation, histories, and relationships to one another. Physics 105 is concerned primarily with mechanical and thermal objects, while Physics 106 emphasizes objects involving electromagnetism, light, special materials, and nuclear energy. They may be taken in either order.

The course was designed for non-scientists and built around everyday objects. The course became exceptionally popular. For more than a decade, 500 students took the course each semester, however enrollment is now capped at 200 students. The impact of the course *How Things Work* has been widespread. At the University of Virginia, many non-science students who would otherwise have no exposure to physics are now learning physics and finding it useful. There is less fear of physics indicating a significant cultural change. Physics has become a valued part of the university curriculum, and other physics courses are flourishing. The *How Things Work* textbook which grew out of the course has been used in over 200 other colleges and universities.

“Technology and Human Values,” Stephen H. Cutcliffe, Lehigh University

This course addresses the impact of technology on society in relation to ethical problems raised by the exploitation of technological innovations. Material includes illustrations from history, social studies, philosophy, literature and film. The course satisfies the institutional STS requirement.

“Science at Work: Technology in the Modern World,” Kate Disney, Mission College [26].

This course is designed for students of all disciplines who are interested in principles and applications of science. Students will experiment with technological applications to discover scientific principles. Concepts of science discovered through experimentation and observation include: force, work, and power; the conversion of energy and the transmission of power; Newton’s Laws; thermodynamics and heat engines; Faraday’s Law of induction; Radiation; atomic mass energy; and materials science. Students will dissect an engineering system after the instructor provides a presentation and/or demonstration or the related scientific theory. Experiments will enable students to verify or disprove their initial hypothesis as to how the system functions and employs science. There is a Credit/ No Credit option

"Fuel Cell Systems," Camille George, University of St. Thomas [28]

A discovery-oriented pedagogy devoted to all aspects of fuel cells: types, operation, design, safety, economics, policy & implementation. The class will examine the chemistry, physics, design, system integration, energy analysis and cost of fuel cells. Considerable time will be spent on hydrogen generation, storage & distribution. Class will follow the 'inquiry- based learning' pedagogy, not the traditional lecture/exam model.

"If you are interested in energy policy & the new hydrogen economy, join us. **No prerequisites.** *All interested students are encouraged to enroll!"*

"The Hidden World of Engineering," William Hammack, University of Illinois at Urbana-Champaign [29].

Simple objects shape our lives, yet are engineering masterpieces. To unveil this hidden world, the course uses a humanistic approach. Designed to appeal to all majors, it uses human stories - filled with failures and triumphs - to reveal the methods of engineers. The course enchants with tales of ancient steel making, today's pop cans, huge stone monuments, and salt. The course will change how a student looks at his or her world. Several sessions focus on women engineers and the environment.

This course for non-engineers attracts 60% business majors and 40% from other majors. An emphasis is placed on engineering decisions or choices: Why did an engineer decide to design an object in a particular way? Bill Hammack also created the *Engineering and Life* program on public radio which reaches beyond the classroom to a mass audience.

"Science and Technology of Everyday Life," John Krupczak, Hope College. [30,31]

This course studies the wide variety of technology used in everyday life. Modern society would not exist without the aid of technology. We depend upon technological devices for communication, food production, transportation, health care and even entertainment. The course objectives are to develop a familiarity with how various technological devices work and to understand the scientific principles underlying their operation. Topics covered include the automobile, radio, television, CD players, microwave ovens, computers, ultrasound, and x-ray imaging. Concepts from basic science are introduced as they appear in the context of technology. Laboratory projects include construction of simple objects such as radios, electric motors, and a musical keyboard.

Since its introduction in 1995, this course has been taken by more than 1000 non-engineering students, participants were 60% women and 26% preservice teachers. To evaluate student outcomes, the Motivated Strategies for Learning Questionnaire (MSLQ) was applied. Statistically significant increases were found in intrinsic motivation, task value, and self-efficacy. A decrease in test anxiety was also found. These results show that non-engineering students can have increased motivation for learning science and technology, increased perceived value for science and technology, and increased self-confidence about learning science and technology.

"The Digital Information Age," Roman Kuc, Yale University [32,33]

An introduction to information transmission and storage and their impact on society. Technological issues and trade-offs that affect the design of communication systems. The binary number system, elementary computer logic; digital speech and image coding on compact disks; information transmissions-from touch-tone telephones to modems and faxes to World Wide Web; UPC bar codes, and a glimpse into the future. Projects include implementing a single digital system and Web pages. Intended for students in the humanities and social sciences and for freshmen considering an electrical engineering major. No prerequisites other than a working knowledge of elementary algebra.

Course enrollment reached 500 students per year making this one of the largest and most popular classes at Yale. Positive student response includes a sense of empowerment through having developed an understanding of how information systems work. Many of the students reported this the most worthwhile course they had taken at the University.

"The Engines of Our Ingenuity," John H. Lienhard, University of Houston [34-36]

The Engines of Our Ingenuity is a daily radio program that is carried nationally on some 46 Public Radio stations as well as other markets. Associated with it is a website that gets approximately third of a million page hits per week and is widely used in schools[34].The radio program that tells the story of how our culture is formed by human creativity.

Engineering in the Modern World," Michael Littman and David Billington, Princeton University [37].

Among the works of concern to engineering are bridges, railroads, power plants, highways, airports, harbors, automobiles, aircraft, computers, and microchips. Historical analysis provides a basis for studying urban problems by focusing on scientific, political, ethical, and aesthetic aspects in the evolution of engineering over the pasts two centuries. The precepts and the papers will focus historically on the social and political issues raised by these innovations and how they were shaped by society as well as how they helped shape culture.

The class attracts many first and second year students. Engineering students can take the course to satisfy a "historical analysis" graduation requirement. The course is conducted using the language of science and mathematics, including heavy use of formulas. Despite the use of mathematics and a laboratory component, about one-fourth of all Princeton non-science majors take this class.

"Electrical Machines and Information Technology Systems," Deborah Mechtel, United States Naval Academy [38]

Modeling and analysis techniques are applied to rotating electrical machinery. Basic principles of digital logic circuitry and computer architecture are introduced. The principles of analog and digital communications are presented, including common digital modulation techniques. Link budget analysis and satellite communications principles are presented. Other topics include network topology, connectivity, routing, queuing, bandwidth, spectrum utilization, the OSI Model, TCP/IP, and the Internet.

All students at the Naval Academy, regardless of their major, must take two electrical engineering courses. These courses are taught to more than 600 students each year. The results show that students across range of majors can achieve a level of knowledge comparable to engineering students. Because the material is strongly related to naval applications, the midshipmen see this knowledge as important to them. All students have the necessary prerequisite knowledge since all students also have three semesters of calculus before taking these classes. Success is also based on a supportive laboratory environment and class sizes that facilitate individual attention if needed. Students respond positively to a obtaining an in-depth understanding of electrical engineering topics. A non-engineering student learning about radar remarked: "I have wanted to know this for so long." This is a frequent student response.

"Technological Literacy: How Things Work," David Ollis, North Carolina State University. [39]

Lecture survey on evolution and current status of thirteen modern technologies involving electricity, information, sound, light, imaging, recording, engines, materials, and language codes. The laboratory allows both lecture-demonstrations and team-based explorations of modern technologies. Lab topics include cell phones, electric and acoustic guitar, FAX machines, optical fibers, engines, Internet search engines, CD systems, photocopiers, video cameras and digital cameras, satellite TV, and water purifiers. Lectures and labs together provide context, content, and contraption. Case examples reported as written papers.

The course attracted students from Colleges of Humanities and Social Sciences, Art and Design, Education, and Management. Organization of the laboratory portion of the course demonstrated how to effectively share equipment between a technological literacy course and engineering department use. This sharing of resources increased the use efficiency of both space and equipment. The course demonstrated a novel, multi-dimensional approach to technology literacy as a new format for delivery of this topic: each topic is approached through study of device historical origin and technical evolution, description of principles and key operations of the modern device, and the opportunity to use, dissect and reassemble the device at a basic level, sufficient to encounter major process paths.

"Technology 21", Albert J. Rosa, University of Denver [40]

This is a course for leadership in the new millennium. It prepares students to make wise technological decisions. Decisions on technology that affect all of us are rarely made by scientists or engineers, but rather by business people and politicians who often are swayed by emotion, popular, opinion, misconceptions and/or mistrust of technology. This course provides students with sufficient background to help them make smart technological decisions. The first two quarters help students understand the basic resources available to develop technology: energy, materials and information. These resources comprise the fundamental building blocks of a modern technological society. The last quarter allows students to practice making smart technological decisions on a national or global issue.

This course has been taught successfully for 14 years. Initially an experiment, the course has become fully institutionalized and is seen as an important offering by the Department of Engineering. A variety of different instructors have taught the course with success. The course is able to attract students from liberal arts, business, law, and other non-technical disciplines. Enrollment is capped at 90 students with a considerable waiting list. The department has also been successful in attracting a diverse array of experts from outside the university to assist in their areas of expertise.

"Electrical Signals and Systems," Albert J. Rosa, University of Denver, (formerly of the United States Air Force Academy).

This course is an introduction to signal analysis and electronic system design. Topics include signal representation, signal analysis in the time and frequency domains, digital systems, basic circuit analysis, and realization of electronic functions used in the design and operation of Air Force instrumentation, communication, and digital signal processing systems.

This course was originally created in 1979 and is required of ALL non-engineering students at the Air Force Academy. It has evolved along with the technology over the past 25 years, but is still meeting the same basic goals of informing all cadets of the role that electrical engineering technology will have in their lives in the Air Force.

“Innovation, Invention, and Technology,” Tarek Shraibati, California State University Northridge. [41]

Exploration of the history, processes, methods, and creators of technological innovations and invention. Global contributions, creator diversity, and technological failures are addressed. Critical assessments of technological innovation and invention.

“Introduction to Computer-Aided Graphics Tools,” Tarek Shraibati, California State University Northridge. [41]

Introduction to the use of computer-aided (CA) graphics tools. Development of skills and techniques in graphical, pictorial and rotational representation. Students will be able to work on an individual project tailored to meet the needs of their field of study, and post their project on the Web. (Available for General Education, Section E, Applied Arts and Sciences; not available for credit towards an engineering degree)

This course has been successful at a culturally diverse, comprehensive regional university in which many of the students are the first members of their families to attend college. The course is successfully established as a regular offering at the university. Students taking the course are drawn from a variety of majors including: graphic design, art, math, urban studies, journalism, biology, health science, English, history, speech communications. Many of the students in the class are freshmen. In a recent survey, 41% of the students indicate they would be interested in taking another course of this type.

“Technology and the Human Built World,” Krishna Vedula, University of Massachusetts-Lowell.

Humans have been called the animals which make things and at no time in history has that been so apparent as the present. Today, every human activity is dependant upon various tools, machines and systems, from growing food and providing shelter to communication, healthcare, entertainment and security. The average citizen, therefore, needs to be more knowledgeable of the history and nature of technology that sustains the modern world. This will ensure that the public is engaged with the decisions that help shape its technological future.

In this course, students will develop an understanding of the Nature of Technology including relationships among technologies and the connections between technology and other fields. Students will develop an understanding of Technology and Society including the cultural, social, economic and political effects of technology; effects of technology on the environment; role of society in the development and use of technology; and influence of technology on history. Students will develop the abilities to apply the design process, use and maintain technology and assess the impact of products and systems. Students will develop an understanding of the designed world including selecting and using medical technologies, agricultural and biotechnologies, energy and power technologies, information and communication technologies, transportation technologies, manufacturing technologies and construction technologies.

"Engineering for Non-Engineers," Larry Whitman, Wichita State University [42]

An introduction to the engineering discipline using hands-on exercises and demonstrations using LEGO Mindstorms. Technical and practical aspects of aerospace, computer, electrical, industrial, manufacturing, and mechanical engineering are presented. Intended for freshman and sophomore non-engineering students who want to understand how engineering impacts their lives.

The class targets students who are not "techies" and are not intending to become engineers. The versatility of LEGO Mindstorms is exploited to serve as a common platform to carry out projects representative of several different engineering fields including: mechanical, electrical, industrial, aerospace, and programming.

Summary Comments

Inspection of the titles and contents of these courses reveals some similarities and many differences in content. A much clearer picture arises if we recall John Truxal's advice: "Teach from what you know'" The table below shows the clear correlation between the disciplinary training of the instructor, and the major theme(s) of each course summarized above.

Table 6: Correlation of Research Interests with Technological Literacy course themes.

Instructor	Engineering Discipline	Dominant Course Theme
Lienhard*	Mechanical	Engines of Our Ingenuity
Bloomfield	Physics	Physics of Everyday Life
George	Mechanical	Hydrogen Economy – Fuel Cells
Kuc	Electrical	Digital Information Age
Krupczak	Mechanical	Mechanical,Electrical items
Mechtel	Electrical	Electrical, computer eng'g; digital communication
Littman/ Billington	Physics/ Civil	Civil infrastructure
Balmer	-----	(multiple course & fac.)
Ollis	Chemical	Photophysics and Photochemistry in many devices

*Course last taught in 2000. Theme is text title.

5. SUMMARY OF OTHER CONTRIBUTIONS

Summary of plenary remarks made by Renee Lerche, University of Michigan (formerly of Ford Motor Company)

"The World of Literacy Definitions: How to Succeed/Fail in Business without Really Trying."

(Note: this summary was prepared using verbatim excerpts from the presentation)

Experience in working with various literacy campaigns shows that it is difficult to find a common language that resonates with all concerned groups including employers, educators, policy makers, and the public.

Lessons learned show that narrowing definitions by making them more specific made it easier to develop curricula and assessment tools. Narrowing definitions did not make them more usable nor did it heighten their ultimate impact.

The key is taking complex concepts and making them simple and actionable. It is critical to find a definition that functions like a Brand. A Brand creates a concept/issue and an emotional connection to that concept/issue. A Brand statement is short and concise. It can be repeated five minutes after hearing it once. Developing a Brand can be very time consuming.

A definition of technological literacy might start with what is required for a high-performance workforce. This might be commitment, competence, and capacity. Commitment consists of workers who want to do the work. Competence is workers who have the skills and knowledge to do the work. Capacity describes workers who have the tools and means to do the work.

Described differently, what is needed are workers and workplaces that are adaptable and flexible. This requires clarity about business strategy and aspiration. Also required are the skills, knowledge, and strategies that enable people to learn how to learn. A further necessities are the tools and support systems that allow them to learn and put into practice what they learn.

From the perspective of workforce development the definition of technological literacy outlined in *Technically Speaking* is useful for two reasons. The definition highlights the importance not only of high-level thinking skills but also of using the "product" of that thinking to solve problems. The definition also focuses on the application of knowledge as well as the creation of knowledge. This is both a strategic and tactical approach.

What may be problematic is the complexity of the definition and the confounding of concepts. By narrowing the focus to technological literacy, a broader need is missed.

In summary, successful literacy efforts require making the complex both simple and actionable. Efforts should focus on those skills, knowledge development and problem solving processes that enable adaptability and flexibility. A goal must be to create and identify definition language that is broad enough to resonate with the multiplicity of expert and lay audiences you want to impact and motivate to action.

Sherra Kerns, President, American Society for Engineering Education and Vice President for Innovation & Research Franklin W. Olin College of Engineering, Needham, MA.

Science and engineering use formulas and specialized vocabulary to gain the efficiency and precision necessary to work in an area in depth. As we particularize our understanding about a specific area it becomes difficult to communicate without using this formal language or habits of communication. We become separated by a common language.

How might it be possible to encourage both sides to attempt to cross the communication barrier? It might be that it is the object or technological device that both have in common. The experience of the technologist and non-technologist overlaps at the object.

From the point of view of the scientist or engineer, it is critical to recognize that ignorance does not equal stupidity. A starting point for communication would be to retrace steps to where the everyday experience last branched off from the technical specialist.

It is apparent that there are enough great ideas and experiences that could make a difference if disseminated. Whose job is it? All of engineering. Also, as in some engineering design problems, waiting until all unknown information is known before proceeding renders such a task impossible.

Kathryn Neeley, School of Engineering and Applied Science, University of Virginia

"Technological Literacy: All dressed up and no place to go?"

These remarks and observations are being made from the point of view of a person who has worked on the other side of the technological interface: teaching engineers to communicate with non-experts. If we are to have an effective and productive interface between technical experts and the non-expert public, we need to think in terms of a complete system consisting of (1) engineers who can communicate effectively with non-experts, (2) citizens who are able and inclined to participate effectively in public discourse about technology, and (3) a forum or set of forums for deliberation and decision-making.

Consider the sculpture made in 1893 often called: “Darwin’s Monkey.” The sculpture shows a monkey contemplating the skull of a human. One point of this sculpture is that the monkey has a point of view, too. To make real headway, we must recognize that the academic humanists social scientists, and other citizens may have a valid point of view that deters them from becoming “technologically literate.”

Some non-technologists or non-engineers have concerns about some of the themes embedded in the current technological literacy efforts. These concerns should not be dismissed lightly. It is a critical but often overlooked fact that unless the non-technologist’s views are taken into consideration, then any technological literacy effort will not be successful.

The current efforts to promote technological literacy are in danger of leaving people: “all dressed up with no place to go.” Goals advanced for being technologically literate such as being a more effective consumer are not sufficiently compelling. The critical problem is not consumer safety but rather that we neither understand at a high level how technology is created nor have a clear notion about how to influence that process. A central problem is to create a new means to make decisions related to technology.

It is easy to forget that even technical experts are not expert in *all* areas of technology. In the technical realm as elsewhere, the question of communication across disciplinary cultures is a difficult one. Even within a specific discipline, shared or common experience diverges. Engineers tend to move into specialized realms of experience. This becomes progressively more isolating. It not an exaggeration to note that specialization often means that engineers have to work at communicating with other engineers.

Metaphor matters; words evoke an emotional response or mental image. It is a serious question as to what this endeavor should be called. To the “lay” audience, the term “literacy” implies condescension. Literacy implies an entry-level skill set; it implies remediation. However, the issue at hand should not be considered as primarily a remediation effort. The ideal outcome involves the development of sophisticated skills that many well-educated people do not yet possess.

The issue is important because it determines the extent to which decisions about technology will be democratic decisions.

Norman Fortenberry, Director Center for the Advancement of Scholarship on Engineering Education (CASEE). National Academy of Engineering

For a time the individuals at the National Science Foundation used the term "competency" in the context of understanding technology. This perspective may help in trying to find terminology to describe a technologically literate person.

Phil Wankat, Purdue University

Potential Benefits of Technological for Engineering Students

Engineering students will benefit from a technological literacy course. Involving engineering students outside their disciplines would be very useful and will increase their understanding of concepts. Professors teaching such a course would learn a great deal of engineering. I would suggest that there should be a technological literacy section in the Fundamentals of Engineering exam that would test for basic understanding of concepts, not the ability to calculate.

An analysis of objectives and questions in technological literacy based on Bloom's taxonomy might prove very interesting. Many of the objectives appear to be at the knowledge and comprehension levels, and the important objective of producing a savvy consumer is at the evaluation level. Contrast this with the almost exclusive use of application and analysis levels in engineering science courses and the synthesis plus analysis levels in design classes. This preliminary analysis shows that a technological literacy course would help round out the education of engineering students.

6. SUMMARY of GROUP DISCUSSIONS

A. Obstacles to Courses on Technology

A main obstacle is ownership. This was cited in 50% of pre-conference surveys. This shows up in a variety of ways:

- Overload
- Only owned by a single person (sustainability)
- Approvals might be hard
- “Death” to non-tenured faculty

Change focus of the discussion from obstacles to opportunities. The key to helping with this problem:

- Define a core or theory-base for the discipline. What it is that we want to teach?

- Develop textbooks. If a well-developed core exists, we can then find ownership. This gives the course identity

- Alternatively, a well-defined core would facilitate the selection and use of primary source material, which may be an appropriate substitute for textbooks.

Additionally, the debate over literacy is related to the 40 year old debate between “real world” engineering and “engineering science” (symbolic manipulation).

Do not use the word “literacy” in describing courses; it creates a negative impression that seems to drive people away.

B: Learning Objectives, Student Outcomes, Assessment

Technological literacy lacks a consensus definition. Further, there is a need to define this in an operational way that can be measured.

Consider defining technological literacy as a combination of knowledge, skills and attitudes. Example definition for a technological literate person:

- Savvy consumer of technological products.

- Savvy citizen about public policy, including identification of trade-offs and unintended consequences.

- Ability to transfer to new situations.

- Utilize engineering design process to analyze technological situations.

- Having an attitude that “I can understand any technical situation I choose to.”

Assessment possibilities for different attributes of technological literacy might include:

- Savvy attribute and process attribute
  - Design projects and case studies, learning with embedded performance assessment.
- Transfer attribute
  - Design projects in new contexts. Can students transfer process knowledge from one project context to another?
- Attitude attribute
  - Self-report surveys

C: Developing Scholarly Community, Stimulating Interest in the Topic

It would be helpful to clarify on what the “community” will do before suggesting the what and how of establishing a community. That said, the scholarly “community” must provide these capabilities and services for its members:

- A locus for supporting faculty who do technological literacy.

- An acceptable place to publish. The specific format/forum left open.

- Create a community of scholars – could be an annual conference or organization but it is important to remember that most people already have many commitments.

- Provide a mechanism(s) for spreading word beyond engineers per se.

- Engineering Deans (350) represent only about 10% of the total number of institutions of higher education.

- Draw in other institutions – see Taft Broome’s list – broadly constituted as STS community. No one institution will be able to do this alone.

The ASEE might be a starting point as an interest group or constituent committee.

D: Implementation in Different Institutions, Underrepresented Groups, Inclusion of Physically Challenged.

- Technological literacy now seen as potential engineering recruiting tool in community colleges

- An issue to address is in some institutions 60% of students are entering with math and English language deficiencies.

- It is recognized that there may be benefits of possible collaborations between large and small institutions.
    - Small schools have less overhead for trying something different
    - Partner with larger school to create more relevance for their results.
    - Within these need liberal arts and technical people

- Collaboration: Develop a "Course in a Can" that could be shared. Something like Calculus I where there is a standard body of knowledge with some flexibility for individual variations in how the course is taught.

- It was noted that technological literacy is a subset of teaching in general, and therefore has the same types of issues related to institution as any other course. In many ways, the institutional issues are not unique to technological literacy.

- There are gender, race, and cultural differences in technological literacy courses but these are not necessarily different from other academic subjects. Issues of gender learning styles affects this issue like others.

- Uncomfortable trying to move forward without a definition of technological literacy. Perhaps raised more questions here than answers. There is a need to define the problem.

- Need to find the Icon or Brand on this problem.

- Like the issue of faculty member diversity, there are several models of what technological literacy means.

- Engineering not necessarily a female-friendly career.

E: Perspectives from the Humanities, Social Sciences, and STS Fields. The Connection Between STS and the Technological Literacy Effort.

- Many humanists and social scientists are not interested in technology, but there are enough people in STS to establish a successful network of collaborations.

- STS people will be interested in participating in tech "savvy" efforts if the goal of the activity is to enable people "to think about the social, political, and ethical implications of their work," and if the activity gets beyond technological determinism. ("Improving Technological Literacy," Young, Cole, and Denton, 2002 Summer, *Issues in Science and Technology*.)

- All faculty involved must be comfortable with broad perspectives and must operate in areas outside of core expertise and good at collaboration.

- Collaboration must occur at peer-to-peer level; we need to build community, not replicate hierarchy.

- History of science and technology can play a key role in tech savvy efforts.

- Efforts should focus on the kinds of issues and questions that are owned by everyone: is a new technology possible? Is it desirable?

- Addressing such questions requires that all participants learn from each other and learn how to translate their expertise for others.

- Not all STS people are interested in pedagogy, but many are.

F: Research Issues Arising from Presentations and Discussions

Definitions and Dimensions of Technological Literacy

The definition of technological literacy was visited often during the discussions. Technological literacy has been defined and developed from a variety of sources. Participants considered these points to be of importance or needing emphasis:

Revise the term "Technological Literacy"
A different term and more succinct definition must be developed for the idea of technological literacy. Engineering academics are comfortable with using the term, but among the general public and non-technical faculty, technological literacy evokes negative connotations of remedial education. Experience shows that non-technical students avoid courses with titles including the terms "technological literacy" or "engineering." A different term is needed which conveys the desired sense of confidence and knowledge about technology. "Savvy" evokes some of the desired competence, defined as comprehension, knowledge, practical know-how, and common sense. The concept needs a definition in the language of citizens.

Engineering Design as a Creative Process
There should be an emphasis on understanding engineering design as a creative process. The creative aspect is appealing to non-engineers and children. Creativity and design are themes found in many disciplines and could form the basis of collaborations between engineering and other disciplines.

Engineering Thinking
An objective is the ability to carry out engineering thinking. This activity can occur in a variety of contexts, such as understanding how things work, historical aspects of technological development, or contemporary specific issues such as nanotechnology. These contexts provide the means by which nonengineers can become interested and excited about the topic and appreciate the value of engineering thinking. This ability also

takes the form of a qualitative or intuitive understanding that allows the technologically savvy citizen to make informed judgments about a technological issue.

History of Technology
The history of technology and awareness of the historical context of technological developments is an important element in understanding technology.

Definition through Exemplars
In developing a definition of technological literacy, it would be helpful to identify exemplars. The objectives, attitudes, and abilities of a technologically savvy person could be identified.

Connection to Success in the Workplace
Concepts of technological literacy should be linked to the U.S. Department of Labor SCANS Commission. This commission identified the skills needed by adults to be successful in the workplace. This connection would allow issues of employability to provide impetus for understanding technology.

Avoid an Exclusively Skills-Based Definition
There is a danger in promoting too much of a vocational view of the issue. Technology is changing so rapidly that vocational skills will soon be obsolete. The issue should be addressed at a higher abstract level and not be defined exclusively through any practical skills.

Establish an Underlying Theory of Technological Literacy
Can technological literacy be theory based? Is there a core theoretical framework for this concept?

Connection between Technological Literacy (TL) and Humanities and Social Sciences (HSS).
There is little understanding of how the topic could embrace engagement with the humanities and social sciences.

Investigate Technologically Savvy Hobbyists
Many people outside of engineering and technology professions are technologically savvy. For example, hobbyists in some areas such as vintage steam tractors have developed a high level of technological understanding on their own without the aid of formal training or even manuals. Engaging the experience of these people may provide useful insights.

Technologically Savvy as Designer, Engineer, or Artist?
If being a technologically savvy citizen is an art, how do we teach it? Should this person be seen as a designer, engineer, or as an artist?

System Understanding
Identify and define the social-technical system of which technologically literate citizens are going to be a part.

Explore ABET 2000 Criteria
The ABET criteria could serve as defining a technologically savvy graduate. A list of characteristics describing a person who understands technology might be the ABET criteria. It was noted that ABET has a set of criteria for accrediting applied physics degrees and that list is similar to the one used for engineering. This implies a degree of universality in the ABET criteria. The concept of a technologically literate citizen is implied in the ABET 2000 engineering accreditation criteria. Explore ways by which this may be made more evident and widely known.

Challenges in Addressing the Theoretical and Practical Side of Engineering
An issue in determining what constitutes technology literacy arises from the broad scope of engineering activity. Engineering includes both theory and practice. It might be compared to learning both sociology and social work. How can this dual nature be addressed?

Why Is There Poor Understanding of Technology In the First Place?
Why does technological illiteracy exist in the first place? The information needed for anyone to become technologically literate is readily available. Addressing the issue from this direction could lead to new insights.

History of Technology and STS Contributions
What is the essence of Science, Technology and Society, and the History of Technology that people teaching technological literacy need to know? The literature of these fields can be impenetrable to those outside the discipline. There is a need to make some of this available jargon-free to engineers.

History as a Starting Point
Our understanding of the technical content of our field often deepens when we learn about its history. This approach could be used as a starting for understanding technology by non-technical students.

Public Policy Perspective
What is the public policy side of technological literacy?

Global Perspective
The definition of technological literacy may be different in different cultures. The process of defining technological literacy should investigate the cultural differences in technological literacy on a global basis. What are the technological literacy needs of the developing world?

Assessment

Measure Decreased Fear
Establish a method to measure a decrease in fear of science and technology. Assessment should provide means of evaluating overcoming fear and building confidence about understanding science and technology. Methods are needed for evaluating technological literacy courses and their impact on changing attitudes of the student population.

Competency Model
What do technologically savvy people do that non-tech savvy people cannot do? What kinds of things can they do? What does a technologically savvy person look like? Developed a competency based approach that can be measured.

Longitudinal Study
A longitudinal study of students who take technological literacy courses should be done. Such long term tracking would help establish if and how people who take such courses are changed by them.

Measure Ability to Understand Unfamiliar Technology
There is a need to measure if technological savviness has been enhanced. For example this might be a reliable method to assess the ability to make sense of unfamiliar personal technology or technology based problems. Such tools should then be used to assess the technological literacy of the nation.

Assessment definition
An assessment of technological literacy might include such components as ability to address technical problems and seek solutions, ability to engage in debate on technical issue, accuracy in making scientifically sound arguments, capacity to consider the multi-dimensionality of solutions, and use of scientific principles to explain observed phenomena.

Assess Crossing Boundaries
What are methods for assessing scholarly contributions of faculty who cross disciplinary boundaries? How can it be established what research is worthwhile, especially in technologically savvy areas?

Inheritability of Technological Understanding
Conduct a study of the inheritability of technological savvy from parents to children and teachers to students.

Assessment based on Explaining an Unusual Phenomenon
How does this rattleback work? This is an elliptically-shaped solid that, when placed on a surface, will first rotate in one direction then the other seemingly without outside interference. Go to a cross section of society in all areas and write a narrative account of what is encountered. Use these results to inform how to assess technological literacy.

Link Course Assessments with National Data

If or when national data on technological literacy is available, compare course assessments to national data. Correlate national technological literacy exam results with performance of students using an appropriate scoring rubric.

Rubric for Socio-technical Projects

Develop a rubric for evaluating socio-technical design projects. Such projects include both social and technical innovation.

Assess Individual Motivation

What are the factors that influence someone to become, or want to become, technologically literate?

Developing and Maintaining a Scholarly Community

Form On-line User Group

A loosely organized user affiliation such as a Yahoo group would facilitate communication among peers. Group members could get quick response and support for specific questions and problems, which would not require external funding to establish or support.

Web-based Resources

There is a need for a technological literacy clearing house or website where instructors can go to find materials. There is a need for a best practice collection, not just a journal devoted to the topic. The commercial website "howstuffworks.com" is great starting point for explanations.

Review of Previous and Existing Efforts

A number of efforts are underway at many levels. There is a need for a comprehensive review of all on-going efforts. It is time-consuming for new comers to identify what others are doing.

Training Programs for Faculty

Training materials and a training workshop are needed for faculty. After such workshops, faculty should be able to walk out, ready to go. This might be an annual gathering.

Short Workshops

Use could be made of the workshops held before the ASEE conference. One topic might be "Putting History to Work as an Engineering Educator." People from humanities and technological disciplines could conduct the workshop.

Assessment Best Practices Conference

Create a conference on assessment "best practices" in technological literacy. This event might provide a new outlet for people to disseminate results.

Regional Communities
Develop scholarly communities on regional level. How is it possible to stimulate regional level cooperation that could grow and sustain itself? One example can be found in the NSF Engineering Education Coalitions. Some of these started miniconferences which have continued for a number of years. These are informal in format and focus on current issues of interest of member groups.

Work with ITEA
The International Technology Education Association (ITEA) has embraced the technological literacy issue. How do those working on technological literacy at the undergraduate level coordinate with existing ITEA efforts?

Utilize Understanding of Community Growth
More is known now about the growth of communities. Information is available about obstacles and opportunities. In creating a scholarly community, take advantage of any lessons learned.

History of Technological Literacy Efforts
There is a history of the efforts to promote technological literacy, including a nascent data base of past efforts. If that data base were more readily available, that would be helpful.

Multidisciplinary Scholarship
Engage in multidisciplinary scholarship on the history of technology. It is difficult for any one disciplinary group to fully address the topic. For example, historians and engineers might collaborate.

Collaborative Fellowships
Collaborative or dual fellowships might be established to facilitate work between engineering and humanities. Some type of collaborative faculty development grants might accelerate work.

Dual Society Memberships
To promote interdisciplinary scholarship supporting technological literacy, universities should cultivate faculty who are members of two different disciplinary organizations or societies.

Recruit Younger Faculty
We have to clone ourselves and find more people with whom we can work.
There is also a need to attract some younger faculty to this type of work.

Role of university
There is a need to overcome the perception that universities are concerned with symbolic ideas and not objects. For a scholarly community to grow, other colleges and universities need to view understanding technology as a compelling issue.

Technological Literacy as a Second Career
Find a way to attract engineers into the technological literacy effort as a second career.

Funding Between the Cracks
There is a need develop guidelines on how to conduct interdisciplinary research and obtain funding for work "between the cracks."

Obstacles to Courses Promoting Technological Literacy

Faculty Time
Time is an obstacle for faculty to work on this initiative. A solution is top-down support from the administration. Administrative effort can also make cross-campus collaborations possible by providing support for this type of activity.

Safety
Safety is a hidden obstacle. If students are working in direct contact with some types of technology, there will be safety concerns. Is it possible to provide the kind of direct experience with technology comparable to that received in the early 20^{th} century, while maintaining a modern safety standard eliminating all scratches?

Liberal Arts Acceptance
One obstacle is how to ensure that people from the liberal arts are convinced of the importance of technological savviness. If understanding technology is accepted as part of mainstream knowledge, efforts are more likely to be successful.

Devaluing of Scientists, Engineers, and Teachers.
An obstacle is the pervasive anti-intellectualism that exists on college campuses and in society. There is a deliberate devaluing of teachers, scientists, and engineers. There is little data-driven decision-making in public policy, with predictable consequences.

Pedagogical Ideas, Issues, and Opportunities.

Develop Case Study Problems
Develop case studies of general societal problems with a technological component. These could be timely topics of interest to both students and instructors.

Utilize Non-Print Formats
While faculty are accustomed to print format, current students are less and less readers. An effort should be made to utilize other media that students find engaging.

Utilize Museums
Educational opportunities exist through museums. For example the Henry Ford Museum is essentially about technology. Museums like these have fine collections of artifacts.

Improving understanding of technology offers engineers an opportunity to work with these cultural institutions. Having big events would attract people and publicity.

Textbook Series

Develop a textbook or module series that cuts across the engineering disciplines. This would be a more in-depth explanation of "how things work" aimed at an audience of engineers or scientists. It would serve as a resource for any scientist or engineer attempting to understand or explain a technical topic that is outside his or her particular specialization. Explanations could use mathematics and be at a more in-depth level than those intended for a general audience. This would be similar to the MIT Radiation Laboratory series produced after WWII. Admittedly, this would be a big project. The results could be web-based.

Identify and Utilize the Motivation Behind "Engineers Without Borders"

There is something about "Engineers Without Borders" that is drawing students. What is it? What are they getting out of it? Can this be built into other programs?

Engage Liberal Arts Faculty

Collaborations could take place with Liberal Arts faculty to come up with new pedagogy for this topic. Possibilities might include theater and role playing. Consider theater as an approach to understanding technology. These collaborations could be widely disseminated.

Promote Multidisciplinary Study of Technology

Develop the study of technology across disciplines in the form of modules. For example look at technology from viewpoints spanning several fields.

Cross-Cultural Awareness of the Two Cultures.

Investigate the cultural awareness research question. The engineering profession has woken up and now has a cultural awareness of issues that exist beyond the purely technical realm. The humanities and social sciences have a cultural awareness in the other direction. Engineering and the humanities and social sciences could develop courses that overlap in the middle.

Expand NSF REU Program to non-technical students

Expand the NSF Research Experiences for Undergraduates program so that engineering students are paired with a non-technical student.

Engineering Students Reach out to K12

An opportunity exists to improve understanding of technology at the K-12 level. This could take the form of service learning for engineering students. K-12 engineering and technology does not have to be just robotics. If approached as service learning, efforts can utilize the existing infrastructure to support service learning activities, as well as conferences and places to publish results.

College-level Courses for K12 Teachers

K12 Teachers need to have courses at the college level which enable them to become technologically literate and able to teach engineering topics to their students. While engineering is being introduced into K12, there is a question of who is going to teach this material. It was noted that Technology Education graduates do not all proceed to teach in K12, many, possibly even a majority, go into industrial and corporate training.

Investigate Linkage with "No Child Left Behind"

Investigate whether or not the "No Child Left Behind" has any connection to technological literacy. If so, this might be a way to connect with K12 curriculum and teacher training at the undergraduate level.

Under-represented Groups

Corporate support

A technological literacy effort that is effective in recruiting women, girls, and minority groups into technical fields would attract attention of corporate philanthropy programs.

Handicapped and Aged

It is not clear how the concept of technological literacy should be viewed for the handicapped and the aged. It may be possible to challenge undergraduate groups to act out for these segments of the population.

Inventing Freedom

Create an exhibit called: Inventing Freedom: Slave Inventions in North America. The Ford museum has a collection of these. Draw public attention to emphasize the technological accomplishments.

Other Issues

Ramifications of Technologically Empowered Public

A technologically literate public may have unanticipated consequences for the engineering community. Such a public would feel empowered to have a say in what and how technology is developed. Is the engineering community prepared to accommodate these people?

Broader Collaboration See a Bigger Picture

The issue has been framed too narrowly. It should be viewed as an entirely new discipline. Engineers themselves have not reached the level of consensus on the topic that is assumed. Since engineering is not the only group with an interest in the technological literacy concept, a broader collaboration should be assembled. This could include a wide spectrum of society including the media. The goal would be to define the issue and achieve consensus across a broader spectrum of the nation. Retreating to familiar disciplinary niches and routines is not likely to be productive. There is a need to have more imagination and ambition about where this issue can and should go.

7. IMPACT OF THE WORKSHOP & ACTIONS AFTER THE WORKSHOP.

In the one-year time period from the conclusion of the workshop in April 19, 2005 to May 1, 2006 the following activities have taken place.

Workshop Panel at Frontiers in Education Conference

Workshop participants conducted a panel discussion entitled: *"The Technological Literacy of Undergraduates: Identifying the Research Issues,"* at the 35th IEEE/ASEE Frontiers in Education Conference, October 19-22, 2005, in Indianapolis, Indiana. The panelists were: Mary Kasarda, John Krupczak, David Ollis, Russ Pimmel, and Phil Wankat. At the panel, twenty-four individuals requested copies of the workshop final report.

ASEE Technological Literacy Constituent Committee Established

In the April 2005 workshop discussions, the workshop participants voted to encourage ASEE to create a Technological Literacy Constituent Committee. Participant, Sherra Kerns, President of ASEE, carried this request to the ASEE board, with positive results: a Technological Literacy constitutive group was authorized, and at the June 2005 ASEE annual meeting in Portland, Oregon, the Technological Literacy Constitutive Committee was formed. A description of the committee by-laws can be found on the ASEE website: http://www.asee.org/members/organizations/divisions/index.cfm.

If committee reaches 200 members in three years then it will attain permanent Division status within the ASEE. The Technological Literacy Constituent Committee and ultimately an ASEE Technological Literacy Division can serve as the focus for a scholarly community investigating and developing this issue.

The committee officers for 2006 are Chair: John Krupczak, Chair-Elect: W. Bernard Carlson, Program Chair: David Ollis, Program Chair-Elect: Kathryn Neeley, Secretary/Treasurer: Tarek Shraibati, Publications Chair: Mary Kasarda, Technological Literacy Representative: Sarah Pfatteicher.

The Technological Literacy Constituent Committee was allocated two sessions at the ASEE 2006 Annual Conference in Chicago, Illinois. One session is being conducted jointly with the ASEE Liberal Education Division. The committee has organized ten presentations at this conference and one pre-conference workshop. A listing of the Technological Literacy Constituent Committee program for the ASEE 2006 conference can be found in Appendix F.

PRISM Article by Phil Wankat and Frank Oreovicz

Workshop participant Phil Wankat co authored an article with Frank Oreovicz that appeared in the March 2006 issue of *Prism* magazine. Wankat and Oreovicz encourage engineering educators to teach multidisciplinary courses for nonengineers and to bring the goals of technological literacy into all engineering classes. To accomplish this, they suggest showing engineering students how the principles of engineering and engineering science are applicable to products in common use, how products developed for one application can serve different functions, pointing out how most consume products are the outcome of work in several engineering disciplines, and how engineering can aid people by finding effective and economical solutions to the ever changing problems facing society. A copy of this article is included in Appendix G.

Robert Balmer "Minority Report"

Following the workshop, Robert T. Balmer, Dean Emeritus of Engineering and Computer Science at Union College in Schenectady, New York, developed a set of suggestions for future work. This "minority report" is included in Appendix H. In affirming the critical nature of increasing the understanding of technology among all Americans, Balmer advances these suggestions about how to proceed to make progress on the issue. First, develop a widely-accepted working definition of technologically literacy, next establish a national commission to assess the issue. Following this, partnerships should be created involving mostly smaller schools to implement changes on a pilot scale. Efforts should then proceed to implementation in larger institutions eventually reaching nation wide dissemination.

Center for Technological Literacy

Workshop participants Mary Kasarda and Renee Lerche are seeking support from the National Science Foundation to establish at Center for Technological Literacy. This center will link technological literacy and innovation.

8. CONCLUSIONS AND RECOMMENDATIONS

In this section some of the major themes that arose during the course of the workshop are summarized. Conclusions and recommendations are organized under the topics of the original workshop charge from the NSF.

Review of successful implementations.

The variety of successful technological literacy courses presented establishes that such courses can be implemented across a wide range of different types of undergraduate institutions. The technological literacy courses represented by the presenters contained substantial variety and focus in their subject matter and approaches. This variety in actual course content, and widespread success spanning diverse campuses, demonstrates that non-engineering students can respond enthusiastically to technological literacy courses.

Definitions and dimensions of technological literacy.

Different Terminology for Technological Literacy

A different term and more succinct definition must be developed for the idea of technological literacy. Engineering academics are comfortable with using the term, but among the general public technological literacy evokes negative connotations of remedial education. Experience shows that non-technical students avoid courses with titles including the term technological literacy or engineering. A different term is needed which conveys the desired sense of confidence and knowledge about technology. Savvy evokes some of the desired competence defined as: comprehension, knowledge, practical know-how, and common sense. A goal must be to create and identify definition language that is broad enough to resonate with a multiplicity of expert and lay audiences.

Broader Goals for a Technologically Literate Public

Goals advanced for being technologically literate such as being a more effective consumer are not sufficiently compelling. The critical problem is not just consumer safety but rather we do not understand at a high level how technology is created and have influence on that process. The problem is to create a new means to make decisions related to technology. Efforts should include a focus on the kinds of issues and questions that are owned by everyone: is a new technology possible? Is it desirable? Also, is the engineering community prepared to accommodate a public that would feel empowered to have a say in what and how technology is developed?

Develop an Underlying Theory

Develop a theoretical core or theory-base for what it is that we want to teach. Is there a core theoretical framework for this concept? This core framework would facilitate assessment and development of educational materials.

Emphasize Engineering Design as a Creative Process

There should be an emphasis on understanding engineering design as a creative process. Creativity and design are themes found in many disciplines and could form the basis of collaborations between engineering and other disciplines.

Engineering Thinking as a Fundamental Outcome

A key objective is to establish the ability to carry out engineering thinking. This can occur in a variety of contexts such as understanding how things work, historical aspects of technological development, or contemporary specific issues such as nanotechnology or the hydrogen economy. These contexts provide the means by which non-engineers can become interested and excited about the topic and appreciate the value of engineering thinking. This ability also takes the form of a qualitative or intuitive understanding that allows the technologically savvy citizen to make informed judgments about a technological issue.

Connection between Technological Literacy and Humanities and Social Sciences.

There is very little understanding of how the topic could embrace the engagement with the humanities and social sciences. Additionally, the history of technology and awareness of the historical context of technological developments is an important element in understanding technology. The topic is not exclusively the domain of engineering.

Develop Links to Other Competency Criteria

Concepts of technological literacy should be linked to the U.S. Department of Labor SCANS Commission on Workplace Skills. The concept of a technologically literate citizen is implied in the ABET 2000 engineering accreditation criteria. Explore ways by which this may be made more evident and widely known. Also explore linking technological savvy to competencies desired by employers.

Obstacles to courses on technology.

Peer and administrative resistance were the most frequently cited resistances to establishing courses on technology. Work to develop scholarly community and stimulate interest in the topic as outlined below will help reduce obstacles. Top down interest from college and university administration is seen as a critical factor to promote expansion.

Learning objectives and student outcomes.

While some commonality exists, the diversity of student learning objectives in existing technological literacy courses is appreciable. This reflects the diversity of opinion about the definition of technological literacy. Progress in refining the definition and dimensions of technological literacy and relevant assessment techniques must precede learning objectives and student outcomes.

Relevant assessment tools and techniques.

From the assessment perspective there is a need to define technological literacy in an operational way that is measurable. To facilitate assessment, technological literacy should be defined as a combination of knowledge, skills and attitudes. Assessment possibilities for different attributes of technological literacy could be developed including learning with embedded performance assessment, transfer of knowledge from one context to another, and self-reported surveys.

Specific Assessment Needs

Several specific assessment related needs were identified. There is a need to develop a way of measuring a decrease in fear of science and technology. A longitudinal study should be done of students who take technological literacy courses. If or when national data on technological literacy is available, compare course assessments to national data. A rubric should be developed for evaluating socio-technical design projects which involve both social and technical innovation. Develop a reliable method for assessing the ability to make sense of unfamiliar technology on a personal basis or technologically based problems. There is a need to identify and measure the factors that influence someone to become, or want to become, technologically literate.

Assess Faculty Crossing Boundaries

What are some methods for assessing scholarly contributions of faculty that are crossing disciplinary boundaries? How can it be established what research is worthwhile, especially in areas related to technological literacy?

Strategies for developing a scholarly community.

Among the participants, a firm consensus emerged to use existing organizations and groups to maximum possible extent. It was also suggested that those interested engage general educational forums, not just engineering faculty. Use should be made of knowledge of community building efforts as related to this topic. Investigate the obstacles and opportunities to determine why have some organizations failed while others extremely successful. Incorporate lessons to be learned for this effort.

Whatever the nature of the scholarly community, it must provide several essential capabilities and services for its members. The community should be a locus for supporting faculty who do technological literacy, provide an acceptable place to publish work and provide mechanisms for drawing in other groups and institution such as ITEA and extending involvement beyond engineers. The potential of short-distance regional collaborations was also sited.

In the subsequent April 2005 workshop discussions, the participants voted to encourage ASEE to create a Technological Literacy Constitutive Committee. One participant, Sherra Kerns, President of ASEE, carried this request to the ASEE board, with positive results: a Technological Literacy constitutive group was authorized, and at the June 2005 ASEE annual meeting in Portland OR, the Technological Literacy Constitutive Committee was formed. A number of workshop participants are serving on the committee as outlined in the previous sections.

Potential means of stimulating growth of interest in the topic.

A new NSF program to stimulate faculty interest was ranked as the strongest choice. This result was not unexpected, given both the logic itself and the NSF sponsorship of the technological literacy conference.

Resource availability

A number recommendations emphasized making resources available to potential instructors of technological literacy courses. Many of these recommendations would simultaneously promote the development of a scholarly community. There is a need for a best practice collection of easily-adopted materials, not just a journal devoted to the topic. A loosely organized user affiliation such as a Yahoo group would facilitate communication among peers. A comprehensive review of all recent and on-going efforts is needed. It is time-consuming for new comers to identify what others are doing.

Development of textbooks or even a textbook series around a well-defined core would facilitate growth of interest in the topic. In particular, community colleges are seen as a underserved constituency for technological literacy courses. Training materials and a training workshop are needed for faculty. After such workshops, faculty should be able to walk out, ready to go. Use could be made of the workshops held before the ASEE conference.

Implementation in different types of institutions including community colleges.

It was noted that technological literacy as a subset of teaching in general, and therefore has the same types of issues related to institution as any other course. In many ways, the institutional issues are not unique to technological literacy. Respondents felt that smaller, liberal arts campuses might be easier location to initiate new courses.

It is recognized that there may be benefits of possible collaborations between large and small institutions. Small schools have less overhead for trying something different. Partnership with larger schools would create more relevance for innovative results.

Implementation in community colleges must place a very high priority on minimizing the preparation time needed by instructors especially for laboratory activities.

Perspectives and issues concerning women, minorities

There are gender, race, and cultural differences on the issue but these are not necessarily different from other academic subjects. Issues of gender learning styles affects this issue like others.

As in the issue of faculty member diversity, there are several models of what technological literacy means. There is a need to better define the attributes of a technologically literate person and the associated competencies as mentioned above.

It is not clear how the concept of technological literacy should be viewed for the handicapped and the aged. It may be possible to challenge undergraduate groups to act out for these segments of the population.

Progress in this area is possibly confounded by the engineering's persistence as difficult career choice for women. This is true possibly in the both the educational system and the environments of working engineers and engineering faculty.

Other issues

Some participants expressed a concern that issue has been framed too narrowly. It should be viewed as an entirely new discipline. Engineers themselves have not reached the level of consensus on the topic that is assumed. Retreating to familiar disciplinary niches and routines is not likely to be productive. There is a need to have more imagination and ambition about where this issue can and should go.

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APPENDIX A

Workshop Program
Improving the Technological Literacy of Undergraduates

National Academy of Engineering
Washington DC, April 18-19, 2005.

<u>Day One: Monday April 18, 2005</u>

7:15 – 8:00 Breakfast at NAE

8:05-8:30 Welcome and Introduction (Wm. A. Wulf, Pres. NAE)

8:30-8:45 Results from Pre-conference Survey
(Krupczak, Ollis, and NSF)

9:00-10:30 Successful Implementations 1:
(CHAIR 1 = John Lienhard, U. Houston)

1. Lou Bloomfield, U. Virginia
2. Roman Kuc, Yale University
3. John Krupczak, Hope College
4. Deborah Mechtel, US Naval Academy

10:30 –10:50 Coffee

11:00 –12:30 New Liberal Arts and other Implementations
(CHAIR 2 = Steve Cutliffe, Lehigh University)

1. Michael Littman, Princeton University
2. Robert Balmer, Union College
3. James Baish, Bucknell University
4. William Hammack, U. Ill., Urbana-Champaign

12:30-1:30 Lunch
(Plenary Talk: Renee Lerche, U of Michigan)

1:30 – 3:00 Successful Implementations 3:
(CHAIR 3 = Norman Fortenberry, NAE)

1. Albert Rosa, University of Denver
2. Larry Whitman, Wichita State University
3. Tarek Shraibati, California State-Northridge
4. David Ollis, North Carolina State U.

Day One (continued)

3:15 – 4:45 FORUM

All participants are given the opportunity, if they so desire, to address the group with any observations, comments, or questions to be clarified. Remarks may be scheduled in advance.

Scheduled comments

Sherra Kerns, Olin / Pres. ASEE
Kay Neeley, U. Virginia

4:45 – 6:15 Working Groups Meet

Working group A: CHAIR 4 = David Ollis, NCSU
Obstacles to courses on technology

Working group B: CHAIRS 5 = Ron Miller, Colorado Schl.of Mines
Phillip Wankat, Purdue University
Learning objectives and student outcomes.
Relevant assessment tools and techniques.

Working group C: CHAIR 6 = Sherra Kerns, Olin / Pres. ASEE
Strategies for developing a scholarly community
Potential means of stimulating growth of interest in the topic.

Working group D: CHAIR 7 = Taft Broome, Howard University
Nan Byars, UNC – Charlotte
Implementation in different types of institutions including community colleges. Perspectives and issues concerning women and underrepresented groups. Considerations regarding inclusion of the physically challenged individuals.

Working group E: (5:30-6:15) CHAIR 8 = Kay Neeley, U. Virginia
Perspectives from the humanities, social sciences, and STS (Science, Technology, and Society) fields, including the connection between STS and the technological literacy effort.

6:15 Adjourn until day two.

6:15 – 8:00 Refreshments and a stand-up informal dinner

Chairs write reports of working groups A-D

Day Two: Tuesday April 19, 2005

8:00	Breakfast/Coffee at NAE
8:30-9:30	Reporting out from working groups A, B, C, and D.
9:30 – 10:00	General Discussion and Questions
10:00-10:30	Coffee
10:30 – 12:00	New working groups:

Working group E: CHAIR= John Krupczak, Hope College
Formulate/summarize RESEARCH ISSUES arising from presentations and discussions. These topics will arise, in part, from the conclusions of the following working groups A-E above.

Working group F: CHAIR = David Ollis, NC State University
Formulate strategies/proposed or suggested actions to create a permanent professional/social structure of TECHNOLOGY LITERACY ADVOCATES.

12:00 – 1:00	Lunch
1:00 – 2:30	Second reporting out from working groups and discussion.
2:30	Summary and Plans Forward (Krupczak and Ollis)
2:50	Closing remarks: NSF/NAE
3:00	Workshop Adjourn

Also attending:

Haim Bau, U. Pennsylvania
Myles Boylan, National Science Foundation
John Brighton, National Science Foundation
Bernie Carlson, U. Virginia
Patrick Carriere, National Science Foundation
Kate Disney, Mission Community College
Camile M. George, U of St. Thomas
Kenneth Gentili, National Science Foundation
Rosemary Haggett, National Science Foundation
Daniel Householder, National Science Foundation
Mary Kasarda, Virginia Tech.
Sue Kemnitzer, National Science Foundation
Greg Pearson, National Academy of Engineering
Sarah Pfatteicher, U. Wisconsin
Russell Pimmel, National Science Foundation
Patrick Quinn, Worcester Polytechnic Institute
Gerhard Salinger, National Science Foundation
Roger Seals, National Science Foundation
Krishna Vedula, U. Massachusetts-Lowell

APPENDIX B
Workshop Participants

Improving the Technological Literacy of Undergraduates

National Academy of Engineering
Washington DC, April 18-19, 2005.

James Baish
Professor of Mechanical Engineering
Bucknell University, Lewisburg, PA
James Baish teaches engineering design as a liberal art at Bucknell. His “Designing People” course is open to first year students in the residential college for Society and Technology. He also teaches the design course: “Form and Function: Design in the Natural and Fabricated Worlds.”

Robert Balmer
Dean of Engineering
Union College, Schenectady, NY
As Dean of Engineering at Union, Robert Balmer was responsible for implementing a program of “Converging Technologies” courses for liberal arts students and engineering majors. Converging Technologies at Union focuses creative thought from engineering and the liberal arts on new ideas that are changing the landscape of global society,

Haim Bau
Professor of Mechanical Engineering and Applied Mechanics
University of Pennsylvania, Philadelphia, PA.
Haim Bau was a participant in the Sloan Foundation New Liberal Arts Program. During this time, he created “Introduction to Technological Concepts through Kitchen Experiments.” His other published educational work includes improvements in the Undergraduate Engineering Laboratory Course and teaching undergraduate thermodynamics with Mathematica.

Lou Bloomfield
Professor of Physics
University of Virginia.
Lou Bloomfield developed Physics 105-106 “How Things Work.” at the University of Virginia. This course is taught to more than 300 students each year. He is also the author of *How Things Work: The Physics of Everyday Life. 2nd Edition* (Wiley, New York, 2001).

Myles Boylan
Program Director, Division of Undergraduate Education
National Science Foundation
Myles Boylan currently serves as lead program director for Assessing Student Achievement, and co-lead program director for the National Dissemination component of

the Course, Curriculum, and Laboratory Improvement program. He was also a Scholar-in-Residence in the NAB Center for the Advancement of Scholarship on Engineering Education (CASEE).

John Brighton
Assistant Director, Directorate for Engineering
National Science Foundation
John Brighton is the Assistant Director in the Directorate for Engineering at the National Science Foundation. Before joining the NSF, he served on the faculties of Michigan State, Penn State and Georgia Tech.

Taft H. Broome, Jr.
Professor of Civil Engineering,
Howard University, Washington, DC.
Taft Broome has written and spoken widely on the topics of engineering ethics, engineering education, and technological literacy. He served as a member of the NAE Committee on Technological Literacy. Dr. Broome has served in leadership positions of major national organizations, including the American Association for the Advancement of Science, American Society for Engineering Education, and the National Association for Science, Technology, and Society.

Nan A. Byars
Professor Mechanical Engineering Technology,
University of North Carolina, Charlotte, NC.
Nan Byars has developed and taught a technological literacy class at the University of North Carolina. Her review: "Technological Literacy Classes for Liberal Arts Students: the State of the Art," appeared in the *Journal of Engineering Education,* in January 1998.

W. Bernard Carlson
Associate Professor History of American Technology and Business
University of Virginia
Bernie Carlson's work includes co-editing the MIT Press book series, "Inside Technology: New Social and Historical Approaches to Technology." His recent books include *Innovation as a Social Process: Elihu Thomson and the Rise of General Electric, 18 70-1900.* He also teaches a course on American Inventors and Entrepreneurs. Bernie has served as chair of the Liberal Education Division of the ASEE.

Patrick Carriere
Program Director, Division of Undergraduate Education
National Science Foundation
Patrick Carriere is a Professor of Civil Engineering, Chair of the Department of Civil and Environmental Engineering, and Associate Dean for Research and Graduate Programs, College of Engineering at Southern University. Prior to joining Southern University-Baton Rouge in 1998, he held faculty positions at both Texas A&M-Kingsville, Texas and West Virginia University-Morgantown, West Virginia. He is a registered engineer in the State of Texas.

Stephen H. Cutcliffe
Professor and Director: Science, Technology, and Society Program
Lehigh University, Bethlehem, PA
Stephen Cutcliffe is a historian of technology. He is the author of several books including *Ideas, Machines, and Values: An Introduction to Science, Technology, and Society Studies.* He also coedited *In Context: History and the History of Technology--Essays in Honor of Melvin Kranzberg* and *Visions of STS: Counterpoints in Science, Technology, and Society Studies.*

Katy Disney
Instructor in Engineering
Engineering Department, Mission Community College, Santa Clara, CA
Katy Disney has worked on the development and teaching of a technical literacy course for a non-technical population of community college students. She and her coworkers created a portable technological literacy lab suitable for use in other community colleges in California.

Norman Fortenberry
Director Center for the Advancement of Scholarship on Engineering Education (CASEE). National Academy of Engineering
Norman Fortenberry is the founding Director of the Center for the Advancement of Scholarship on Engineering Education (CASEE) at the National Academy of Engineering (NAE). He is responsible for designing and developing the programs, organizational linkages, and personnel required to achieve and maintain excellence in engineering education. Prior to joining NAE he held managerial positions within the National Science Foundation's (NSF's) Directorate for Education and Human Resources (EHR) including Senior Advisor and Division Director.

Kenneth Gentili
Program Director, Division of Undergraduate Education
National Science Foundation
Kenneth Gentili is the Assistant Lead Program Director for the Advanced Technological Education (ATE) program. He has more than three decades of educational research and teaching experience in engineering and physics at Tacoma Community College, where he was the Coordinator of the Engineering Transfer Program.

Camille George
Assistant Professor of Engineering
University of St. Thomas, St. Paul, MN.
Camille George has developed an innovative engineering course on fuel cells. With support from the NSF, she has also worked to improve undergraduate engineering pedagogy by developing and testing innovative instructional approaches with non-engineering majors.

Rosemary Haggett
Director, Division of Undergraduate Education National Science Foundation
Rosemary Haggett served as the Associate Provost for Academic Programs at West Virginia University, where she continues to hold the rank of Professor in the Division of Animal and Veterinary Sciences. Dr. Haggett was also the Dean of the College of Agriculture, Forestry and Consumer Sciences at West Virginia University.

William Hammack
Associate Professor Chemical and Biomolecular Engineering
University of Illinois at Urbana-Champaign
Bill Hammack works to explain engineering and technology to the general public. His objectivc are to increase “engineering awareness” and to add a human face to engineering. Bill’s activities include his *Engineering and Life* program on public radio, and teaching an innovative course called *The Hidden World of Engineering* to students who are not majoring in science and engineering.

Daniel Householder
Program Director, Division of Elementary, Secondary, & Informal Education
National Science Foundation
Daniel Householder’s program responsibilities include the Centers for Learning and Teaching, Information Technology Experiences for Students and Teachers, Instructional Materials Development and the Teacher Professional Continuum. He was a participant in the International Technology Education Association’s Technology for All Americans Project.

Mary Kasarda
Associate Professor of Mechanical Engineering,
Virginia Tech, Blacksburg, VA.
Mary Kasarda conducts research in the area of rotor dynamics. Within the engineering community she has become an advocate for technological literacy. Her article: “Paper or Plastic? Why all students must become more technologically literate.” appeared in *ASEE Prism* in October 2004. She recently served as Visiting Professor in the Engineering Program at Sweet Briar College.

Sue Kemnitzer
Deputy Division Director (Education) and Program Director
Division of Engineering Education & Centers, National Science Foundation.
Sue Kemnitzer’s areas of responsibility include the Engineering Education Programs, Ethics Education in Science and Engineering and Grants for the Department-Level Reform of Undergraduate Engineering Education.

Sherra Kerns
President, American Society for Engineering Education
Vice President for Innovation & Research Franklin W. Olin College of Engineering, Needham, MA.
As ASEE President, Sherra Kems has led the ASEE toward encouraging engineering and

technology careers, and increasing opportunities for women, minorities and under-represented groups in engineering and related professions. Dr. Kems is also the F.W. Olin Professor of Electrical and Computer Engineering at Olin. She is a fellow of the IEEE and a recipient of IEEE's Millennium Medal.

John Krupczak, Jr.
Associate Professor of Engineering,
Hope College, Holland, MI.
John Krupczak has taught: "Science and Technology of Everyday Life," to non-engineering students at Hope College since 1995. He has written "Demystifying Technology," *ASEE Prism*, October 1997 and "Reaching Out Across Campus: Engineers as Champions of Technological Literacy," in *Liberal Education for 21st Century Engineering.* He has organized sessions on technological literacy at four ASEE national conferences and is chair-elect of the ASEE Liberal Education Division.

Roman Kuc
Professor of Electrical Engineering and Director of Educational Affairs,
Faculty of Engineering, Yale University, New Haven, CT
Roman Kuc teaches a popular course on electrical engineering to non-engineering majors at Yale. His work on teaching non-engineers has appeared in *IEEE Transactions on Education* as well as *ASEE Proceedings.* He also serves as Director of the Intelligent Sensors Laboratory at Yale.

Renee Lerche
Professor, University of Michigan Business School, Ann Arbor, MI
Renee Lerche was formerly the Director of Global Workforce Development at Ford Motor Company. She was also Director of Human Resources Strategy and Process Planning and Director for Global Education, Training and Development at Ford. In this capacity, she was responsible for all education and training delivered to *345,000* employees world wide. Dr. Lerche serves on the National Science Foundation study panel on the future of the U.S. Science and Technology Workforce.

John Lienhard
M.D. Anderson Professor Emeritus of Mechanical Engineering and History
University of Houston, Houston, TX
John Lienhard is author of *The Engines of Our Ingenuity: An Engineer Looks at Technology and Culture.* He also speaks to an audience of several million people via the *Engines* radio program. John received the ASME Ralph Coates Roe Medal for contributions to the public understanding of technology. He is a member of the National Academy of Engineering.

Michael Littman
Professor, Department of Mechanical and Aerospace Engineering
Princeton University, Princeton, NJ.
Michael Littman's research interests include control of optical and quantum systems, tunable laser design, and bio-mimic robotics. At Princeton, he has co-taught "Engineering

in the Modem World" with David Billington for many years.

Deborah Mechtel
Associate Professor, Electrical Engineering Department
United States Naval Academy, Annapolis, MD.
Deborah Mechtel has taught a core competency course in electrical engineering to all Naval Academy students, including non-engineering majors. She is co-author of "Teaching Engineering to Non-Electrical Engineering Majors" *American Society for Engineering Education Proceedings* (1998).

Ronald Miller
Professor of Chemical Engineering
Colorado School of Mines, Golden, CO.
Ron Miller's research includes innovative methods for learning and teaching; measurements of intellectual development; psychological models of learning and assessment of learning. He developed graphics-based interactive software which measures students' intellectual development using expert system and neural network technologies. His recent publications include: "Assessment in Engineering Education: Evolution, Approaches, and Future Collaborations," *Journal of Engineering Education* (January 2005).

Kathryn Neeley
Associate Professor, Technology, Culture, and Communication
School of Engineering and Applied Science, University of Virginia
Kay Neeley has been president of the Humanities and Technology Association and chair of the Liberal Education Division of the ASEE. She is an editor and contributing author of *Liberal Education for 21st Century Engineering*, and a co-author of the Liberal Education Division's White Paper on "Recommendations for Liberal Education in Engineering." She is the recipient of the ASEE Olmstead Award.

David Ollis
Distinguished Professor of Chemical Engineering North Carolina State University
David Ollis' work includes development of a "take-apart" course for first-year undergraduate students. Dave served as Chair of the Liberal Education Division of the ASEE. He has received the United Technologies Excellence in Teaching Award, the Corcoran Award from the American Society of Engineering Education, and a Director's Award for Distinguished Teaching Scholars (DTS) from the National Science Foundation.

Greg Pearson
Program Officer, National Academy of Engineering
Greg Pearson directs the NAB efforts related to technological literacy. He most recently served as the responsible staff officer for the NAB Committee on Technological Literacy. He is coeditor of *Technically Speaking: Why All Americans Need to Know More About Technology*, Committee on Technological Literacy National Academy of Engineering National Research Council (2002).

Sarah Pfatteicher
Assistant Dean, Academic Affairs, College of Engineering
University of Wisconsin, Madison, WI
Sarah Pfatteicher's work focuses on improving undergraduate student advising and retention, curriculum assessment and revision and accreditation projects. She is also director of the Wisconsin Engineering Education Laboratory and has served as Chair of the Liberal Education Division of the ASEE.

Russell Pimmel
Lead Program Director, Division of Undergraduate Education
National Science Foundation.
Russ Pimmel's responsibilities include lead program director for the Course, Curriculum and Laboratory Improvement (CCLI) program. Prior to joining the NSF he held faculty appointments in electrical engineering at the University of Alabama, Ohio State University, University of North Carolina, and University of Missouri.

Patrick Quinn
Professor and Department Head, Humanities and Arts.
Worcester Polytechnic Institute, Worcester, MA
Patrick's areas of research cover both American and British literature from 1880 until the end of World War II. His recent books include: *The Conning of America: The Great War and American Popular Literature,* and *Beyond Modern Memory: The Literature of the First World War Reconsidered.* He is a member of the *ASEE* Liberal Education Division.

Albert Rosa
Professor of Electrical Engineering
University of Denver, Denver, CO.
Al has been active in technological literacy since 1979. He created the award-winning course: "Making of an Engineer," to encourage underrepresented groups to seek technical major. He co developed an Electrical Signals and Systems course, required for all non-engineering majors at the Air Force Academy. Al developed and taught "Technology 21" to liberal arts students at the University of Denver for 14 years.

Gerhard Salinger
Program Director, Instructional Materials Development program, Division of Elementary, Secondary and Informal Education, National Science Foundation.
Gerhard Salinger is also the co-Lead Program Director of the Advanced Technological Education program. He was a Professor in the Physics Department at Rensselaer Polytechnic Institute in Troy, New York, and chairman of the department for eleven years.

Roger K. Seals
Program Director, Division of Undergraduate Education, National Science Foundation.
Roger is also a Professor of Civil and Environmental Engineering at Louisiana State

University. His research interests include geotechnical-soil behavior, placement and improvement of soils, use and recycling of industrial by-product materials.

Tarek Shraibati
Professor of Manufacturing Systems Engineering and Management California State University, Northridge, CA.
Tarek has developed and taught several courses for non-engineering students in the diverse environment of Cal State Northridge, an Hispanic Serving Institution in the Los Angles area. These courses include: “Introduction to Computer-aided Graphics Tools,” “Introduction to CAD Animation,” “Women in Mathematics, Science and Engineering,” and “Innovation, Invention and Technology.”

Krishna Vedula
Professor, Department of Chemical Engineering,
University of Massachusetts, Lowell, MA.
Krishna has served as Dean of Engineering at the University of Massachusetts at Lowell and as Program Director at the National Science Foundation. He also founded the “Engineering in Mass Collaborative,” a group of industry and academic leaders working to improve engineering education.

Phil Wankat
Clifton L. Lovell Distinguished Professor and Head of Division of Interdisciplinary Engineering Studies, Chemical Engineering
Purdue University, West Lafayette, IN
Phil is a national leader in the subject of teaching graduate students and new faculty how to teach efficiently and effectively. He has authored the book *Teaching Engineering* which is now available free on-line.

Larry Whitman
Associate Professor of Industrial and Manufacturing Engineering
Wichita State University, Wichita, KS.
With support from the NSF, Larry is developing a cross-disciplinary engineering course for non-engineers. The course uses the popular LEGO Mindstorms to implement projects in six engineering disciplines.

Wm. A. Wulf
President of the National Academy of Engineering
Wm. Wulf is on leave from the University of Virginia, where he is a University Professor. He was formerly on the faculty of Carnegie Melon University and has served as an Assistant Director at the National Science Foundation.

APPENDIX C

Improving the Technological Literacy of Undergraduates

National Academy of Engineering
Washington DC, April 18-19, 2005.

PRE-CONFERENCE QUESTIONNAIRE
4/15/05

David Ollis, North Carolina State University, ollis@eos.ncsu.edu
John Krupczak, Hope College, krupczak@hope.edu

Total number of people responding = 25

Question1: OBSTACLES TO COURSES ON TECHNOLOGY LITERACY.
This conference seeks expansion of the number of campuses on which technology literacy courses are taught in the US. Please indicate your opinion regarding current obstacles to achieving such expansion.

	Question	Agree	Neutral	Disagree
a	The dean takes no responsibility for this topic on his/her campus	35%	13%	52%
b	Department heads take no responsibility for this topic on their campus	41	9	50
c	Faculty take no responsibility for ownership of this topic	43	10	48
d	Laboratory space for demonstrations and devices is not available	24	19	57
e	Funding for instructional salary is not available	22	30	48
f	Engineering in general does not take ownership of this topic	36	14	50

Other potential or real obstacles to expansion of technology literacy courses.

The entire campus may not feel this is an important issue unless it is part of the mission/vision of the institution.

Unless required it's hard to get non engineers to enroll

The obstacles may be particular to my university. My perception is that there is lack of recognition of the importance of technological education on the part of the non-engineering faculty and that there are financial barriers. I will clarify the latter. In our university, each school is run as an independent budgetary unit. Tuition units are considered as income. The school of engineering has a clear incentive to offer courses with broad appeal (i.e., technological literacy) while the school of arts and sciences is reluctant to make technological literacy a requirement to avoid exporting course units.

Faculty distaste, inertia, overwork, lack of rewards, tradition, personality mismatches between technical people and non-technical people.

Cost of labs and demonstrations and the overall work load to set-up and teach the course.

- *a. Perceived overcrowding in the current curriculum*
- *b. Resistance of engineering departments to offer 'service' courses to non-majors*
- *c. Institutional disincentives to team teaching*
- *d. Lack of faculty rewards for teaching introductory level courses*

a. Getting 'Science with Lab' requirement for general non-majors approved by general university committees. Science committee does not perceive these classes as having enough 'scientific method'. Science committee in general does not perceive technology or applied science as having enough 'depth' to qualify as a 'science with lab'. Traditional courses serving non-majors like intro to Biology or intro to Geology perceive that they will have decreased enrollment numbers.

b. Course that satisfy the 'Science with Lab' requirement for education majors must fulfill various state requirements. It is difficult to implement these requirements without cooperation of the School of Education.

My own time – we could fill with 500+ in a semester if I had the time to teach.

An obstacle to expansion of interest is the problem of creating genuine interest or demand from the non-engineering student population. To be successful, Technological Literacy courses must address the real interests and needs of the non-engineering student for knowledge and understanding about technology versus meeting some externally defined standard that does not speak to the real concerns of non-engineers.

Technological literacy courses must find an academic home. Courses will not be successful in the long-term without fitting into the primary needs of departments and faculty.

An obstacle to expansion is the existence of a diversity of materials that are easy to locate, appropriate to the target audience, and flexible in adaptation.

Faculty initiative: course competes with research time/activity/topics.

I doubt that such courses are effective. I think that we need to work on bringing our own influence into, say, existing humanities courses, as well as creating a more welcoming ambience to non-engineers in our own courses.

Research Universities, funding organizations, and most faculty members do not place great value on teaching – when given the choice to teach a literacy course versus writing a proposal or a paper, faculty will choose the later. Funding organizations interested in teaching, use the research model to choose which faculty to support. Instead they should find top educators through the "grapevine" and challenge these faculty members to broaden their reach through grants. While I am on this topic – over reliance on "education research methods" is a huge impediment to getting many (most) scientists and engineers involved. Education is a lot more about "lighting a fire" than it is about "filling a bucket". Quantifying the motivational effects of top educators is hard -- in my view the best way to measure success is to chart how many students sign up for these courses.

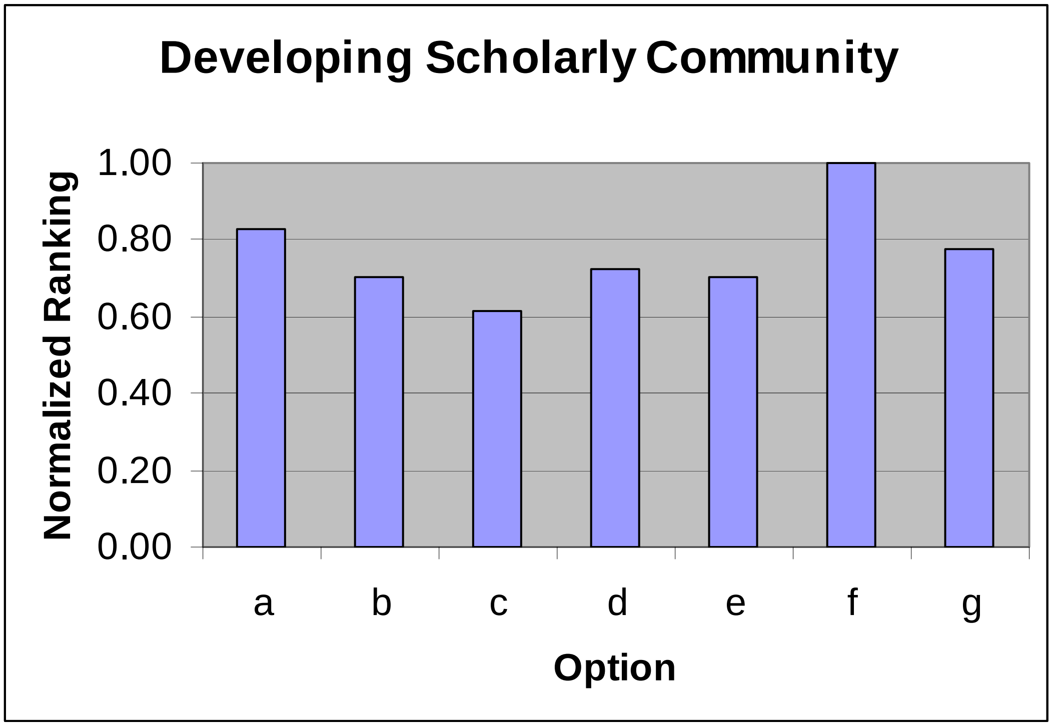
Lack of rigorous approach for many tech. lit. efforts

If we are talking about technological literacyeracy courses taught by engineers or within the college of engineering, I think the issue is that our college does not see this as part of its mission. What courses are available on our campus that might fit under a "technological literacy" heading are offered through other programs and departments, such as Science & Technology Studies, History of Science, History of Medicine, and Integrated Liberal Studies, none of which are housed in engineering and which have only (at best) modest ties to the College of Engineering.

Convincing the general faculty curriculum committees that Technology-literacy belongs on campus.

Provost needs to take ownership and ensure all advisers (faculty and staff) are familiar with this course, so that students are encouraged to take it when students seek their advice

Question 4 : STRATEGIES FOR DEVELOPING A TECHNOLOGY LITERACY SCHOLARLY (RESEARCH) COMMUNITY OF FACULTY



Higher number = more promising. Normalized to score of highest ranked option.

Option	Explanation
a	Form new ASEE and/or FIE interest group/division
b	Form new group/division at other professional societies, especially IEEE, ASME, ASCE, Am. Inst. Phys.
c	Form new annual conference on topic
d	Create a new column in periodical, e.g., PRISM
e	Presentations at annual Engineering and Science Deans' conferences
f	New NSF thrust in Technological literacy area
g	Submission of scholarly articles on Technological literacy courses to journals (J.Eng. Ed, Int'l. J. Eng'g. Ed., Physics Today, etc)

Other suggestions for developing a scholarly community:

It appears to me that the engineering faculty (at least in my institution) is well aware of the importance of technological literacy. The main issue is to convince the non-engineering faculty that technological literacy is a must in highly- technological society.

Why not use the existing conferences and organizations—IEEE's Technology and Society group of the International Assoc. of STS. Let's not duplicate effort here.

Have woman engineer on Sesame Street! That is, we need to make cultural changes! Don't just focus on engineering groups. How about technical literacy sessions at conferences for general education scholars? How do we get Hollywood on this bandwagon? How about a regular article in the NYTimes Magazine? TIME Magazine? Glamour Magazine? Let's talk!

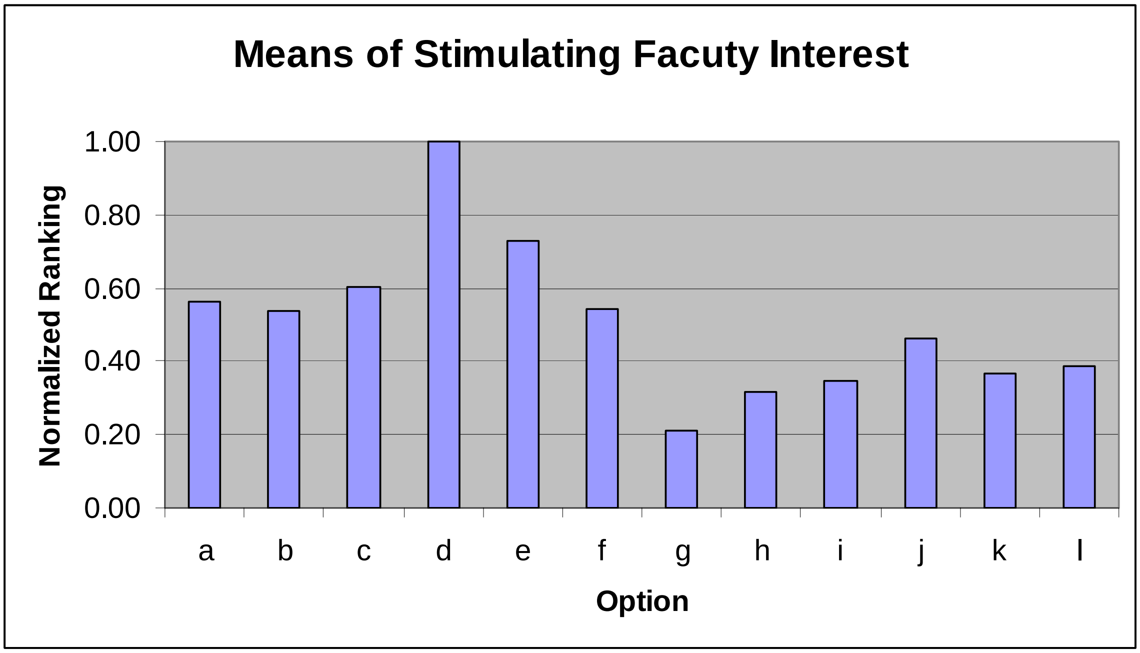
I believe that we need to engage the public, not one another. We need to find our voice in reaching the nontechnical publics. To do that requires demonstrating that we are literate in the areas of people we are speaking to – not just our own. We need to make it clear, for example, that English Lit. plays a role in our understanding of engineering. Technical literacy is a two-way street. And who are these publics? Some very important ones are high school students -- and their teachers, college students outside of engineering -- and their faculty. Parents of high school students.

MacArthur-like support for successful educators
Development of new textbooks focused on engineering and society

clarify and develop the specific decision-making contexts in which technological literacy could be meaningfully exercised
connect literacy to intellectual agendas of STS groups

Initiate discussions that cross disciplinary boundaries – I'm not convinced that scientists and engineers are the only folks who should be involved in or responsible for improving technological literacy. I also think that it might be better to work within structures that already exist – for example, rather than creating a new division within ASEE (there are already too many of them, in my view), it would be more productive to introduce the topic of tech literacy into existing divisions, including the Liberal Education Division, the New Educators' Division, Engineering Research & Methods, and so on, encouraging folks to think about what role tech literacy might play in the work they do.

Question 5: POTENTIAL MEANS OF STIMULATING GROWTH OF FACULTY INTEREST IN TEACHING TOPIC



Higher number = more promising. Normalized to score of highest ranked option.

Option	Explanation
a	Professional society presentations
b	ASEE new division formation
c	ASEE disciplinary sessions on technological literacy courses
d	New NSF thrust in Technological literacy area
e	Creation and maintenance of Technological literacy website for teachers (to contain links to all known technological literacy courses/campuses/instructors)
f	Dissemination of materials inventory (websites, books, radio/TV programs and videos/CDs) to campus faculty and administration
g	Broader use of existing radio presentations in undergraduate courses.
h	Broader use of existing TV documentary (PBS videos/CDs, etc) in courses
i	Broader use of existing texts (Bloomfield, Billington, Petroski, Lienhard, Florman, etc) in courses
j	Partner teaching and research with colleagues in other colleges e.g., history (of science/technology), industrial design, technology education, etc.
k	Partner teaching Technological literacy with instructors of "device dissection " labs.
l	Submission of scholarly articles on Technological literacy courses to journals (J.Eng.Ed, J. Int'l. Eng'g., Physics Today, etc)

Question 6: IMPLEMENTATION IN DIFFERENT TYPES OF INSTITUTIONS INCLUDING COMMUNITY COLLEGES

Please comment on development of such courses as a function of the type of institution: public vs. private, two-year vs. four yr., HBCUs, co-ed vs. all male or female campuses; college vs. university campuses, technology campuses/institutes.

It seems to be easier to implement change at a small institution provided there is a mandate for it. The bureaucracy is less, and there are fewer hurdles to cross.

Bucknell is a medium sized liberal arts and pre-professional institution. Our environment is as one of the best for such courses.

I don't think that it matters much. All of these institutions would do well to develop better technical/science literacy courses. Most students arrive at college with precious little understanding of science and technology, even at supposedly technical schools.

There is competition for science courses that satisfy the science requirement for the AA & AS degrees. These high enrollment science courses bring in WSCH for departments, and so competing courses are sometimes difficult to pass through the curriculum committee.

I don't see special considerations based on institution type other than a possible desire by some institutions (across the types listed) to pursue lower-cost options for implementation.

implementation at all female campus (College of St. Catherine(CSC)) has been very successful. Strategy has emphasized 'de-mystifying' common everyday technologies, capitalizing on liberal arts methods such as historical context, discussion, and structured controversy. Students are afraid of courses with the name 'engineering'. Fun names have been more successful: ex.' Makin' and Breakin' at CSC.

I am at a four-year college, which is mostly a research institution. My promotion, tenure, recognition, etc comes from activities other than this course.

I worked on establishing an engineering school at an all-women college (Sweet Briar). My experiences are anecdotal but I believe they have a lot of relevance. The general society does not understand technology and are generally intimidated by it and/or learning about it. If you explain engineering and HAVE THEM DO ENGINEERING I believe you will have a bigger impact. I believe the engineering design process is an excellent context for teaching technical literacy. Walk through the steps from "concept generation" to "prototype building" and have them actually design and build things. Explain how engineering disciplines and courses enhance the design process (i.e. all of a sudden you put "fluid dynamics" or "statics" in an actual context they understand – there design project).

Technological literacy is an issue that is brought about by the technological nature of the world in which we live. As such, it is an educational problem that cuts across institutional boundaries. In some ways, technological literacy could be viewed as falling into a category with freshman composition, basic calculus, or languages. It is a subject with a broad audience.

The teaching of technological literacy then would need to be adjusted to fit the needs of the students in particular institution. On this issue I do not have any broad view since I only am confident in speaking about the needs of students in my own institution. This is a 4 year private college with most students in the 18-22 year old range. We have a very large liberal-arts curriculum of 54 credit hours. To be viable, a course must be either a major requirement of fulfill part of the liberal arts core curriculum. Also any course that is not for majors must be viewed positively by the student body by whatever cost-benefit analysis they employ, or it will be avoided by the students.

For widespread implementation across different types of institutions, technological literacy courses will need to be both standardized and adaptable. This seems a contradiction but an example of what I mean here would be a course like Calculus I. This is extremely standardized and uniform in terms of the essential subject matter. However it can be, and is, taught differently across the wide spectrum of post-secondary

Course must be adapted to student needs and be consistent with the mission of the institution.

As I've said, I don't think such courses are a strong answer to the problem.

These courses are universal.

Ethical considerations from a current and historical perspective. Influence of technology on economic and social issues.

I'm not sure that I see any clear correlation between institutions and types of courses. My impression is that it depends largely on whether there are individuals at an institution who are interested in taking on this mission and whether there is financial support, either from outside or because of student demand.

No obvious connection, but literature on gender in technology is appreciable: sociologists may have view to offer here

I think context always matters, so clearly the type of institution will affect what is realistic, natural, a stretch, and so on, as well as how reforms or changes can be implemented. But to the extent that any institution of higher education exists to prepare its students to contribute to the world they enter after graduation, all these types of institutions have a stake in technological literacy.

The development is not limited to any particular type of college or function. The issues are the same across the board.

I don't see any obvious differences based on type of institution.

CSUN is a public 4 yr institution technical literacy type courses are relegated to the a portion of General Education program required of all students. Getting courses into the package usually requires a certain level of politicking.

Such courses must be taught at ALL higher education institutions. Community colleges, all female campuses and HBCUs are particularly critical in order to reach a diversity of student body.

Question 7: PERSPECTIVES AND ISSUES CONCERNING UNDER-REPRESENTED GROUPS

Please comment on development of such courses to enhance recruitment and retention of students from under represented groups.

I see no impact on recruiting minorities. However, courses and summer programs to recruit women into engineering can work if done properly.

It would help to make science and technology literacy more socially acceptable. The current anti-intellectual climate of society is even worse among the under represented groups (except among women, who are probably less anti-intellectual on average then me).

A good recruitment tool for sure, however the core engineering courses are much more math based.

Such courses may stimulate or sustain initial interest, but if the rest of the curriculum is taught the same way, these new entrants will be "flushed" out.

These courses must make engineering concepts familiar, relevant, and engaging. Abstract technical concepts must be bridged with familiar tangible realities. Confidence must be built up, many students believe they 'can't understand or master technology'.

In my class the students work in teams, I find this helps with the retention, etc.

From my experiences at Sweet Briar, I learned that single-sex classes do make a difference! I would have argued against this until I turned blue until I saw what happens in that scenario. Women become fearless! They don't hesitate to ask questions or jump in and try to do something it was refreshing!

Technological literacy courses could offer an alternative entry point into engineering and related careers for students from underrepresented groups. Developing engineering training takes time and dedication. Technological literacy could provide the big-picture perspective some students need to pursue an engineering degree.

This is a huge problem. We speak to under represented groups in very unintended ways. Example: A colleague in Special Collections is making a big deal out of seeking to increase diversity among Spec Col users. Writing articles and building her name. Yet, right outside this unit is a locked Staff-Only bathroom. These people say all the right things in their words, yet make it clear that they won't share a toilet with our diverse student population. Which do you think the students will believe – the scholarly papers or the segregated bathrooms? We, all of us, need to study our own general semantics very carefully.

These courses potentially can draw new students to engineering

To the extent that such courses emphasize the historical and social context of technology, they should be helpful in recruiting and retaining under represented groups.

May make use of past injustices re/credit for invention in order to show that women and minorities have long been active just "under-represented"!

It's possible that those who don't readily see themselves in a technological field might have their eyes opened to new possibilities via a course on tech literacy. It's also possible that such courses might open the eyes of those already in technological fields – I take "tech literacy" to mean something that would benefit everyone, whether they identify as scientists/engineers or not. In other words, part of tech literacy is being able to view technology in a broad context. I could go on about this point for some time, so I'll save my more detailed thoughts for our in-person discussions.

I have created a course to motivate under-represented groups to seek technological majors. Course is a college-level, 4 QH, summer course designed for high school rising juniors. "The Making of an Engineer" has been offered to about 60 students drawn nation-wide since 1987. A companion course "The Making of a Scientist" was spun in 2001 after the former won a Presidential Award.

Technological literacy can be an excellent way to motivate youth from under-represented to become more active and interested in participating in issues that are critical to our technological society.

Question 8 PERSPECTIVES FROM THE HUMANITIES AND SOCIAL SCIENCES

Please identify dimensions from the humanities and social sciences which you (would like to) see included in technology literacy courses.

I don't understand the question, however, modern languages, philosophy, political science, anthropology, geology, etc. (i.e., all of them) should be included.

Economics is valuable.

History of technology/science, Societal impacts of technology/science, Ethics of technology/science.

See comment above—Technology is inherently a value laden enterprise therefore in my opinion it cannot be taught outside the societal context within which it is framed.

The social costs of technology and the impacts of the habits and preferences of technologically advanced countries on the world.

Technology and public policy, societal implications on the use of technologies, how technologies change human interactions (e.g., change in power relationships via on-line communication mechanisms).

historical context, discussions and structured controversy, local and global impact of technology, policy, ethics and responsibility. Students must connect the everyday world to the technical world. Students must feel that they can make a difference once they understand the global technical inequities.

My course has a significant humanities component, I believe we need to place technology in context (cultural, societal, political, etc).

Frued's Civilization and It's Discontents

history of technical developments in engineering disciplines and their impact on society, how decisions are made in industry and government.

I have addressed this in several places above. We need to be true colleagues to our friends in these areas – learning their languages and going nose to nose with them. The surest way to show them that they should not be afraid of our expertise is to show them that we are not afraid of theirs.

Technology influences artists (eg. photography and its impact on impressionists) and artists have influenced technology (eg. Samuel Morse (portrait painter and art professor) and the telegraph); Engineering has been affected by and affects politics (patents, regulation, legislation), economics (corporate/individual/national wealth, philanthropy, labor) and society (growth and decline of cities and towns, natural resources and environment)

Ethical considerations from a current and historical perspective. Influence of technology on economic and social issues.

I think the whole STS literature is relevant. I tend to view technological literacy as a combination of basic knowledge, ability to ask pertinent questions about technology, and critical thinking. From my perspective, STS and tech literacy very much overlap, largely because the main reason for promoting tech literacy (at least in my view) is to promote better decision making with regard to technology at all levels and a better understanding of the ways in which technology and society mutually shape each

*Per Sam Florman, the history of technology is a logical bridge to the humanities. Sadly, the partnering of historians and engineers is remarkable for its lack !*_

an awareness of what it is like to be a citizen of the world; an awareness of the difference in approaches to problems between engineers and humanists; a sense of environmental responsibility and what it means to live in a global society.

History of technology as it affects society is interesting.

Students should develop an understanding of the connections between technology and other fields. Students should develop an understanding of Technology and Society including the cultural, social, economic and political effects of technology; effects of technology on the environment; role of society in the development and use of technology; and influence of technology on history.

Question 9 RESEARCH ISSUES

(a) For the various NSF divisions below, please suggest appropriate research issues for Technology Literacy instruction:

(i) Engineering

How to keep the costs down and teach a good course that is hands-on and experimental.

Investigating the impact of modern technology on culture and society

Affect of courses on engineering enrollments and retention.

What constitutes technological literacy ? Can we define the body of knowledge or the process of acquiring the knowledge ?

Engineering faculty must begin to see the critical role that only they can play in technical literacy.

Promoting Technological literacy for all

Environmental and humanistic ramifications

Explore student learning styles vs. the various formats for "Tech Lit" instruction present at the workshop

Development of new curricula in engineering stressing the scientific, social, and symbolic aspects of engineering as taught through history, science, and art.

How can tech literacy gain traction in a discipline-driven environment?

What fundamental courses are needed to provide a foundation for technology literacy courses in engineering?

Structure and contents of courses, good demonstrations, good laboratories, good use of modern teaching technology (e.g. computer animations), course supporting materials (testbanks, project ideas, artwork, worked examples, case studies).

How is public understanding of engineering affected by various modes of tech lit instruction? Does early exposure to technological literacy topics affect interest or aptitude in traditional engineering courses?

Evaluation of pedagogy effectiveness.

Focus on outreach and CULTURAL change/perceptions

The development of course, curriculum, and laboratory materials to support the technological literacy of all students.
Identification of content areas seen as critical to understanding emerging technology.

Kits or software modules that illustrate the science and technology for K-12

(ii) Education

Developing and teaching multidisciplinary courses (e.g., technology across the campus).

If we tie into science centers and the like, then perhaps we can get funding from the Informal Science Education

Effectiveness of courses in developing a technologically literate electorate.

The differences in the pedagogy of teaching technological literacy; in particular, identifying the prior knowledge base and assisting the students in organizing the new knowledge in relation to their prior knowledge.

Must recognize the need to work with Engineering faculty to develop the scope of what is technical literacy and start paying more attention to technical literacy at the K-12 levels

Preparing teachers for promoting the importance of technological literacy. Also encouraging their students to seek technological careers.

Explore how/if material devices and their manipulation enhances learning, and why

Study how non-technical people learn about technology and science. What can you expect them to learn, what do they want to learn, and what will they find useful.

How does an understanding of the dynamics of becoming technologically literature (i.e., learning to be) support engineering/science education?

How can humanities, social science, physical science and engineering instructors team to create technically literate graduates
How to best improve the skills of non-technical educators so that they are able to teach introductory courses in technology and engineering; How to best improve the skills of technical educators so that they can bring a larger societal perspective to their teaching

Are there inherent pedagogic differences in teaching technology literacy versus other curricular content? If so, how do those difference affect instruction? How should instruction be modified to promote effective learning within technological literacy courses.

Example problems describing physics and technology in addition to buying and sharing candy.

Focus on outreach and CULTURAL change /perceptions.

Assessment of abilities and skills related to technological literacy. Methodology for teaching technological topics to diverse groups of learners.

(iii) Social Sciences

The political impact of technological development in emerging countries.

Focus on outreach and CULTURAL change /perceptions.

How can the social sciences encompass technology literacy as a fundamental part of a liberal education.

Impact of technological literacy on society: benefits in the social, economic and political dimensions.

Does participation in tech lit courses affect (increase/decrease) public anxiety about the uses of technology? How does delivering tech lit courses affect the attitudes and viewpoints of engineering faculty toward communities of non-engineers. Does teaching such courses affect the interactions among engineering faculty?

Must recognize the need to work with engineering faculty to develop the scope of what is technical literacy and start paying more attention to technical literacy at the university level.

Living in a highly technological society requires understanding of technology and its impact on society – both positive and negative.

Political and environmental studies.

How does technology/science literacy affect peoples' lives?

Explore scientific analysis vs. engineering creativity…what are the missing dimensions of engineering self-representation which could make the field intellectually richer. Please suggest other federal agencies and appropriate research issues re/Technology Literacy several agencies including NASA sponsor programs on middle and high school recruitment of students into science and technology. Perhaps these would also be receptive to an undergraduate "Tech Lit" program.

Support for research into the history of engineering

In what social contexts can tech literacy be meaningfully used? How does tech literacy relate to the democratic management of technology?

Examples of engineers and inventors, their upward social movement, and their impact on their society. Successes and failures of engineered systems.

Integration of technological content with social science topics. Finding ways of integrating the technological component of social issues with more standard presentations of material.

(b) Please suggest other federal agencies and appropriate research issues re/Technology Literacy

Foundations are more apt to support this kind of work.

Bring back Sloan !

Don't know.

Dept of Education

Dept. of Education (but no money)

Department of Education should be active in this area; all teachers in K-12 must be technologically literate in order to be effective… They should investigate how technological literacy of teachers in K-12, particularly in elementary school can produce a better citizenry for the future.

Dept of Energy, Dept of Defense, NASA

Department of Education – Institute for Educational Sciences, FIPSE

Homeland Security! NIST! DOE! DOD! Who else needs a more diverse and creative work force???

NEH, Fulbright Foundation, etc. The nontechnical ones.

Dept. of Energy

Dept of Education
Effective integration of engineering topics into K12 education

(c) For private foundations, please suggest those with a mandate/interest consistent with expansion of Technology Literacy as a scholarly field.

Sloan

Sloan, Carnegie, Ford foundations

Mellon, Kresge, Howard Hughes??

Hewlett Fdn, Packard Fdn, Sloan Fdn, Corp Fdns

*Gates foundation, Dell foundation_*

Don't know. I suspect that individual donors should be asked.

Toyota USA Foundation, HP Foundation, Xcel Energy Foundation

All Foundations interested in the quality of education from K-16 and its impact on the quality of future citizens must be interested in this topic.

Private Foundations
Identifying promising ideas about promoting technological literacy that do not fit into the standard programs maintained by government agencies. Providing small amounts of venture capital to novel ideas for necessary proof of concept work.

Catalyzing change by moving with flexibility to provide critical support for proof of concept ideas in a more agile and less formal process than appropriate at the NSF or other government agencies.

Question 10 FORMATION OF TECHNOLOGY LITERACY ADVOCATES

The continual advancement of Technology Literacy as an undergraduate area for growth will require strong, effective advocacy from stakeholders on campuses, in professional societies, and in industry and government. Please indicate what social/professional structure(s) you would believe could most effectively advocate and sustain interest in technology literacy .

We need to engage the liberal arts faculty and their organizations to make this happen. If they don't believe in it or want it, there is very little we can do without their support.

ASEE subsection is most important, followed by getting more visibility at NSF for implementable programs.

The initiative must come from the universities' presidents/provosts. Technological literacy courses should be made part of the liberal arts education - just as science and math courses are a standard requirement in the arts and sciences curriculum.

National, State, and Institutional incentives to work toward technology literacy. There are plenty of smart people around, just few incentives to work on technology literacy. At research universities, it's generally careericide. It may be better at colleges and 2-year institutions, but developing new stuff is hard work for already overburdened and underpaid people. Without good incentives, who wants to do this stuff? Just small numbers of committed people who are willing to do too much for too little.

The STUDENTS. If they like the course they will tell their friends and if there is WSCH then the course can thrive and grow (assuming there is a faculty member who is championing the course.) Perhaps consider student aides to create a more lively, social community for the course.

Need a dedicated cadre with credibility among their faculty peers AND need folks willing to dig in and fight for the funding necessary to sustain research and development activities in this area.

ASEE

We need to get our message out there via MASS MEDIA – we must be reaching millions at a time, not a few hundred

Congressional Mandates. I think you need something with some real teeth in it. How about making "impact on technical literacy" a requirement for induction in NAE???

The ITEA (International Technology Education Association) is one national organization that is attempting to serve as the focal point for technological literacy efforts. However they draw from a very limited pool of members, primarily K-12 technology education teachers. In my opinion, they have laid claim to the technological literacy issue without the diversity of membership and research orientation needed to effectively address the problem.

The issue of technological literacy needs broad participation from the engineering community, educators at all levels, and contributions from humanities and other disciplines. It is people from these groups that lack an effective organizational structure around the issue.

Ideally a more broad-based group such as the American Society for Engineering Education (ASEE) should be home to the technological literacy effort. Modern technology is created primarily by engineers. Technological literacy work should originate within an engineering society. The ASEE, as an interdisciplinary organization with an educational focus would seem the most appropriate home rather than a specific engineering disciplinary society such as ASME or IEEE. The ASEE also has a history of participation by non-engineering professionals in such divisions as ERM (Educational Research and Methods), LED (Liberal Education Division), EECC (Ethics Constituent Committee).

Efforts within the ASEE are diffuse and lacking the funding and level of organization that exists at the ITEA. The ITEA, while well-intentioned and certainly with a major role to play, is not likely to attract many members from among university faculty. Ideally, the

ASEE with its intellectual resources could absorb the ITEA with its well-developed organization, to create a Technology Education Division.

IEEE, ASME, etc : Re-tread unemployed engineers into educational units.

Here in Houston, I take the technical literacy issue to my colleagues in the Colleges, to schools, to industries, and to local organizations. I wouldn't want to push one to the neglect of the others.

Lecture series, outreach to local public schools

NAE, IEEE, especially education and social implications

Those who can represent engineering and science well to non-technical majors appear to have found larger contexts within which to satisfactorily set technology. Thus Lienhard and Petroski combine the disciplines of history and engineering; Florman has advocated bridging areas (e.g., history of technology) as paths to interdisciplinary appreciation; Billington and Littman place large scale civil engineering as "structural art" , and Bloomfield and Krupczak place technology within the survey of physics, or use technology to survey physics. So how to increase the number of, and rewards for, faculty who seek polydisciplinarity in the mono-disciplinary environment of present academia ?

I'm not sure at this point, but would like to discuss the pros and cons of some possibilities at the meeting.

A university system which recognizes the importance of technology and humanism in the modern world and a government which would put some financial support into the work that is involved in creating a mental awareness of the issues of technology and liberal studies.

Need buy-in by faulty groups like Faculty Senates, Curriculum Committees, Deans Groups, and Professional Societies. Government funding will also help significantly to validating efforts in this area.

SME, ASME, ASCE, IEEE, etc.

A highly visible advocacy group (perhaps a Center for Technological Literacy, similar to Centers for Teaching and Learning which have become quite common) on campuses is critical. This should include faculty, staff, students and administrators

APPENDIX D

STS Communities Hospitable to Technological Literacy

Prepared by Taft Broome

Despite its name, the STS field includes the mature and robust disciplines "engineering ethics" and "history and philosophy of technology." Some would include "engineering and public policy." They are all multidisciplinary in nature bringing science, engineering and technology together with philosophy, history, and other disciplines. Their objectives may focus on one or another aspect of responsible citizenship or generalist expertise, but of course their graduate programs focus on specialist expertise. The following list is not complete, but it is a base of information that may be useful to the conference.

Universities Having Degree-Granting Programs in STS
Stanford, Rensselaer Polytechnic Institute, MIT, Cornell University, Penn State University, North Carolina State University, University of Michigan, Vassar College, Claremont Colleges, Colby College, et al., and abroad (e.g., in Canada, England, Norway, Sweden, Holland, and Australia)

Societies/Associations/Networks
4S - Society for Social Studies of Science
AsSIST - Association for Studies in Innovation, Science and Technology (United Kindom)
A^2HPS^3 - Australasian Association for the History, Philosophy and Social Studies of Science
BSHS - British Society for the History of Science
BSPS - British Society for the Philosophy of Science
EASST - European Association for the Study of Science and Technology
ESST - European Inter-University Association on Society, Science and Technology
GWTF - Gesellschaft für Wissenschafts- und Technikforschung (Germany)
HSS - History of Science Society
International Association for Science, Technology and Society (IASTS)
NECSTS - Network of European Centres in Science and Technology Studies
PCST - International Network on Public Communication of Science and Technology
PSA - Philosophy of Science Association
STS-CH - Swiss Association for the Study of Science, Technology and Society

Journals
British Journal for the History of Science
British Journal for the Philosophy of Science
Bulletin of Science, Technology & Society
Configurations
EASST Review. The quarterly journal of the European Association for the Study of Science and Technology
GEGENWORTE (german)

Innovation policy Review (ex Science and Technology Policy)
ISIS
Issues in Science and Technology
Metascience
Minerva
Nature
Osiris
Perspectives on Science
Philosophy of Science
Public Understanding of Science
Research Evaluation
Research Policy
Science
Science and Public Policy
Science and Society
Science as Culture
Science in Context
Science Studies. An Interdisciplinary Journal for Science and Technology Studies
Science, Technology & Human Values
Scientometrics
Social Epistemology
Social Studies of Science
Technology and Culture
Technoscience (Newsletter of the Society for Social Studies of Science and Technology)
The Scientist

Institutions
Australia, Melbourne: HPS (Dept of History and Philosophy of Science)
Australia, Wollongong: University of Wollongong
Austria, Linz: AG Kulturphilosophie und Wissenschaftsforschung
Austria, Vienna: Institute for Philosophy of Science and Social Studies of Science
Austria, Vienna: ITA (Institut für Technikfolgenabschätzung)
France, Paris: CSI (Centre de Sociologie de l'Innovation)
Germany, Berlin: Max-Planck-Institut für Wissenschaftsgeschichte
Germany, Berlin: WZB (Wissenschaftszentrum Berlin für Sozialforschung)
Germany, Berlin: ZTG (Zentrum Technik und Gesellschaft)
Germany, Bielefeld: IWT (Institut für Wissenschafts- und Technikforschung)
Germany, Cologne: MPIfG (Max-Planck-Institut für Gesellschaftsforschung)
Germany, Hannover: ZEWW (Wissenschaftstheorie und Wissenschaftsethik)
Germany, Karlsruhe: FhG-ISI
Germany, Munich: Münchner Zentrum für Wissenschafts- und Technikgeschichte
Netherlands, Amsterdam: Science and Technology Dynamics
Netherlands, Maastricht/Amsterdam/Twente: Netherlands Graduate School of Science, Technology and Modern Culture (WTMC)
Netherlands, Twente: Centre for Studies of Science, Technology and Society
Sweden, Umeå: Inforsk

Switzerland, Basel: Professur für Wissenschaftsforschung
Switzerland, Bern: CEST
Switzerland, Zürich: Professur für Wissenschaftsforschung
The Netherlands, Enschede: University of Twente
United Kingdom, Edinburgh: Science Studies Unit
United Kingdom, Edinburgh: STS@Ed
United Kingdom, Lancaster: Centre for Science Studies
United Kingdom, London: STS@UCL
United Kingdom, Manchester: PREST - Policy Research in Engineering, Science and Technology
United Kingdom, Sussex: SPRU
United Kingdom, York: SATSU
USA, Ithaca NY: Cornell University
USA, Raleigh NC: NCSU - North Carolina State University
USA, Rochester NY: RIT - Rochester Institute of Technology
USA, San Diego CA: UCSD - University of California
USA, Stanford CA: Stanford University
USA, Troy NY: RPI - Rensselaer Polytechnic Institute
USA, University Park PA : Pennsylvania State University
USA, Washington: OTA - Office of Technology Assessment (Archives)

Appendix E
Improving the Technological Literacy of Undergraduates
Washington DC, April 18-19, 2005.

Workshop Presentations

<u>Plenary Address</u>

Renee Lerche, "The World of Literacy Definitions"

<u>Successful Implementations (alphabetical by presenter)</u>

James Baish, "Design as a Liberal Art at Bucknell University."

Robert Balmer, "The New Liberal Arts: Some assembly required."

Louis Bloomfield, "Teaching Physics in the Context of Everyday Objects."

William S. Hammack, "The Hidden World of Engineering"

John Krupczak, Jr, "Science and Technology of Everyday Life at Hope College."

Roman Kuc, "Teaching Technology to Non-Science Majors at Yale."

Michael Littman, "Engineering and the Modern World: A First Year Course on Engineering and History"

Deborah Mechtel, "Technological Literacy at the United States Naval Academy"

David Ollis, "Technological Literacy: Connecting through Context, Content, and Contraption."

Albert J. Rosa, "Technology 21, A Course on Technology for Non-Technologists."

Tarek Shraibati, "Responding to expectations of non-technical students: Selling technical courses to non-technical students in a large comprehensive regional institution"

Lawrence Whitman, "WSU Shocker Mindstorms:Engineering for Non-Engineers."

The World of Literacy Definitions

How to Succeed/Fail in Business Without Really Trying

Renee Lerche

Lessons From My Experience With "Literacy" Definitions

- Defining Adult Literacy
- Defining Employability Literacy/Skills
- Defining People Competencies for Ford Motor Company

Lessons Learned

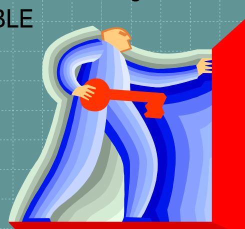
- Difficulty in finding common concepts/language that resonated with:
  - Employers
  - Educators
  - Policy Makers
  - Public

Lessons Learned

- Narrowing definitions by making them more specific made them easier to develop curricula and assessment tools
- It did NOT make them more usable nor did it heighten their ultimate impact

So... What Is Key?

- Taking complex concepts and making them SIMPLE AND ACTIONABLE



And...

- Finding a definition that functions like a Brand creating a concept/issue and an emotional connection to that concept/issue

Let's Start With What is Required for a High Performance Workforce.......

Commitment – Workers want to do the work…

Competence – Workers have the skills and knowledge to do the work…

Capacity – Workers have the tools and means to do the work….

Simply Put...

- We want workers and workplaces that are adaptable and flexible which require:
  - Clarity about business strategy and aspiration
  - The skills,knowledge and strategies that enable people to learn how to learn
  - The tools and support systems that allow them to learn and put in to practice what they learn

From the Workforce Development Perspective...

- Your definition of technological literacy is useful because:
  - You highlight the importance of not only high level thinking skills but also of using the "product" of that thinking to solve problems -
  - You focus on the application of knowledge as well as the creation of knowledge – strategic and tactical approach

What May Be Problematic...

- Complexity of definition
- Confounding of concepts
- By narrowing focus to technological literacy, you miss the broader need

To Sum Up...

- Make the complex simple and actionable
- Focus on those skills, knowledge development and problem solving processes that enable adaptability and flexibility
- Work to create/identify definition language that is broad enough to resonate with the multiplicity of expert and lay audiences you want to impact and motivate to action

Design as a Liberal Art at Bucknell University

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1

Experiences

- Exploring Engineering
- Society and Technology Residential College
- Designing People
- Form and Function: Design in the Natural and Fabricated Worlds
- Engines of Evolution and Revolution

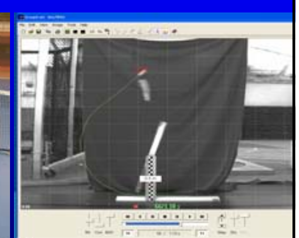
2

ENGR 100: Exploring Engineering

- 180 First Year Engineering Students
- 30 Arts and Sciences Students
- 4 Modules
  - Overview of Engineering Disciplines with ADA Design Project
  - 2 Technical Seminars (24 students each)
  - Engineering in Society with Professional Ethics with 'Book Project'

3

ENGR 100 Seminar: Flinging Things



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It's not the thing you fling. It's the fling itself.

Northern Exposure

5

Book Project

- Johnstown Flood, Oryx and Crake, The Cuckoo's Egg, Comm Check
- 5 Page Paper on Professional Ethics

6

Society and Technology Residential College

- First Year Living-Learning Community
- 4 Thematically Linked Foundation Seminars (15 students each)
- Weekly Common Hour
- College trips and activities

7

Common Hour

8

Foundation Seminar: Designing People

- 15 Students
- Satisfies College of Engineering
  - Social Science
  - Writing Level 1
- Satisfies College of Arts and Sciences Requirements
  - Foundation Seminar
  - Natural and Fabricated Worlds
  - Writing Level 1

9

Communal Values Clarification Model

10

Team Design Projects

- Technically accessible
- Complex enough to require a team
- Strong societal interaction
- Real customers - real product
- Broad appeal

11

Moravian Water Works

12

Moravian Water Works

13

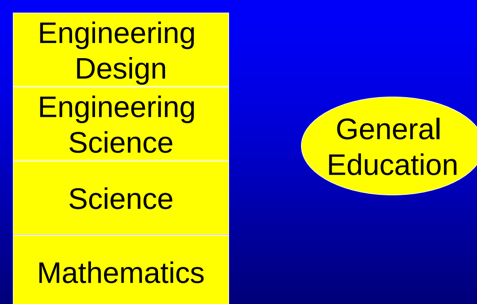
Moravian Water Works

14

Form and Function: Design in the Natural and Fabricated Worlds

- Elective for Engineering and Arts & Sciences Students
- 6-10 Upper Level Students
- Studio/Laboratory Exercises
- Qualitative Physics and Mathematics
- Unstructured Evaluation

15



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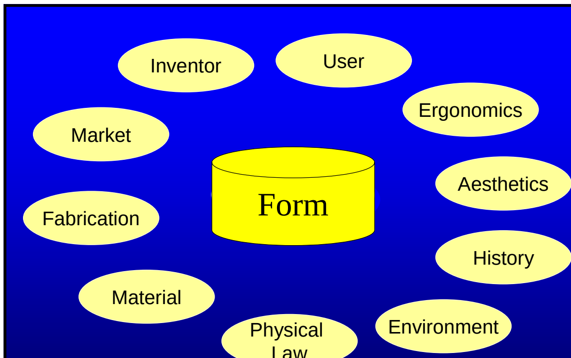

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18

A picture is worth 500 words

19

Coming Attractions
Fall 2005

Bucknell in London: Engines of Evolution and Revolution

21

Lessons Learned

- Design Projects = Active Learning
- Math Phobia = Challenge not Barrier
- Degree Requirement = Enrollment

22

NSF Sponsored NAE Workshop
Improving the Technological Literacy of Undergraduates

THE NEW LIBERAL ARTS

(SOME ASSEMBLY REQUIRED)

Dr. Robert Balmer, Dean
Engineering & Computer Science
Union College, Schenectady, NY
April 18 & 19, 2005

The Durability of the "Liberal Arts"

- **In ancient Athens the purpose of a liberal arts education was to develop the mind and character of future leaders.**
- **By the 12th century the seven liberal arts (language, rhetoric, logic, arithmetic, geometry, astronomy, and music) became the basic curriculum of the new universities.**
- **Of the 66 institutions that existed continuously from 1530 to 1980, 62 were liberal arts universities.** (Carnegie Council for Policy Studies, 1980.)
- **Today the liberal arts continue to purport to provide general knowledge and intellectual skills needed to produce a "whole person" (still exclusive of occupational or professional skills).**

The Future of Liberal Arts

In an era when technology is changing everything, does the definition of 'an educated person' still include a background in the liberal arts? It is clear that our nation's education system is at a crossroads. (Joyce Baldwin, "Liberal Arts for a New Millennium" Carnegie Reporter, Vol. 1/No. 1, Summer 2000)

Hundreds of colleges still call themselves liberal arts, but they graduate thousands with a degree to match almost any job one can imagine (e.g., journalism, business, criminal justice, nursing, etc.). (Paul Neely, "The Threats to Liberal Arts Colleges," Distinctively American, S. Koblik and S.R. Graubard, eds.)

Modern Leadership

- **The liberal arts were constructed as a practical platform to train future leaders at a time when there was little technology.**
- **21st century technology is so completely woven into the fabric of society that no one can lead effectively without understanding the practical impact of technological decisions.**

So is Technology Part of the New Liberal Arts?

- **The new generation of liberal arts (arts, humanities and the sciences) and engineering faculty are more aware of the impact of technology on society.**
- **NCEES thinks ABET's criteria 2000 is too "liberal."**
- **Decreasing number of credits required for an engineering degree (140s to 120s).**
- **Engineering "BA" with the MSE as the first "professional" engineering degree (Dartmouth, ASCE).**
- **Liberal arts students today are more career oriented (practical) than in the past.**

20th Century Changes in Liberal Arts Education

- **In the 1940s, most of the 20% of high school graduates who went to college studied liberal arts.**
- **By the mid 1970s, only half of all baccalaureate degrees were granted in the liberal arts.**
- **Today, 65% of high school graduates go to college and nearly 60% of the degrees granted are in a pre-professional or professional field.**
- **The number of students attending community colleges increased greatly since 1970, and now two-year associate degree schools account for more than 40% of the college population.**

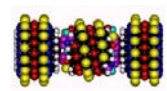
Today Traditional Programs Lead to New Opportunities

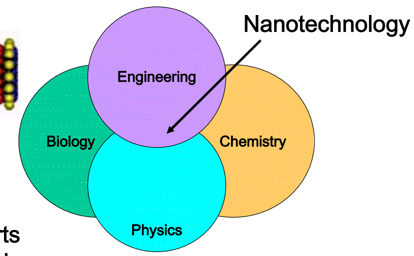
- Computer Eng.
- Electrical Eng.
- Mechanical Eng.
- Computer Science
- Biology
- Chemistry
- Physics
- Arts & Humanities

Changing World

- Nanotechnology
- Bioengineering
- Mechatronics
- Pervasive Computing
- Neurosciences
- many others

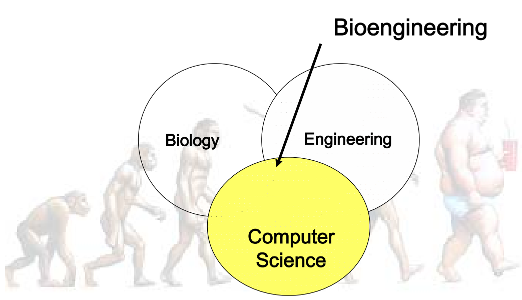
NANOTECHNOLOGY



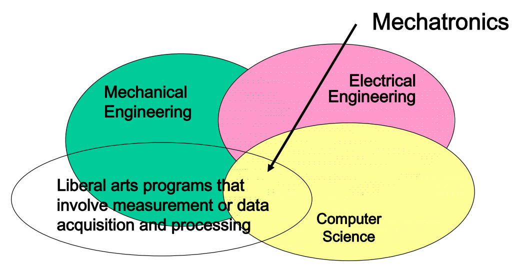


Liberal Arts & Engineering

BIOENGINEERING



MECHATRONICS



Pervasive Computing

This includes all forms of engineering, computer science, ethics, and applications within the liberal arts.

Barriers to Change in Academia

It has often been said that:

"Changing a university is like moving a grave yard - you do it one (faculty) grave at a time!"

So, really, how do you do it?

Exploring the Psychology of Change

The following 10 rules for change were developed by Joseph Zolner, Director, Harvard Institutes for Higher Education.

Note: Most academic institutions attempting curricula change violate one or more of these rules.

Zolner's Rules

1) Loss of Control - Change is exciting when it is done *by the faculty* but not when done *to the faculty*.
2) Too Much Uncertainty - Significant uncertainty can spell doom for administrators seeking to introduce new ideas into their institutions.
3) Surprise, Surprise - Some (falsely) believe that the best way to implement change is to "sneak up" on faculty and inform them of a change at the moment of implementation.
4) The "McDonalds Factor" - Familiarity breeds comfort, so build on institutional strengths faculty know, understand, and appreciate about their program, department, or institution.
5) Ripple Effects - Inevitably, changes send ripples beyond their intended impact.

Zolner's Rules

6. Loss of Face - Change often implies that someone's past actions or prior leadership were "wrong," or at least ill-conceived.
7. Concerns About Competence - Change inevitably raises troubling questions about an individual's ability to get a new job done.
8. More Work - One reason faculty resist change is that it often requires more work, adding new demands to an already-full agenda.
9. Past Resentments - Skeletons in administrative or departmental closets can easily impede change.
10. Sometimes the Threat is Real - Sometimes a threat posed by change is a legitimate source of concern and reason to embrace the status quo.

LESSONS LEARNED

At Union College we identified the following five steps in leading change in academia:

1) Create a vision that establishes a sense of urgency for change.
2) Communicate the vision and the urgency to the administration and faculty.
3) Empower faculty to act on the vision
4) Facilitate short-term successes.
5) Institutionalize the vision and its results.

Case Study

How these five steps were used to implement the "Converging Technologies" paradigm at Union College

Step 1: Create a Compelling Vision

- Technology is now growing at the interfaces of traditional academic fields.
- To achieve appropriate education goals we need to break down the barriers between departments.
- The convergence of traditional fields to create new fields of study is clearly an aspect of the 21st century.
- We call this process "Converging Technologies."

Step 2: Communicate the Vision

- Make presentations to the faculty, administration, alumni, and students describing the meaning of the term “Converging Technologies.”
- Bring local leaders onboard to lend credibility to the proposition.
- Put articles in newspapers, alumni magazines, college catalogs and brochures touting the values of a 21st century converging technologies education.

Interlude 1: So, just what is “Converging Technologies” anyway?

What is it? In academia it depends on your point of view.

- Converging Technologies are the new and often unexpected technologies that appear at the interfaces of existing fields of study.
- Converging Technologies focuses creative thought from engineering and the liberal arts on new ideas that are changing the landscape of global society.
- Converging Technologies is the same as Converging Thought (for the more conservative liberal arts faculty).

Interlude 2: Why is it important?

Why is it important? This has more to do with the future of the students.

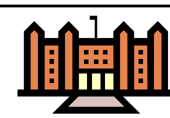
"Students who do not understand how the new and converging technologies work, how they construct meaning, how they can be used, and how the evidence they present can be weighed and evaluated are, in contemporary cultures, considerably disadvantaged and disempowered.” (Abbott & Masterman, "Working Paper No. 2", Centre for Literacy, 1997.)

Step 3: Empower the Faculty

- Establish Converging Technologies (CT) faculty working committees to discuss curricula revision, course development, industrial support, etc.
- Hold faculty CT retreats with speakers from industry.
- Reward faculty participation with released time to develop new courses or modify existing courses.
- Support faculty seeking funds in CT areas from NSF, DOE, etc.
- Encourage faculty to develop academic minors or areas of concentration in CT areas of interest.

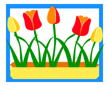
Step 4: Short Term Successes

- Advertise new CT courses to the faculty, administration, and student body.
- Distribute CT material added to existing courses.
- Industry and government sponsored CT research and student projects.
- Get CT minors and areas of study approved.
- Hire new faculty with interdisciplinary backgrounds and interests.



Step 5: Institutionalize the Results

- Win administrative support with short term successes.
- Ask trustees and influential alumni to support institutionalizing CT programs.
- Ask the development office to establish alumni funded CT Chairs and endowments.
- Advertise CT courses and programs on the web site and in the college catalog.
- Provide CT material to K-12 secondary schools.



We began our Converging Technologies initiative in the spring of 2001, and today it is well integrated into Union College curricula

In each of the following interdisciplinary areas, students benefit from the close collaboration between engineering and the liberal arts that CT fosters at Union.

- Bioengineering and Computational Biology
- Environmental Studies
- Entrepreneurship
- Mechatronics
- Nanotechnology
- Neuroscience
- Pervasive Computing
- Science, Medicine and Technology in Culture (SMTC)
- CT Organizing Theme Major

CT has become one of the pillars of excellence at Union College

(see: http://www.union.edu/CT)

- Created approximately 30 New CT courses
- Created one new CT major and four new CT minors
- Integrated CT material into countless existing courses
- Created a common advance microscopy laboratory containing AFM, STM, SEM, and NMR equipment for undergraduate use
- Created a new "Center for Bioengineering and Computational Biology"
- Appointed a full-time CT Director
- Designated a building to be remodeled as the "Center for CT"
- Received full support and encouragement from the Board of Trustees
- Created an new external CT Board made of influential alumni

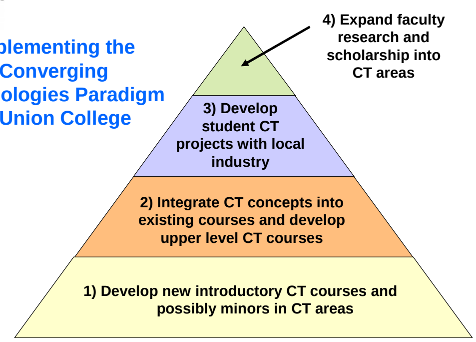
Converging Technologies and Research

While we are strictly an undergraduate institution, since 2001 we have noticed a significant increase in funded research in areas such as:

- NSF supported Aerogel Fabrication, Characterization and Application Lab (ME and Chemistry)
- Initiated digital mapping of historic Cordoba Spain (ECE and Modern Languages)
- Search for Equidistant Letter Sequences in Homer's Iliad (Computer Science and Classics)
- Bioinformatics (Computer Science and Biology)

Plus several CT program and planning grants

Implementing the Converging Technologies Paradigm at Union College



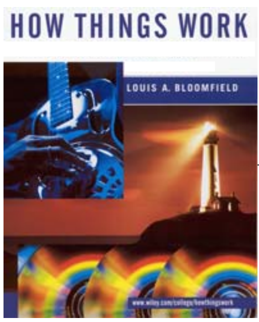
Summary

- Converging Technologies (CT) represents a paradigm shift in integrating technology into the liberal arts.
- Advancements in CT have created a need for new curricular approaches to undergraduate and graduate education.
- CT provides a mechanism to develop new educational structures that gain the support of faculty and administration to produce graduates with the social and technological skills to become leaders in the 21st century.

CONVERGING TECHNOLOGIES

THANK YOU

Visit Union College
Converging Technologies at
http://www.union.edu/CT



Teaching Physics in the Context of Everyday Objects

Louis Bloomfield
University of Virginia

National Academy of Engineering
April 18, 2005

What is *How Things Work*?

- Physics in the context of objects
  - Objects before physics concepts
  - Physics concepts before formulas
  - A "backward" approach to teaching physics
- The "case study" method
  - I accidentally rediscovered it in general
  - I accidentally reapplied it to physics
- How scientists actually learn science
- What truly makes science fun

Overview of this Talk

- Motivation for *How Things Work*
- Structure of *How Things Work*
- History of *How Things Work*
- Examples of Objects: What I Do!
  - Roller Coasters
  - Bicycles
  - Clocks
  - Microwave Ovens
- Observations about *How Things Work*

Why *How Things Work*?

- "Oh, I'm a physicist" … *(end of conversation)*
- Physics and technology education easily becomes:
  - magic & mysteries *(no explanation)*
  - factoids *(what, where, when, but never why or how)*
  - names *(memorization of random information)*
  - recipes *(mindless plugging and chugging)*
  - formalized "scientific method" *(repeating canned experiments)*

Why *How Things Work*? (con't)

- Physics and technology education should:
  - emphasize thought and understanding
  - grow naturally from the real world
  - explain rather than obscure
  - build confidence rather than destroy it
  - be useful in everyday life

What's Wrong with "The Usual"?

- "The Usual" is *Physics-for-Physicists*
- To non-scientists, *Physics-for-Physicists* is
  - Academic *(exists only in the classroom)*
  - Unfamiliar *(is invisible elsewhere)*
  - Irrelevant *(offers no apparent value outside the classroom)*
  - Boring *(it's an ordeal)*
  - Frightening *(it's a mythically dangerous ordeal)*
- Neglects how science evolved – in context of objects
- Active learning, hands-on work, enthusiasm can't fix

Structure of *How Things Work*

- A hierarchy with three levels
  - Level 1: Areas of Physics – for the instructor
  - Level 2: Objects of Everyday Life – for the students
  - Level 3: Concepts of Physics – for both

Heat and Phase Transitions
  Woodstoves
    (thermal energy, heat, temperature, chemical bonds and reactions, conduction, thermal conductivity, convection, radiation, heat capacity)
  Water, Steam, and Ice
    (phases of matter, phase transitions, melting, freezing, condensation, evaporation, boiling, relative humidity, latent heats of melting and vaporization)
  Incandescent Lightbulbs
    (electromagnetic spectrum, light, black body spectrum, emissivity, Stefan-Boltzmann law, thermal expansion)

Creating *How Things Work* in 1991

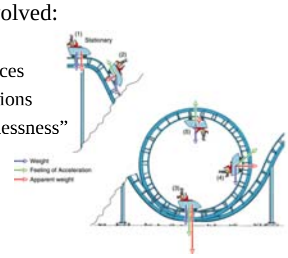
- Designed for non-scientists
- Built around everyday objects
- Focused on concepts, not on formulas
- Goals: students should
  - learn physics concepts well
  - encounter physics in context, in their world
  - learn how things around them work
  - begin to feel that physics is important

The Development of *How Things Work*

- Enrollment at Virginia
  - First semester: 92 students
  - Second semester: 262 students
  - Typical for 10+ years: 500 students
  - Now capped at 200 students
- Side Effects
  - My lecture notes evolved into a book
  - *How Things Work* courses have sprung up elsewhere
  - Early physics education is becoming more object-oriented

Roller Coasters

- How do loop-the-loops work?
- Physics concepts involved:
  - Inertia
  - Acceleration and forces
  - Centripetal accelerations
  - Weight and "weightlessness"

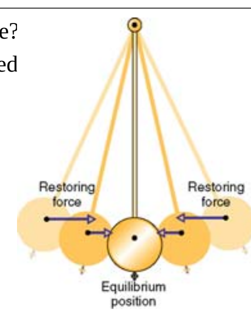


Bicycles

- Why are bicycles so stable?
- Physics concepts involved:
  - Equilibrium
  - Energy and acceleration
  - Stable and unstable equilibriums
  - Static stability
  - Gyroscopic precession
  - Dynamic stability

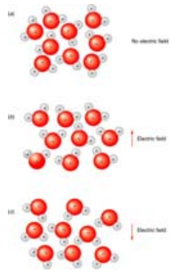
Clocks

- How do clocks keep time?
- Physics concepts involved
  - Time and Space
  - Forces and Acceleration
  - Harmonic Oscillators



Microwave Ovens

- How do microwave ovens cook?
- Physics concepts involved:
  - Electric fields
  - Polar molecules and free charges
  - Electrostatic forces and torques
  - Electromagnetic waves
  - Wavelength and frequency



Observations about *How Things Work*

- The impact of *How Things Work*
  - Many non-science students are now learning physics
  - These students find physics useful
  - There is less fear of physics – a cultural change
  - Physics has become a valued part of the curriculum
  - Other physics courses are flourishing

Observations about *How Things Work* (con't)

- My own experiences
  - I'm enjoying teaching more than ever
  - I feel as though I make a difference
  - I get to explain physics widely
  - I've learned a great deal of science

The Hidden World of Engineering

William S. Hammack
Department of Chemical & Biomolecular Engineering
University of Illinois at Urbana – Champaign
Email: hammack@netbox.com

Presented at
Improving the Technological Literacy of Undergraduates
National Academy of Engineering
April 18-19, 2005

The REALLY big picture

1. Democracy

We require technologically literate citizens to make informed decisions.

2. Economic productivity

Technology savvy workers to ensure long-term economic health.

3. Life-long growth

Helping a person apply technology in their own life and as workers, parents, and consumers.

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What should we mean by technological literacy?

Hard scientific literacy

A toolbox of skills in math, physics, chemistry, etc.

Error: “Engineer Lite”

Herb Simon, Nobel Laureate in Economics:

"Far more important than subject matter is the method of science: The nature of scientific evidence, the ways in which that evidence is obtained, and the ways in which it can be interpreted."

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(See reference at end)

Technological awareness

1. An awareness of how the engineering enterprise works

2. Focus on decisions made by engineers (and therefore design)

3. Understand what can be expected from engineering

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Another way to phrase it:

> Technological Humanism: Develop the habit of comprehending a technology in its completeness.

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Another way to phrase it:

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(See reference at end)

My course

- Focus on decisions or choices: Why did an engineer decide to design an object in a particular way?
- Modules:
  - Greek-Roman engineering
  - Aluminium beverage can
  - VCR (contains math module)
  - Salt
  - Structures/non-verbal aspects engineering
  - Ball Bearing (final project)
- 60% business students, 40% other majors

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Core content: Themes used for design

1. Economics

2. Notion of "Best"
- **a.** Availability of energy
- **b.** Economic Resources
- **c.** Cultural Contraints
- **d.** Societal Needs
- **e.** Consumer Preferences

3. Intellectual tools
- **a.** Scientific facts & methods
- **b.** Mathematics
- **c.** Knowledge of materials

4. Empirical methods & attitudes
- **a.** Trial & error
- **b.** Building on past knowledge
- **c.** Trade offs

Core content: Themes used for design

1. Economics — De-emphasize for business students!

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Methodology a central part of the core

Pedagogical aspects

- Students work in teams throughout course (7 short exams, followed by projects)

Format: Reading → Individual exam → Group exam → Group project

- Projects: Want students to use different types of skills (text interpretation, non-verbal, mathematical)

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Examples:
- Non-verbal: Given component of a VCR cassette to put back together
- Mathematical: Using design equations to see the trade-offs made in a VCR

Interesting reading

Simon, Herbert A. "Scientific Literacy as a goal in a high-technology society." *The Tanner Lectures on Human Values*, November 11, 1983. University of Utah Press, Salt Lake City, 1984, volume V.

Ashby, Sir Eric "Humanism in Technology" in *Engineering: Its role and function in human society* (edited by W.H. Davenport and D. Rosenthal, Pergamon 1967)

Lewis, C.S., *The Abolition of Man* (Harper, first published 1946)

Details of projects

- Greek/Roman
  Establishes idea of engineering as economic enterprise tied into politics, culture and society.
- Beverage Can
  Materials as key in making design choices, esp shape
- VCR
  With focus on how it works: Cover Math and non-verbal
- Salt
  Emphasizes the notion of "best" when applied to engineering problem
- Mind's Eye
  Non-verbal thinking most:ly: Students build structures
- Ball Bearing
  Students given bearings: Cover all aspects, verbal, math, non-verbal.

"Science and Technology of Everyday Life"
at
Hope College

John Krupczak, Jr.

Associate Professor of Engineering
Hope College
Holland, Michigan

Improving the Technological Literacy of Undergraduates

National Academy of Engineering
Washington DC, April 18-19, 2005.

Outline

Presentation objectives:

- Institutional Environment
- Specific Implementation
- Learning Objectives
- Assessment Methods
- Student Outcomes
- Research Issues
- Possibilities for Stimulating interest in the topic.

Hope College

Hope College

- Location: Holland, Michigan
- on Lake Michigan.
- Liberal Arts College.
- Founded 1863.
- 3000 students.
- BS Engineering.
- ABET Accredited.

- 80-100 Engineering Students.
- Continuation to Graduate study.
- 46% of Engineering majors continue for MS or Ph.D. in Engineering (Since 1994)
- 52 % to *US News* Top 10 Engineering Graduate Schools

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Science and Technology of Everyday Life

Course for Non-Engineers
- Survey of Modern Technology.
- Focus on How Things Work.
- Key Scientific Principles in applied context.
- Lecture / Lab Format.
- Satisfies "Core" Requirement

- Topics:
  - Automobile,
  - Basic Electrical Devices
  - Electronics and Telecommunications
  - Computers
  - Other: Medical Imaging, Flight, Refrigeration.
- Survey. Inspiration: *History of Art or Music 101*
- Theme of "empowerment"
- Content derived in part from surveys of students.
- (Learner Centered ie: Engineering Design Method)

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Enrollment Statistics

- 1032 Non-Engineering Students Total
- 25 Times Taught Since 1995
- 623 Women (60 %)
- 259 Pre-Service Teachers (25 %)
- Others: Business, Performing Arts Majors
- Class Size:
  - Lecture 48 (Krupczak)
  - Lab Sections 24 (Krupczak + Others)

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Laboratories

- Traditional format science labs and activities
  - Electricity, Magnetism, Sound, Light.
- Take apart and put back together
  - Automobile engines (not working)
  - Telephones (working)
  - Computer (working)
- Build and take home
  - Electric motor
  - Crystal Radio
  - Electrodynamic speaker.
  - Audio amplifier.
  - One-octave keyboard.
- Projects redesigned specifically for non-science, non-engineering student.
  - Robust, High impact, Readily explained

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Summative Assessment

- Writing Assignments
- 5 page papers
  1. Investigate a Car Problem: What Happened and Why?.
  2. Savvy Consumer: What are you getting for your money?.
  3. Benefits and Risks: Technological Controversies.
- Final paper (10 pages)
  - Topic of choice. Emphasis on How it Works.

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Outcome Evaluation: MSLQ

- Motivated Strategies for Learning Questionnaire.
- Developed at University of Michigan, Psychology Dept.
  Pintrich, P.R., D.A. Smith, T. Garcia, W.J. Mckeachie, "Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (MSLQ)," *Educational and Psychological Measurement*, 53 (1993) p 801-813.
- Reliable and valid measure of student learning and motivation in higher education.
- Used by 100s of schools in 25 countries, several languages.

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MSLQ Components

Optimal learning requires a sense of interest and purpose in a particular field.

- *Intrinsic Motivation*: Inspired to learn due to curiosity about the topic.
- *Extrinsic Motivation*: Inspired to learn due to rewards such as grades or money.
- *Task Value*: Extent to which learning is relevant, useful, personally meaningful.
- *Self-Efficacy*: Belief about their ability to achieve on school-learning tasks. Extent to which they feel competent and empowered.
- *Control Beliefs*: Extent to which students believe that hard work in school will result in accomplishment.
- *Critical Thinking*: Extent to which students analyze and critique arguments and assertions.

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MSLQ Results

Result from Fall 2003 Course

Maximum value of 7.0 each category.

Scale	Pretest Mean	Post Mean	Change	p
Intrinsic Motivation	4.72	5.02	0.30	0.030
Extrinsic Motivation	4.56	4.48	-0.08	0.659
Task Value	5.03	5.41	0.38	0.015
Control Belief	5.43	5.68	0.25	0.116
Self-Efficacy	5.39	6.05	0.66	0.000
Test Anxiety	3.59	3.10	-0.49	0.013
Critical Thinking	3.95	3.70	-0.25	0.122

Change is statistically significant if

$p < 0.05$

Statistically significant increases in: **Interest, Task Value, Self-efficacy**, and decrease in **Test anxiety**.

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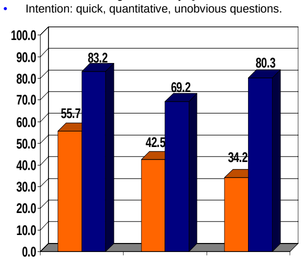
Technological Literacy Quiz

- Created Technological Literacy Quiz.
- Intention: quick, quantitative, unobvious questions.



Sample Test Questions

- In electronic devices weak currents are increased in strength through the action of which component?
  Diode / Circuit breaker
  Transistor / Solenoid
- In an automobile what is the function of the "cam" ?
  Ignite fuel / Maintain wheel alignment
  Open valves / Circulate coolant
- A LASER can NOT be which color?
  Blue Green Red White.

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Student Comments

- Favorable Comments.
- *"This course was very beneficial in helping me get over my fears about learning the technological side of things."*

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Student Comments

Favorable Comments.

- *"It was very useful to me seeing that I'm going to be an elementary teacher. I need to know how things work and be able to explain it in an understandable manner."*

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Student Comments

- Paradox: At a Liberal Arts College one of the most popular courses is in the engineering department.
- Usually first "closed" course.
- *[Getting in] "harder than getting concert tickets"*
- *"I have learned so much in these past few weeks and never had so much fun doing it."*
- *"I will be able to contribute to the never-ending car talk that goes on. Now I just have to get my mom involved!"*

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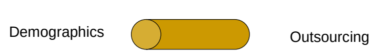
Research Issues

- Have examples of success here today.
- Goal is to sustain and expand tech lit.
- This goal has existed a long time.
- What is different now that might lead to success?
- Engineering Education itself is in trouble.
- Pipeline drying up at both ends.



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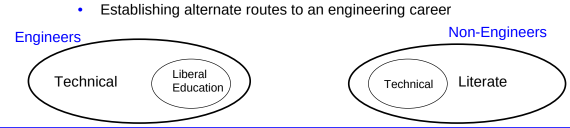
Research Issues

- Technological Literacy Classes are an audience of potential engineers.
- Engineers now need type of education provided by many technological literacy classes. (NAE: Engineer 2020).
- Future of technological literacy is in adding engineering students.
- Opens up interesting issues – Grand challenges
  - Blending engineers and non-engineers.
  - Integration with engineering curricula
  - Establishing alternate routes to an engineering career



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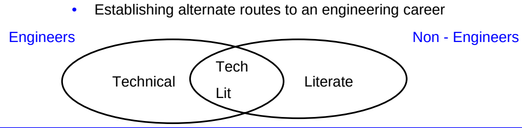

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Science and Technology of Everyday Life 2.0

- Science and Technology of Everyday Life (including engineers)
- Engineering students need a broad overview or survey of technology too.
- Appreciate hands on exposure to interesting technological devices.
- Engineering students not getting experience informally as was the case in the past.
- They do not arrive having a broad repertoire of meaningful technical experience.
- This experience formerly provided essential context for the whole of engineering science education.
- Possibly Integrate how things work survey perspective and empowerment theme with Introduction to Engineering.

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Acknowledgements

- National Science Foundation
  CCD 9752693
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- Student and Faculty collaborators including:
- Lou Bloomfield, David Ollis

Website : www.hope.edu/academic/faculty/krupczak

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Teaching Technology to Non-Science Majors at Yale

Roman Kuc

Department of Electrical Engineering
Yale University

Overview

- Yale Tech/Lit Requirements
- EE101 – The Digital Information Age
  - Design
  - Topics
  - Example: Data transmission speed on the Internet
- Things I have learned from EE101
  - Based on 10 offerings with enrollments from 4 to 800
- Research areas

Yale Tech Lit Approaches

- Past requirements:
  - Distributional requirement: 3 courses in S-M-E.
  - Goal: Numerical Literacy.
- New requirements:
  - 2 courses each in Science and Quantitative Reasoning.
  - Goal: Numerical Facility.

Design of EE101

Purpose: Tech literacy (increase # of Eng majors, increase Eng presence on campus).

Objective: Prepare students to participate in the knowledge-based economy by teaching digital system fundamentals.

Approach: Start with technological artifacts and teach underlying SME.

Outcomes: Completing EE101, students will be able to:

- Understand basic digital system operation.
- Publish a Web page.
- Analyze and interpret data using modern software tools.

Challenges:

- How to teach to a wide spectrum of student abilities?
- What do students do? (HW, Tests + ?) (? = projects)

EE101 Topics

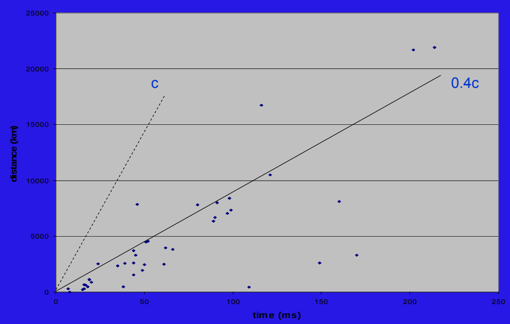
- Sensors (mechanical switches, IR sensors)
- Digital logic (AND, OR, NOT gates, truth tables)
- Systems (sensor – processor – actuator – feedback)
- Probability (Information measure: Entropy = $-\sum P_i \log_2 P_i$)
- Coding for error detection & correction (bar codes)
- Coding for data compression & encryption (fax code)
- Task complexity (simple & hard games)

Internet Project: Data transmission speed

Student tasks:

- Choose 10 Web sites located around the world.
- Find distance (D) from New Haven (*indo.com*).
- Find transmission time (T) with *Traceroute.*
- Plot data using *Excel* (R-T D vs T).
- Fit line and compute slope (= transmission speed).
- Compare with speed of light *c.*
- Explain significant deviations from trend.

Transmission Speed Results
(41 sites)



September 15, 2005 7

What students learn from this project…

- To acquire and work with real data.
- To model behavior of physical systems mathematically.
- To summarize behavior using simple analytic form.
- To perform dimensional analysis.
- To assess performance with deviations from trend.
- To use MS Excel for data display.

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What I have learned – 1

Difficult to mandate Tech-Lit:

- Making it a requirement, students may still not embrace it.
- Students must perceive value in material (empowerment, professional advantage, as well as being liberally educated)
- Tech-Lit competes with courses in the major for student effort and interest
- *Fun* is necessary, but not sufficient, course attribute (also, fun for instructor may not be not fun for student)

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What I have learned – 2

- Humanities students are different from Engineering students
  - Not better or worse, only *different.*
  - But only in interests, not necessarily in SME skill.
  - Students pick and choose topics from syllabus.
    - Tech/Lit is typically not prerequisite for other courses.
    - This may be only Tech/Lit course student ever takes.
- Hands-on projects work best
  - Presented in entirety, but performed in parts, so students see connection to whole.
  - Student-specific values allow discussion without mere copying, but increases grading effort.

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What I have learned – 3

- Tests:
  - Must be more than simply math drills.
  - Use Bloom's taxonomy to assess comprehension.
    - Change "*what is…*" to "*design a…*"
- Teaching a Tech-Lit course
  - Can be rewarding,
  - Is a learning experience,
  - Requires a lot of work, and also
  - Requires a thick skin.

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Research Issues – 1

- Defining technological knowledge goals:
  - Appreciation – recognizing good and bad designs.
  - Literacy – knowing there are constraints and limitations.
  - Facility – problem solving, actively participate in digital economy.
- Implementation
  - Seminar (max 18 students) is better than large lecture.
  - Hands-on projects important.
  - Distance learning?
- Assessment
  - Distance traveled by student.
  - Need reliable measure to determine *initial condition.*

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Research Issues – 2
Objectives?
Single course – what are realistic goals?
Course sequence – data analysis, interpretation, and decision-making (similar to NSF research in sensor systems).
Sustainability?
Is it the course, or is it the Instructor?
Is course related to instructor's research activity?
NSF support? (!)
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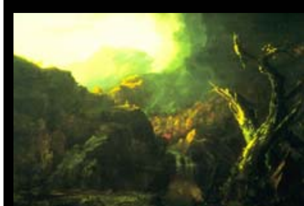
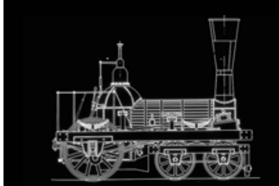
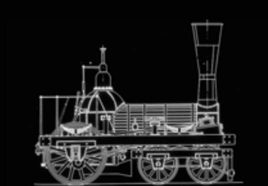
Engineering and the Modern World

A First Year Course on Engineering and History

CEE 102
David Billington and Michael Littman
Princeton University

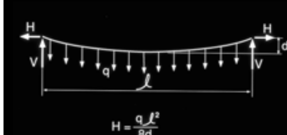






Language and Meaning of Engineering

Scientific: formulas
relationships
Social: history
contexts
Symbolic: images
vision



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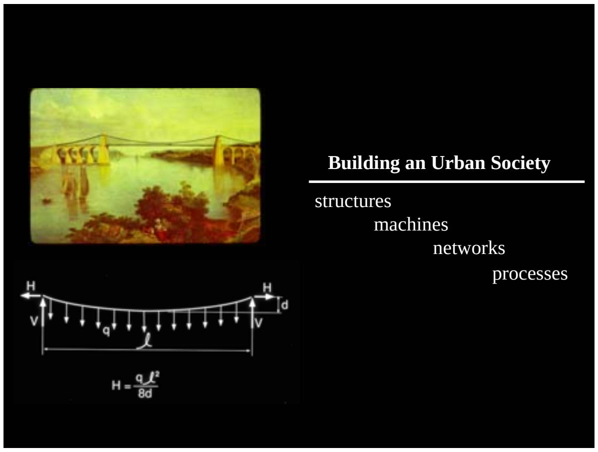
Building an Urban Society
structures
machines
networks
processes
H
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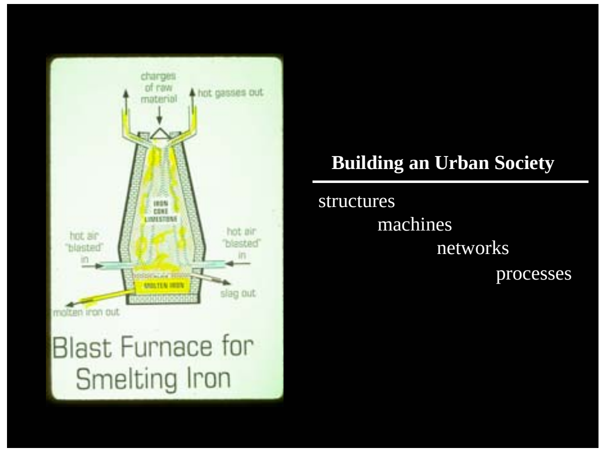
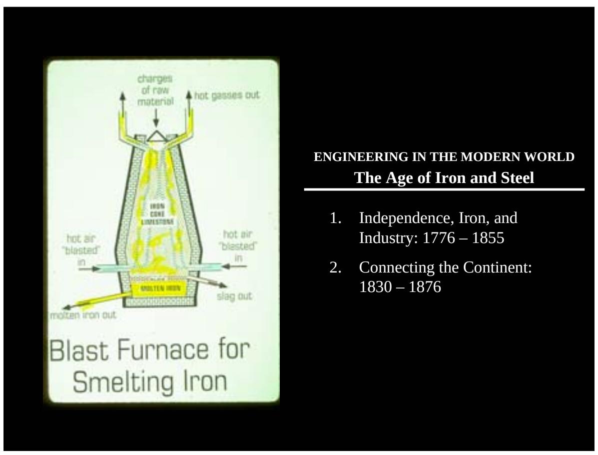
H = qℓ²/8d


charges of raw material
hot gasses out
hot air "blasted" in
slag out
molten iron out
Blast Furnace for Smelting Iron
Building an Urban Society
structures
machines
networks
processes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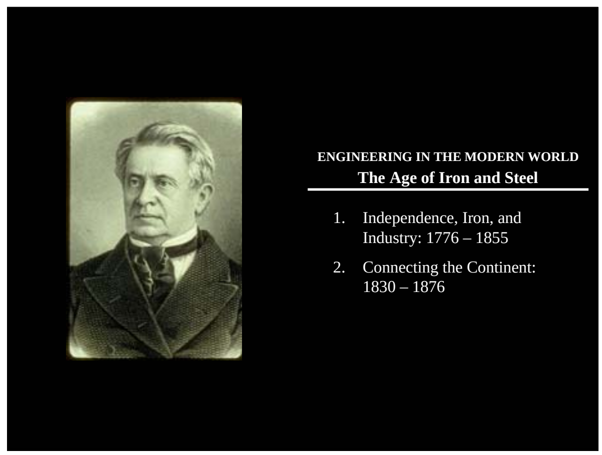
Blast Furnace for Smelting Iron
ENGINEERING IN THE MODERN WORLD
The Age of Iron and Steel
1. Independence, Iron, and Industry: 1776 – 1855
2. Connecting the Continent: 1830 – 1876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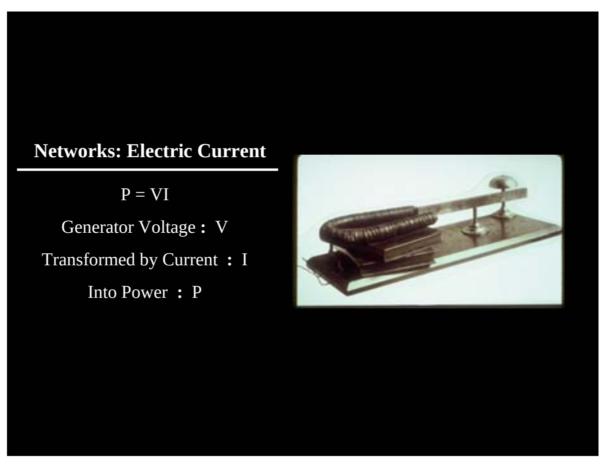
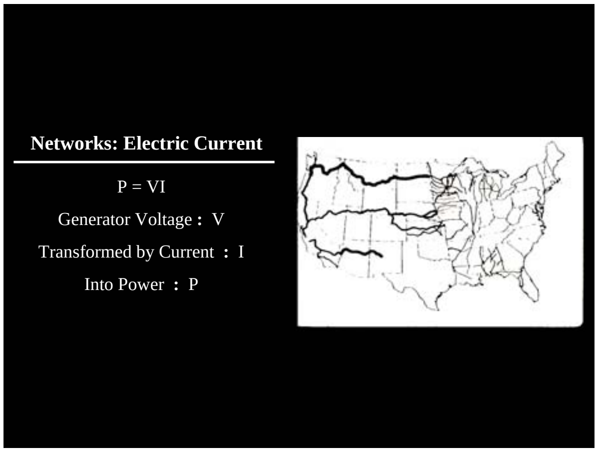

Networks: Electric Current
P = VI
Generator Voltage : V
Transformed by Current : I
Into Power : P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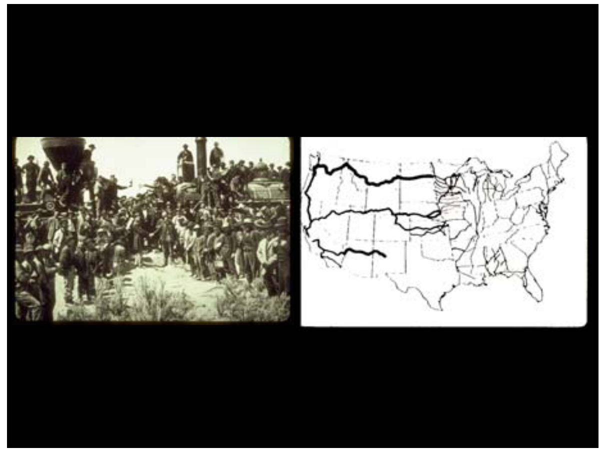

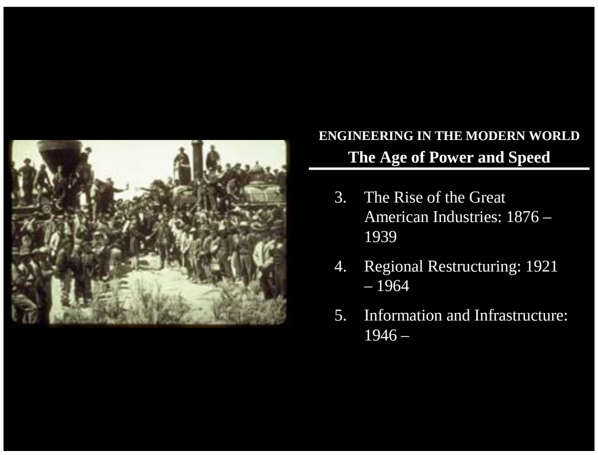
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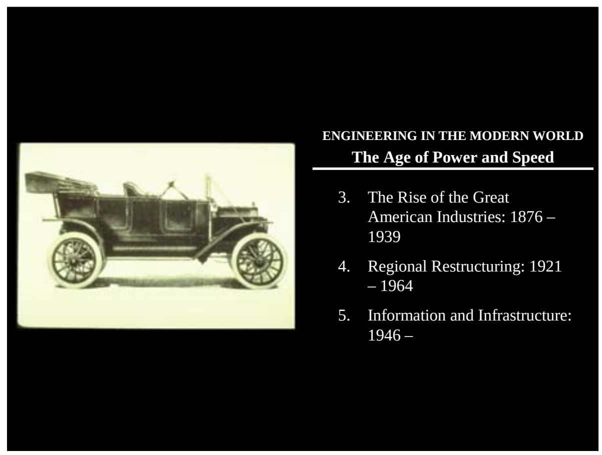
3. The Rise of the Great American Industries: 1876 – 1939
4. Regional Restructuring: 1921 – 1964
5. Information and Infrastructure: 1946 –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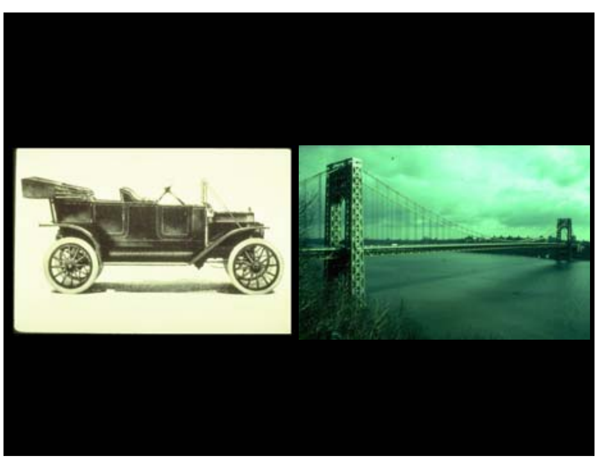


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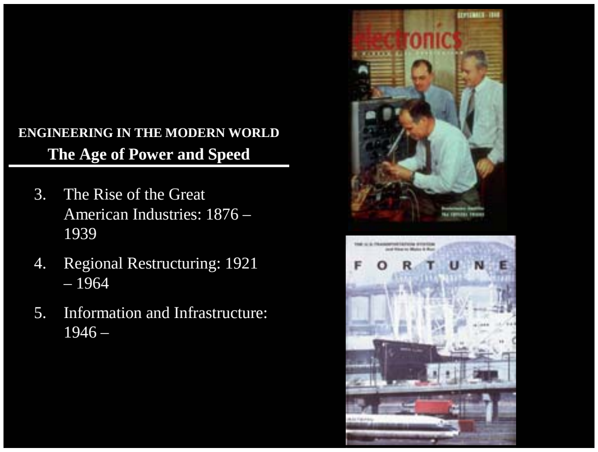
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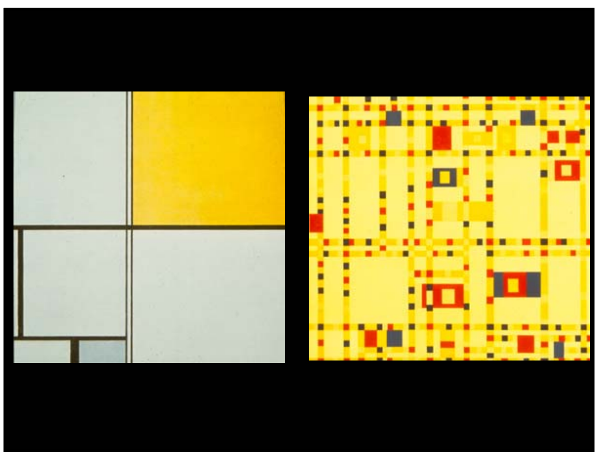
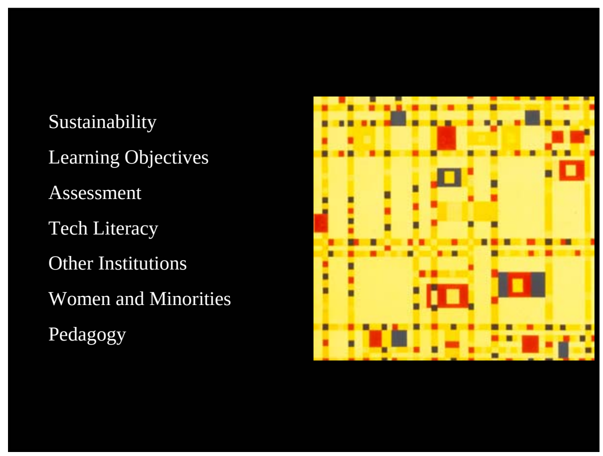
electronics
FORTUNE


electronics
FORTUNE




Sustainability
Learning Objectives
Assessment
Tech Literacy
Other Institutions
Women and Minorities
Pedagogy

TECHNOLOGICAL LITERACY at the United States Naval Academy

Deborah Mechtel

NAE
April 18-19 2005

United States Naval Academy Profile

- 4 year undergraduate institution
- 4000 students from every state in the U.S.
- Class of 2007
  - 16.7% Women
  - 24.6% Minorities
- Faculty is approximately 50% Navy and Marine Officers and 50% Civilian PhDs
- Student-Faculty ratio is 7:1 (most classes have 10 to 22 students)

Technological Literacy at the USNA

- Why technological literacy training is important.
- How we teach technological literacy.
- Assessment –how are we doing?
- How other institutions could use the USNA model.

Why technological literacy training is important

- Navy and Marine officers must be multi-skilled
  - Leadership ability
  - Understanding of geopolitical and cultural implications of command decisions.
  - Communication skills
  - “in an increasingly technical world, our officers must understand what makes their systems tick” Vice Admiral Rempt, USNA, Superintendent

Navy Systems

How we teach technological literacy

- Students choose major sophomore year
- Freshmen year
  - Calculus
  - Chemistry
  - U.S. Government
  - Navy history
  - Leadership and Human Behavior
  - Rhetoric and Literature

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Curriculum Requirements for an English Major (BS)

- Calculus III and Probability
- Physics I and II
- Western Civilization I and II
- Four semesters of a foreign language
- 10 English courses
- Electrical Engineering I and II, Naval Architecture, Systems engineering, Thermodynamics

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April 18-19 2005

Academic support

- Academic Center
- Formal peer tutoring
- Faculty support –Extra Instruction

NAE 9
April 18-19 2005

How we teach Electrical Engineering

- Every student at the USNA takes at least two electrical engineering courses.
- For an English major, those two courses are EE301 and EE302

NAE 10
April 18-19 2005

EE301

- Introductory DC and AC circuit theory
- Resistors, capacitors and inductors
- Steady state and first order transient voltage, current and power
- Impedance matching, filters, transformers
- Three-phase power distribution systems
- Modeling and analysis of rotating machinery

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EE302

- Digital logic
- Computer architecture
- Networks
- Analog and digital communications
- Satellite communication

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Pedagogical Approach

EE 301

- Electrical engineering fundamentals are emphasized
  - Mathematics required is reviewed as needed
  - Studio classrooms

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Studio Classroom

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Studio Classroom

NAE 15
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The studio classroom

- Classroom seating and lab benches are in the same room.
- Classes are 5 hours a week on a 1-2-2 schedule. (MWF or MTR)
- Practical exercises
- Pilot program in 2001
- All EE301 and EE302 are now studio classes

NAE 16
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Pedagogical Approach

EE 302

- Survey Course
- Applications presented have changed as technology has evolved
  - Satellite Communication
  - Networks

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Some of the challenges

- About 600 students are enrolled in EE301/EE302 each semester.
- The majority of instructors are military officers with a Master's degree in engineering on three year duty tours.
- The applications presented and the time spent teaching each topic are constantly evolving to meet fleet requirements

NAE 18
April 18-19 2005

Meeting the challenges

- Department curriculum committee has a three member subcommittee responsible for overseeing the course content of non-major EE courses. (Recently established)
- Clear course learning objectives
- All instructors use the same syllabus, homework assignments, tests and practical exercises.
- Course administrator holds weekly meetings to address changes as the semester progresses.

Ongoing concerns

- Finding a textbook
- Writing text supplements when a textbook isn't available
- Level of course difficulty
- Time allotted to each topic
- Updating practical exercises for:
  - Content
  - Pedagogical value
  - Time required
  - Equipment available

Assessment – how are we doing?

Program level outcomes

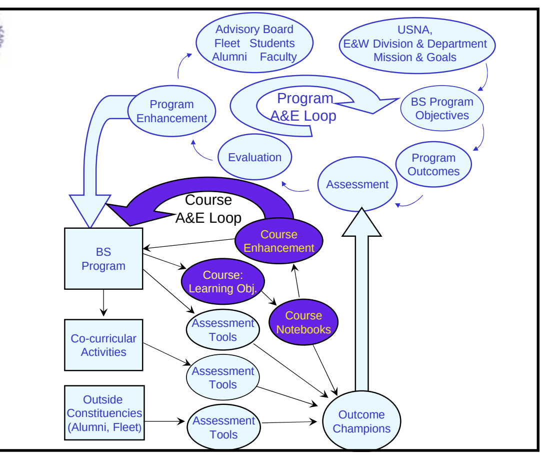
- an ability to apply fundamental principles of mathematics, science, and engineering
- an ability to design and conduct scientific and engineering experiments and conduct software simulations, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs. This includes problem definition, specification, design, implementation, test and operation of systems, components, and/or processes within performance and resource constraints
- an ability to function on multi-disciplinary teams and in one-on-one situations
- an understanding of professional and ethical responsibility

Assessment – how are we doing?

Program level outcomes (continued)

- an ability to communicate effectively, both verbally and in writing
- the broad education necessary to understand the impact of engineering solutions in a global and societal context
- a recognition of the need to continually update their knowledge and skills, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- an ability to identify, formulate, and solve practical electrical engineering problems

USNA Assessment Process



Course level assessment

- Course notebooks
  - Syllabus, learning objectives, exams
  - Course assessment tool (CAT)
- CAT
  - Maps course learning objectives to EE department program outcomes
  - Maps course learning objectives to course coordinator's assessment methods (exams, quizzes, oral reports)
  - A framework for course coordinators to provide assessment information to outcome champions
  - Documents course coordinator's response to outcome champion recommendations (Accept, Reject, Not Applicable)

Assessment – how are we doing?

- Fleet survey
- Alumni survey
- Outcome champions
- Faculty
- Students

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USNA Model

- A clear institutional understanding of the value of technological literacy courses.
- A commitment to a level of technological understanding that can only be achieved with hands on work in the lab.
  - Motivates and excites the student
  - Practical applications are emphasized

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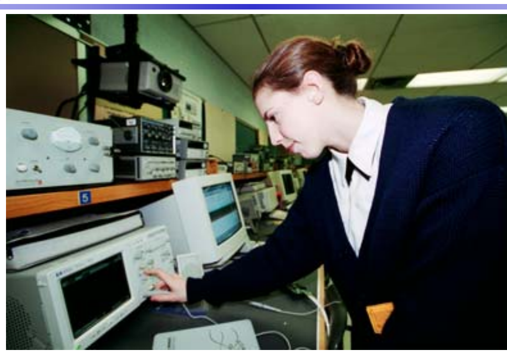
USNA Model



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USNA Model

- Studio classrooms
- Committed and involved faculty
- Technical personnel support
- Funding for updated equipment

NAE 28
April 18-19 2005

Technological Literacy: Connecting through Context, Content, and Contraption.

David Ollis
Chemical Engineering, North Carolina State University, NC 27514

Conceptual organization

- **Context** :lecture survey of prior technologies with similar or related purposes
- **Content**: lecture explanation of the modern technology/device
- **Contraption**: lab , use, take apart,assemble the device, w/questions

Lecture topics: Weeks 1-6

Context: Evolution	Content: Modern Device
Introduction to technology	Engineering: "Design under constraints"
Fuels to work: fire to engine	Internal combustion engine
Electricity to work: Franklin to electric power	Electric motors and drills
Electrons for information: telegraph & telephones	Cellular phone networks
Catching light: Archimides to optical fibers	Optical fiber systems
Tracking commerce: from barter to bar codes	Bar code systems

Lecture topics: Weeks 7-12

Producing sound: Galileo to Grunge	Acoustic and electric guitars
Recording images: Niepce to videos	Video camers & VCRs
Recording sound: Piano rolls to CDs	CDs & CD "burners"
Reproducing information: Gutenberg to photocopy	Black/white & color photocopy
Making new materials:	The integrated circuit
Computers: Eniac to Apple	Personal/laptop computers
Flight: Ancient gods to Wright brothers	Modern jet

Laboratory Devices

- Bar code scanner
- Compact disc player and burner
- FAX machine
- Optical fibers,
- Photocopy / scanner
- Video cameras
- UV water purifier
- Electric and acoustic guitar
- Electric drill
- Bicycle
- Internal combustion engine
- Cell phones,
- (model) Airplanes.

Technology Literacy: Our Student Learning Objectives

- "Students in this course will
- (1) *Develop a basic conceptual framework and vocabulary* for describing the technical and historical origins of modern technological devices
- (2) *Explain the conceptual operating bases* of current and prior technologies which address similar societal needs
- (3) *Use and dissect devices* to develop understanding of the relationships between technical subsystems of a device (e.g., the optical, electrical, and mechanical subsystems of a facsimile (FAX) machine), and their influence on device design and operation.
- (4) *Develop an understanding of the impacts* (technical, economic) of a device in a given context, through lecture and individual analytic written papers.

Reading & Writing (individual)

- Students read one book per month and write a paper analyzing a technical topic involving development of a commercial device (first month), a technology company (second month), and a technology hero (third month). Respective examples are a new computer in The Soul of a New Machine, Amazon.com, and Thomas Edison

Recruiting students

Original advertisement (student newspaper)

Technological Literacy

(result: 3 students)

Revised advertisement (student newspaper)

How Stuff Works

(result: 18 students)

Acknowledgements:

- Funding for development of our "Technology Literacy" course by the National Science Foundation (DUE-0126876) (CCLI-Adaptation and Implementation)
- Advice and assistance: Prof.John Krupczak, Hope College

References

- Beaudoin, D. and D. F. Ollis, "Product and Process Laboratory for First Year Engineering Students," J. Eng'g. Ed., 1995.
- Krupczak, J., et al., "Hands-On Laboratory Projects for Non-Science Majors: Learning Principles of Physics in the Context of Everyday Technology," ASEE Proceedings, St. Louis, MO, June, 2000
- Krupczak, J., "Reaching Out Across Campus: Engineers as Champions of Technological Literacy," in Liberal Education in Twenty-first Century Engineering, editors: Ollis, D.S., Neeley, K.A., and Luegenbiehl, H.C., Peter Lang Publishers, New York, NY, 2004, pp. 171-188.
- Ollis, D. "Installing a Technology Literacy Course: Trials and Tribulations",ASEE Proceedings, Salt Lake City, UT, 2004

Technology Literacy : A Working Definition (Byars, 1998)

- "The ability to understand, intelligently discuss and appropriately use concepts, procedures and terminology fundamental to the work of (and typically taken for granted by) professional engineers, scientists, and technicians; and being able to apply this ability to:
- (1) *critically analyze* how technology, culture and environment interact and influence one another.
- (2) *accurately explain* (in non-technical terms) scientific and mathematical principles which form the bases of important technologies
- (3) *describe and, when appropriate, use* the design and research methods of engineers and technologists
- (4) *continue learning* about technologies, and meaningfully participate in the evaluation and improvement of existing technologies and the creation of new technologies."[12]

Technology 21

A Course on Technology for Non-Technologists

Albert J. Rosa, University of Denver

NAE Conference on
Improving the Technological Literacy of Undergraduates
Washington DC, April 18 & 19 2005

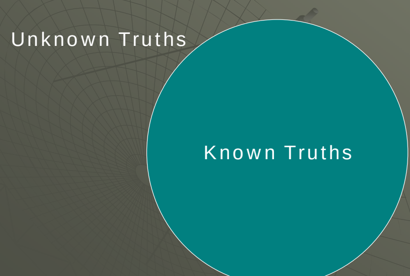
Overview

- In a highly technological world everyone, especially learned individuals, need to understand *Technology…*
- What it is, how it's created, how it affects society, and how to make smart decisions regarding it.

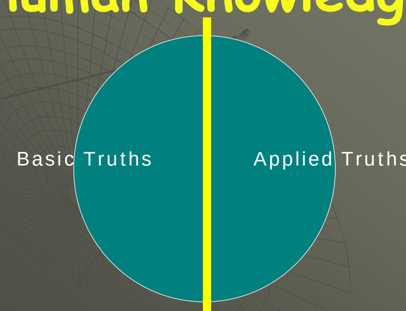
The Challenge

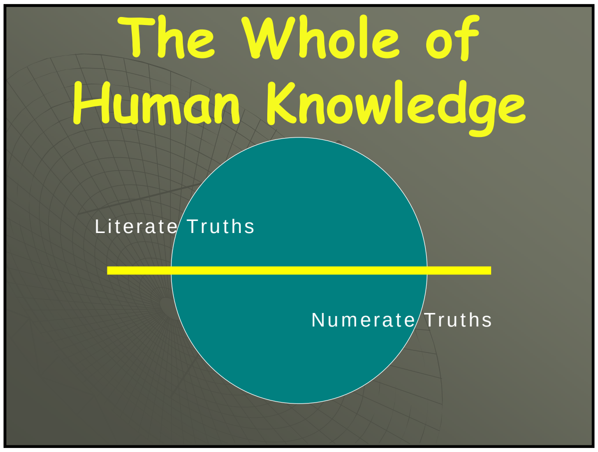
What Do We Mean By "Learned" Individuals

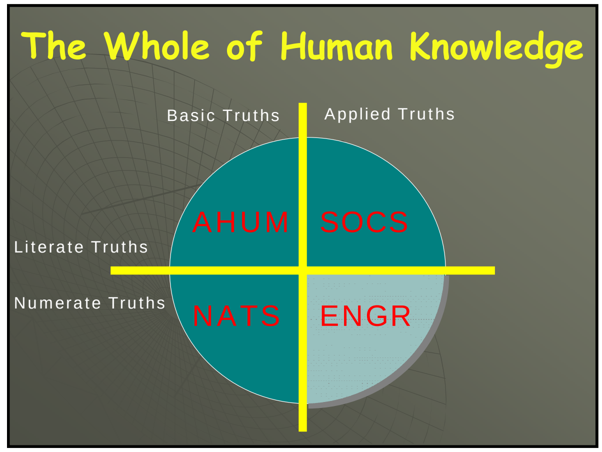
The Whole of Human Knowledge



The Whole of Human Knowledge







Technology 21

-a course for leadership in the new millennium

- **Goals**
  - Expose students to the key basic resources that humankind has to create technology:

    Energy Materials Information

  - Have students bring this new knowledge and of their individual disciplines to bear on solving a national technological problem.

Organization

- A *Core* course. Non-science or non-engineering students must choose one of several courses to fulfill graduation requirement.
- Three Quarters @ 4 QH / Quarter
- Cap at 100 students per offering.
- Two engineering faculty per quarter

Organization

- First two quarters cover (Faculty)
  - 1st Q: Numeracy (Phys)
  - 1st Q: Energy (Phys)
  - 1st Q: Materials (ME)
  - 2nd Q: Information – Processing (CpE)
  - 2nd Q: Information – Transfer (EE)
- Third quarter requires students to solve a national technological problem (Varies Depending on Issue)

First Quarter

- Numeracy:
  - Big and small numbers
  - Exponentials
  - Graphs
  - Lying with numbers
- Energy:
  - Measurements
  - Study of Energy
  - Energy Mechanics
  - Conservation
  - Renewable Energy
  - Fossil Fuels
  - Pollution / Global Warming
  - Nuclear Energy
- Materials:
  - Weight, Strength, Stiffness of Materials
  - Directional Properties
  - Permeability of Materials
  - Loading
  - Dissipation of Impacts
  - Reliability and Flaws
  - Wear and Degradation
  - Team Paper

Second Quarter

- Information - Processing:
  - Computing Issues
  - Computer Organization
  - Encoding Data
  - Music and Pictures
  - Internet and Multimedia
- Information - Transfer:
  - What is Information
  - Encoding / Decoding Data
  - Measuring Information
  - Information Security

Third Quarter

- National Technological Issue:
  - Groups of ten students organize into a consulting company or "Think-Tank"
  - Three weekly lectures by "Experts" from Universities, Industry, Government
  - Two-hour Seminar Session with an "Observer"
  - Must produce 20-page "White Paper" with recommendation for White House
  - Paper Must Consider: Technical, Scientific, Legal, Economic, Social, Political Ramifications of their recommendation

Third Quarter

- Past Issues: "What Should US Policy be Towards-----"
  - Nuclear Energy
  - Petroleum
  - Space
  - Global Warming
  - Automobiles and Light Trucks
  - The Internet
  - The Ozone Hole
  - Renewable Energy
  - Transportation
  - Space Station "Freedom"

Grading

- 1st and 2nd Quarters
  - Module Exams, Term Paper and Finals
- 3rd Quarter
  - Two Block Exams Based on Lectures (50%) Individual Grade
  - White Paper (25%) Team Grade
  - Press Conference Briefing (15%) Team Grade
  - Team Peer Evaluation (10%) Individual Grade
  - Team Grades Are Awarded 50% to All Team Members, 50% Multiplied by an *Effort Percent* Awarded by the Observer (GTA).

Conclusions

- Provides the Missing Segment for a Complete Liberal Education
- Offered for 15 Years – Longest Surviving Core Course at DU
- High Student Demand – Waiting List
- Reasonable Student Critiques
- Almost All Faculty Have Taught in Course Giving Faculty Ownership

Acknowledgements

- Paul Predecki and George Edwards: past instructors and co-authors on the ASEE Paper
- Ron DeLyser, Dan Armentrout, Roger Salters, Marv Hamstad, Chuck Wilson, Jerry Edelstein, Irv Jones, and Anand Ojha: past and current instructors

Responding to expectations of non-technical students

Selling "technical" courses to non-technical students in a large comprehensive regional institution

T. A. Shraibati

Department of Manufacturing Systems Engineering & Management

California State University Northridge

CSUN Background

- •CSUN is a comprehensive regional for year University
- •One of 24 in the CSU system
- •Located in the San Fernando Valley NW of Downtown Los Angeles
- •35,000 students
- •8 colleges including the College of Engineering and Computer Science
- •Culturally diverse
- •Many students are the first in their families to attend College

California State University Northridge

Challenge of teaching non-technical majors

- •Teaching computer illiterate students CAD
  - ➢Fundamentals of computers
- •Teaching non-technical majors
  - ➢Style differences
  - ➢Majors included; RTVF, graphic design, art, math, urban studies, journalism, biology, health science, English, history, speech comm.
- •Teaching freshmen
  - ➢Faculty perspectives

California State University Northridge

Institutional hurdles

Funding issues

Turf battles

The General Education course

AutoCAD as a graphic design tool

- •2D techniques
- •Orthogonal projection
- •Isometric views
- •Wire frame models
- •Surface models
- •Solid models

California State University Northridge

Assessment Method

Anonymous Survey of 162 students at the end of the semester including questions on:

- •General perceptions relative to of Engineering and technology before and after the course
- •Level of computer literacy before and after the course
- •Perception of "technical Literacy" before and after the course
- •Level of satisfaction with the course

California State University Northridge

Developing Sustainability

Survey results

Afraid/concerned about an “engineering” course 41%

Would take another course 42%

Improved technical literacy 83%

Technical literacy is important 89%

Course expectations met 83%

Applicability of Material to Major 45%

California State University
Northridge

Other Tech Lit courses

Women in Science and Technology

- Role of women in technology
- Upper division GE course Cross Cultural

Innovation and Technology

- How things work
- Upper division GE course Applied Science

CAD motion

- Follow on to Introduction to CAD design
- Lower division GE course Applied Science

California State University
Northridge

Wanna have FUN
and get 3 GE section E units too?

Intro to CAD Graphics

MSE 105 is a fun course that will introduce you to computer graphic tools through hands on projects. The course will cover techniques in graphical, pictorial, and rotational presentations. You will learn skills that are in great demand in today’s job market using current computer technology. The final project will be tailored to each individual student’s field of study. Students will post final projects on their own web page.

Spring 2005 MSE 105 Course offerings will be as follows:

Class No.	Day	Time
11928	MW	0930-1045
11849	MW	1100-1215
11850	MW	1230-1345
11851	TR	0930-1045
11852	TR	1100-1215

WSU Shocker Mindstorms:
•Engineering for Non-Engineers

Lawrence Whitman, David Koert, James Steck, Larry Paarmann, &Tonya L. Witherspoon
College of Engineering and College of Education
Larry.whitman@wichita.edu
http://enteng.wichita.edu/mindstorms

Wichita State University
Wichita, Kansas

CCLI Grant

This material is based upon work supported by the National Science Foundation under Grant No. DUE-0411144.

Grant started June 2004 - First class June 2005
So, still in planning stages

Agenda

- History at WSU
  - Competitions
  - Summer Camps
  - Classes for Teachers
  - Freshman Engineering Classes
- Future
  - Engineering for Non-Engineers

Student Competitions

- 5th year of challenges
  - Not FIRST LEGO League, but own design
- 4th - 8th grade students compete
- WSU Engineering and Education faculty and professional engineers judge

Student Competitions

- Challenges address multiple skills
  - Teaming skills
    - Teams design courses (undergraduate students)
    - Engineering Student Organizations Develop the courses
      - Engineering design process
        - Engr dgn review process
        - Usability concerns
        - Manufacturability
        - Recruit judges
        - Coordinate the event
  - IEEE, APICS, AIAA, ASME, SME, IIE, ASQ, Engineering Council, Wallace Scholars

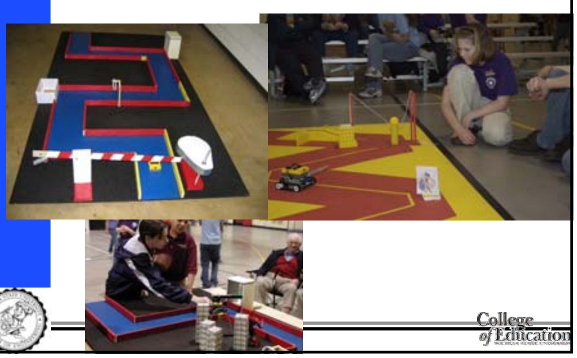
Student Competitions

- Challenges address multiple skills
  - Teaming skills
    - Teams develop robots to complete course
      4th -8th grade students

3 “Apprentice” Courses

5 “Professional” Courses

5 “Professional” Courses



Student Competitions

- Challenges address multiple skills
  - Teaming skills
    - Teams design courses
    - Teams develop robots to complete course
  - Engineering skills
    - Gears
    - Motors
    - Sensors
    - Feedback
    - Strategy
    - Etc.
  - Communication skills
    - Posters
    - Presentations

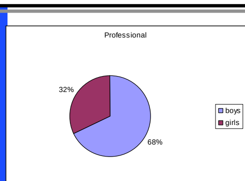
Posters/Notebooks

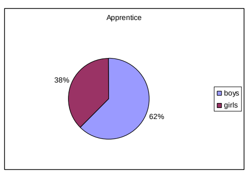
Awards

Badges!

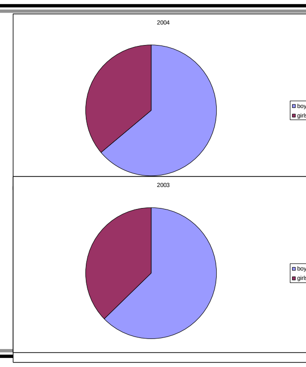
Publicity

Gender – 2005 Challenge





Gender – previous years



Future

- Compare with BEST
- We hypothesize it is lower as girls get older
  - LEGO Mindstorms has a higher ratio of girls than BEST

Further Info

- ..\My Documents\ccli\CCLIAI-0411144\pix\default.htm
- http://education.wichita.edu/mindstorms

Undergraduate Work

- Intro to Engineering
- Class to aid freshmen in:
  - Determining if engineering is right for them
  - Determining what kind of engineer to be
  - Succeeding at university (success course)
  - Some do take the course and decide NOT to become an engineer!

Introduction to Engineering (ENGR101)

- Fall 2003
- Class of 28
- Groups of 4
- Mini-challenge (encourage them to work with RCX and Robolab) – minimize the "student effect"
- Final project to design an apparatus for Mars
  - MLCAD
  - Report
  - Presentation
- Highly rated aspect in course evaluations

Introduction to Engineering (ENGR101)

- Fall 2004
- Class of 27
- Groups of 3, 4
- Taught basics of Mindstorms in two class sessions
  - Interactive class with task to complete in class to minimize the "student effect"
- Final project to complete last years challenges for the competition (2)
  - Only do the challenge and write a memo
- Some even said best part of course in course evaluations

Our Current Task

- Develop a class for non engineers about engineering

Adaptation

- Robolab – Chris Rogers, Tufts
- Curriculum – Robin Shoop, CMU
- Textbook – Eric Wang, UNR
- Instruction Generation and Modules – Kevin Clague

Catalogue Description

- Description of Course:
- An introduction to the engineering discipline using hands-on exercises and demonstrations using LEGO Mindstorms. Technical and practical aspects of Aerospace, Computer, Electrical, Industrial, Manufacturing, and Mechanical Engineering are presented. Intended for freshman and sophomore non-engineering students who want to understand how engineering impacts their lives. No credit for College of Engineering Majors.

Grades

Lab Reports (Individual) (5 labs)	50%
Quizzes (In-Class)	25%
Final Exam (Comprehensive) Part written Part Final Project (synthesis)	25%

Labs

- Assignment given to group
- Students complete as group
- Students rotate roles

- Sample lab provided
- Lab template provided
- Lab rubric provided

College of Education

Format, Style, and Appearance	1 Poor	2 Developing	3 Adequate	4 Exemplary
Professional Appearance	Report is typed; some graphics are hand drawn; and/or 1-5 mechanical errors	Report is typed; graphics are computer generated; 1-5 mechanical errors	Report is typed; graphics are computer generated; absence of mechanical errors	All of the previous and an acceptable electronic copy is submitted
Graphical Communication	The report contains only text.	The report contains text and only one other method of communicating.	The report contains several methods of communicating information (i.e. diagrams, drawings, photos, tables, charts, graphs, written information, etc.). One or more items either don't clearly add value, are not accurate, or are not correctly labeled and captioned.	The report contains several methods of communicating information (i.e. diagrams, drawings, photos, tables, charts, graphs, written information, etc.). Each item clearly adds value and accurate information to the report. Each item is correctly labeled and captioned.
Organization and Style	The information appears to be disorganized. Paragraphing structure was not clear and sentences were not typically related within the paragraphs.	Information is organized, but paragraphs are not well-constructed. Paragraphs included related information but were typically not constructed well.	Information is organized with well-constructed paragraphs. Most paragraphs include introductory sentence, explanations or details, concluding sentence, and transition.	Information is very organized with well-constructed paragraphs and subheadings. All paragraphs include introductory sentence, explanations or details, concluding sentence and transitions well to the next paragraph.
Page Limit	8 or more pages	7 pages	6 pages	5 pages or less (body of report) not including Title and Table of Contents

Title Page	Format incorrect	Format correct	Format correct and contains all group member names	Format correct, contains all group member names, group number, and roles are varied from last report
Drawings	Hand Sketched	MLCAD drawings of most parts	MLCAD drawings including complete parts list	MLCAD drawing showing individual steps to allow reproducibility
Innovation	Absent	Got the basic idea right	Design showed beginnings of a new approach	One of the most innovative ideas in class
Skills used	No clear use of class learnings	Used class techniques	Explicitly used three or more class techniques appropriately	Explicitly used three or more class techniques appropriately and demonstrated the initiative to self-learn by acquiring skills or knowledge beyond coursework
Accuracy	Many errors in the report	Two minor or one major technical errors	One minor technical error	No technical errors
Body				
1.0 Table of Contents	Present, but does not add value	Sections correct but disorganized	Clear TOC, but missing page numbers	Clear, with page numbers
2.0 Abstract	Disorganized	Less than half page summary of the work; unclear objective or no results are presented	Less than half page; useful summary of the work; the objective is clear and accurate; and discussion of results are presented	Less than half page; useful summary of the work; the objective is clear and accurate; and discussion of results **effectively**
3.0 Objective	The purpose of the lab or the question to be answered during the lab is erroneous or irrelevant.	The purpose of the lab or the question to be answered during the lab is partially identified, and is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is identified, but is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.

4.0 Introduction	Does not add value	Partial: Present but not clearly articulated and not understood	Present and clearly articulated and mostly understood	Present and clearly articulated and understood
5.0 Background/Theory	Present, but does not add value	Partial: Present but not clearly articulated and/or weak	Present and clearly articulated and provides a good overview	Present and clearly articulated and understood. Provides a good overview and articulates relevant details.
6.0 Methodology/ Procedure	Present, but not logical or appropriate	Logical, but not appropriate	Logical and appropriate	Logical, appropriate, and presents sufficient detail
7.0 Equipment	Not organized in a useful manner	Present, but not complete	Present and Complete	Present, complete, and special parts are described fully
8.0 Results	Does not provide multiple solutions	Provides less than 3 possible solutions.	Provides at least three possible solutions	Provides at least three possible solutions, articulating pros and cons for each. Also, presents a useful discussion on the rationale for each alternative.
9.0 Discussion of Results	Not organized in a useful manner	Rationale for final design is present, but lacking a logical basis	Rationale for final design is logical, but does not accommodate all variables.	Rationale for final design is logical, accommodates all the pertinent variables.
10.0 Reflections and Future Applications	Absent	Haphazard discussion	Discussion explained some of the results	Clear understanding of principles discussed with content from results

Sample

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College of Education

Course Schedule

- Introduction to engineering, design process;
- Overview of LEGO Mindstorms (Programming I)
- Information Storage and Retrieval (Electrical I)
- Gears and Gizmos – (Mechanical I)
- Computer-Aided Drafting (MLCAD I)
- Flight Controls (Aero I)
- Sensing and Responding (Electrical II)
- Industrial Engineering (Production Design I)

Course Timings

- Starts after memorial day through June
- Class Hours: MTh 9-11AM
  TuesFri 9-Noon
- Classroom: WH 109
- The classroom will be available at other times as well (open lab Wed from 9-Noon) and other times by appointment.
- Education graduate students will have the extra hour on Monday and Thursday to work on curriculum applications. (cross listed as a graduate education class)

Workshop

- Tentative Summer June 2006
- Present Results
- Plan to Come!

Issues

- **Target: Students that are NOT techies!**
- **Target: Students that will NOT become engineers**
  - **May recruit some new engineers, but not the key goals**
- **How do we market/restrict to the target (and still meet class quotas)?**

Summary

- **"We must do this for all students, both those who do and those who do not aspire to be scientists, mathematicians, and engineers." (National Research Council, 1999, pg ix).**
- **According to Wulf, "[Every citizen] should also be familiar with the methods that engineers use to evaluate design alternatives in search of the one that best satisfies constraints related to cost, functionality, safety, reliability, manufacturability, ergonomics, and environmental impact." (National Research Council, 1999, pg 29).**

Acknowledgment

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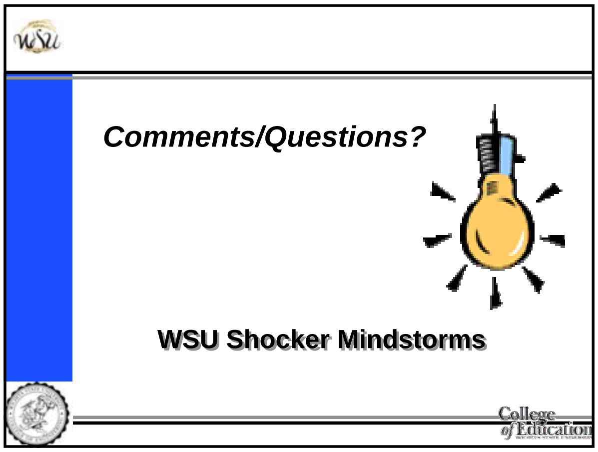
Comments/Questions?
WSU Shocker Mindstorms
College of Education

APPENDIX F

Sessions and Presentations Sponsored by the Technological Literacy Constituent Committee

American Society for Engineering Education
2006 Annual Conference
Chicago, Illinois
June 18-22, 2006

Session 0288: Hands-on Activities for Technological Literacy
Learning how favorite consumer products work can be an effective theme in technological literacy courses for non-engineering students, first-year engineering programs for neophyte engineers and even disciplinary engineering courses for advanced undergraduates. In this workshop, participants will carry out hands-on activities, involving device dissection and device de novo construction, aimed at learning how things work.
2006-2665: HANDS-ON ACTIVITIES FOR TECHNOLOGICAL LITERACY

Session 2588: Defining Technological Literacy
The new topic of "Technological Literacy" is defined variously by five presenters. Formats for teaching technological literacy are summarized from a total of 12 campuses.

2006-695: WHAT IS TECHNOLOGICAL LITERACY AND WHY DOES IT MATTER?
David Ollis, North Carolina State University
Greg Pearson, National Academy of Engineering

2006-744: TECHNOLOGICAL LITERACY AND ENGINEERING FOR NON-ENGINEERS: LESSONS FROM SUCCESSFUL COURSES.
John Krupczak, Hope College
David Ollis, North Carolina State University

2006-426: FROM "HOW STUFF WORKS" TO "HOW STUFF WORKS": A SYSTEMS APPROACH TO THE RELATIONSHIP OF STS AND "TECHNOLOGICAL LITERACY"
Kathryn Neeley, University of Virginia

2006-912: LIBERAL ARTS AND TECHNOLOGICAL LITERACY
Douglass Klein, Union College
Robert Balmer, Union College

2006-1182: TECHNOLOGICAL LITERACY AND EMPOWERMENT: EXEMPLARS FROM THE HISTORY OF TECHNOLOGY
W. Bernard Carlson, University of Virginia

Session 2688: Installing & Assessing Technology Literacy Courses
Technological literacy can be introduced most easily and logically within courses possessing multiple dimensions. This claim is demonstrated through two presentations via first-year engineering and two via engineering design. Approaches to assessment of technological literacy are included.

2006-701: ASSESSING TECHNOLOGICAL LITERACY IN THE UNITED STATES
John Krupczak, Hope College
Greg Pearson, National Academy of Engineering
David Ollis, North Carolina State University

2006-575: ENGINEERING FOR EVERYONE: CHARGING STUDENTS WITH THE TASK OF DESIGNING CREATIVE SOLUTIONS TO THE PROBLEM OF TECHNOLOGY LITERACY
Borjana Mikic, Smith College
Susan Voss, Smith College

2006-1282: FIRST-YEAR ENGINEERING PROGRAMS AND TECHNOLOGICAL LITERACY
Matthew Ohland, Clemson University

2006-655: A SOLAR-POWERED DECORATIVE WATER FOUNTAIN HANDS-ON BUILD TO EXPOSE ENGINEERING CONCEPTS TO NON-MAJORS
Camille George, University of St. Thomas
Elise Amel, University of St. Thomas
Karl Mueller, University of St. Thomas

2006-620: TEACHING TECHNOLOGICAL LITERACY: AN OPPORTUNITY FOR DESIGN FACULTY
David Ollis, North Carolina State University
John Krupczak, Hope College

APPENDIX G

Article Appearing in ASEE *PRISM* Vol. 15:7, March 2006

Teaching: A Nation of Techies.

By Phillip Wankat and Frank Oreovicz

The U.S. needs a more tech-savvy populace. Here's what you can do to help

Students who are not studying science, technology, engineering or mathematics generally know very little about how technology works, often distrust it and, yet, are avid consumers of it—cell phones, iPods and all the rest. In a democracy, this lack of knowledge can have dire consequences, not the least of which are large drops in research budgets. If our nation's populace isn't knowledgeable about science and technology, the related issues won't get the attention and funding they need.

What can engineering and engineering technology professors do about it? They can teach a multidisciplinary course on technological literacy for both nonengineering and engineering students. The courses will not only provide a campus service but also help reduce the isolation of those in engineering. Tech literacy courses will be well subscribed if they count as a lab science elective or as part of the university's general education requirements. We can help by talking it up to students and finding ways to reward professors who teach these courses.

Engineering and engineering technology students could also benefit from more technological courses. Try incorporating technological information from outside your discipline through short discussions in lectures, laboratory assignments, projects and extra-credit projects. These categories may help spark some ideas:

Common Applications. Ask the students to apply their knowledge to common applications. Reaction kinetics has applications in cooking, and students studying electricity could be asked to make a simple electric motor.

Product Use. Ask students to think about how specific products are used and how they could be used differently: The heat produced by light bulbs is usually unwanted, but sometimes light bulbs can be a convenient small heat source, for example.

Supplemental Technologies. Tell your students that new products are rarely the result of a single discipline. Something as simple as a windshield wiper has electrical, mechanical, materials and chemical aspects and requires manufacturing help from industrial engineers.

Different Job Functions. Discuss unusual jobs of engineers and how their training is useful. Engineers work for financial and venture capital companies, as patent attorneys and as medical doctors.

Applications of Engineering Principles to Aid People. The opportunity to help people motivates many engineering students. From creating quiet lawn mowers to developing inexpensive hurricane-proofing for houses, engineering is vital to the way people and technology interact.

If you are concerned about the general lack of technological literacy in the United States, you are not alone. By joining with others, we can address the problem by teaching tech literacy courses to nonengineering students and incorporating more general technological information in our engineering and technology courses.

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APPENDIX H

Improving the Technological Literacy of Undergraduates: Identifying the Research Issues - A Minority Report

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What: A small group of experts met to review the state of the art and formulate fundamental research questions. Participants included individuals who have successfully implemented technological literacy courses at the undergraduate level, representatives of other disciplines who can offer relevant perspectives and key insights, and representatives of the National Science Foundation and the National Academy of Engineering.

Where: National Academy of Engineering, Washington D.C.

When: Mon-Tues April 18-19, 2005

Why: The purpose of this workshop was to catalyze progress in this area. While it is widely recognized that all citizens need to be technologically literate, action has not been widespread at the undergraduate level. A number of educators have, however, achieved some encouraging results. The workshop seeks to collect and analyze these diverse experiences to help move forward in this area.

The Rationale for this Minority Report

This workshop was an excellent vehicle to begin discussions among interested engineering faculty about possible mechanisms for improving the technological literacy of undergraduate liberal arts students. However, whereas it appeared to the participants that this was indeed an issue on national import, they did not have a working definition of "technological literacy" from which to begin discussions. Also, the scope of this issue cannot be limited to, nor burdened upon, a small group of concerned engineering and technology educators that have the best of intentions. So, how should be proceed? Here is my suggestion on how to begin[1].

Step 1

Do we agree that the world today is experiencing extraordinary growth in technology of historical proportion, and that this technological growth is having a pervasive impact (good or bad) on human culture and societal norms around the world? If so, then is technological literacy among the industrialized nations (or the world) a significant and growing problem?

[1] I am using the engineering design method here. Step 1 is "defining the problem", Step 2 is determining the design constraints from the customer, Step 3 is developing alternative solutions, Step 4 is evaluation of the alternative solutions and selecting the best solution, and Step 5 is implementing the final solution.

Relevant Questions:

- What does "technological literacy" mean?
- How can technological literacy be measured (so we can tell if it is improving)?
- Where should technological literacy remediation begin? K-12? College?
- What are the societal ramifications of poor "technological illiteracy"?
- Was humanity "agriculturally literate" during the pre-technological era?
- Are we finally moving toward a technocracy, and is that inevitable given the freedom of a democratic society?

In 1994, the International Technology Education Association (**ITEA**) launched its Technology for All Americans Project (**TfAAP**) as a means to advance student attainment of technological literacy. *Technological literacy is far more than the ability to use technological tools. Technologically literate citizens employ systems-oriented thinking as they interact with the technological world, cognizant of how such interaction affects individuals, our society, and the environment.* ***Technological literacy is the ability to use, manage, assess, and understand technology.*** *It involves knowledge, abilities, and the application of both knowledge and abilities to real-world situations. Citizens of all ages benefit from technological literacy, whether it is obtained through formal or informal educational environments.*[2]

While TfAAP seems to focus on achieving its goals in K-12, it is already in existence (administered through ITEA and funded by the NSF and NASA), so should we not explore an NAE college-level affiliation with this group?

Step 2

Establish a Blue Ribbon Committee composed of select college and university presidents, representatives from ASEE, NAE, NSF, NEH, and national political leaders to assess the current state of technological literacy in America (using an existing definition, such as the one above from TfAAP).

Step 3

Develop partnership relations between a core group of small colleges that have both liberal arts and engineering programs and interested major universities to carry out pedagogical research to develop and test technological literacy courses/programs that could be implemented at minimal cost at large universities across the nation. Small colleges have less curricula bureaucracy and have (or can easily introduce) faculty reward systems that will motivate faculty to seriously engage in pedagogical research.

Step 4

Faculty developing prototype courses/programs would be encouraged to implement them at a large university through a technological literacy sabbatical. They would co-

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[2] See http://www.iteawww.org/TAA/TAA.html. This group has already developed 20 "standards" for technological literacy.

teach their courses with university faculty to provide a bridge over potential content, motivation (for faculty and their students), and assessment issues.

Step 5

Help university faculty embed successful prototype courses/programs into their institutional system. This would require the support of university deans and academic provosts, and perhaps even members of their board of trustees.

Step 6

Establish a national program of technological literacy that transcends all educational levels. The foundations for this can be seen in the following material that was taken from the executive summary of "Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards."[3]

Why is Technological Literacy Important?

We live in a technological world. Living in the twenty-first century requires much more from every individual than a basic ability to read, write, and perform simple mathematics. Technology affects virtually every aspect of our lives, from enabling citizens to perform routine tasks to requiring that they be able to make responsible, informed decisions that affect individuals, our society, and the environment. Citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology.

What are the Characteristics of a Technologically Literate Person?

Technologically literate people understand the major technological concepts behind current issues and appreciate the importance of fundamental technological developments. They are skilled in the safe use of technological processes that may be prerequisites for their careers, health, or enjoyment. A technologically literate person must be able to:

- **solve problems** by considering technological issues from different points of view and relate them to a variety of contexts,
- understand **technological impacts** and **consequences**, acknowledging that solutions often involve tradeoffs, accepting less of one quality in order to gain more of another,
- use a strong **systems-oriented, creative,** and **productive approach** to think about and solve technological problems,
- use concepts from **science, mathematics, social studies, language arts**, and **other content areas** as tools for understanding and managing technological systems,
- appreciate the interrelationships between technology and **individuals, society,** and **the environment**, and
- understand that technology is the result of **human activity** or **innovation**.

[3] See: http://www.iteawww.org/TAA/PDFs/AETLExecutiveSummary.pdf.