Technological Literacy of Undergraduates: Developing Standard Models

Mon-Tues March 26-27, 2007

Sponsor:
National Science Foundation

Location:
National Academy of Engineering

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Contents

Technological Literacy of Undergraduates: Identifying Standard Models

National Academy of Engineering
2101 Constitution Ave
Washington DC, March 26-27, 2007

Day One:	Monday March 26, 2007.
8:00-8:30	Breakfast at NAE. location: Lecture Room
8:30 – 9:00	*Welcome / Introduction*: **William Wulf, President NAE**. location: Lecture Room
9:00-10:30	*Session 1: Candidate Standard Models* Review of results from pre-conference survey Description and discussion of standard models location: Lecture Room
10:30 –10:45	Break
10:45 –12:00	*Session 2: Model Learning Outcomes* Working groups meet to outline major learning outcomes expected from the models. *Technically Speaking*, *Tech Tally*, and ITEA standards help to define outcomes. locations: Lecture Room, EDR, Members Room, NAS 148.
12:00-1:15	Lunch location: Lecture Room
(12:15-1:00)	*Plenary Address* **"Scholarship Assessed," Mary Taylor Huber,** **Carnegie Foundation for Advancement of Teaching.** location: Lecture Room
1:15 – 3:15	*Session 3: Assessment and Evaluation.* **"Introduction to Assessment," Ron Miller, Colorado School of Mines.** Groups meet to identify means to assess outcomes. Also identify existing example methods and materials that need to be developed. locations: Lecture Room, EDR, Members Room, NAS 148.
3:15 – 3:30	Break
3:30 – 4:30	*Reporting from Sessions 2 and 3.* Reporting of group discussions of outcomes, assessment, and evaluation. location: Lecture Room

4:30 – 5:30 *Session 4: Open Forum and Cross Cutting Issues.*
All – Review issues of course formats and methods of pedagogy that cut across the standard models: lecture/demo format, lecture/lab format, integrative format, mechanical dissection, design projects, STS collaborations. Open Forum and Summary.
location: Lecture Room

5:30 Reception/informal discussions
location: Members Room

6:15 – 8:00 Buffet Dinner
location: Members Room

Day Two: Tuesday March 27, 2007

8:00 – 8:30 Breakfast at NAE
location: Lecture Room

8:30-10:15 *Session 5: Proposals for Areas Needing Future Work.*
"Overview of revised NSF CCLI Program," Russ Pimmel, NSF.
locations: Lecture Room

Groups meet to define and prioritize research and development needs for each course model. Groups develop an outline(s) for possible CCLI proposal(s)
locations: Lecture Room, EDR, Members Room, NAS 148.

10:15-10:30 Break

10:30 – 12:00 *Session 6: Next Steps for Core Groups*.

Groups report research and development needs for each course model. Describe outline(s) of potential proposals. Individuals or collaborations may suggest proposal ideas to group for comments and suggestions.
location: Lecture Room

12:00 – 1:00 Lunch
location: Lecture Room

1:00 – 2:00 *Session 7: Summary and Final Discussion, NSF comments*
location: Lecture Room

2:00 Workshop Adjourn

Workshop Groups
Candidates Models for Standardized Technological Literacy Courses.

1. The Technology Survey Course (Broad overview)
2. The Technology Focus or Topics Course (Focus on one well-defined topic)
3. The Technology Creation Course (Engineering design)
4. The Technology Critique, Assess, Reflect, or Connect Course (Technology in context)

1. Technology Survey Course
(Location: Lecture Room)
Bertsch
Disney
Garmire
Krupczak*,+
Oakley
Rose*,+
Simpson

2. Technology Focus Course
(Location: Rm 148)
Dahleh
George+
Lerche
Norton
Ollis*
Shraibati

3. Engineering Design Course
(Location: EDR)
DeGoode+
Devon
Kasarda*
Nocito-Gobel
Sanders
Whitman
Young

4. Technological Impacts and Assessment Courses
(Location: Member's Room)
Broome
Carlson*,+
Klein
Miller
Neeley*,+
Pfatteicher
Seeley

Visiting Any/All Groups
Brawner
Huber
Wulf
NSF/NAE Participants

* = Moderator
+ = Scribe

2. Workshop Charge

A group will be convened which will:

- Identify, explore, and develop a few models of technological literacy courses that could be further developed with instructional and instructor materials for widespread use.

- Define learning outcomes, course outlines, and lists of resource material.

- Evolve in core groups to continue to work.

- Lead to development of CCLI proposals.

Technical literacy is not likely to gain wide acceptance until the scholarly community develops standard courses that are supported by textbooks and other course materials. In 2005, a workshop sponsored by the National Science Foundation identified the research issues in the technological literacy of undergraduates. In addition, an array of successful courses was presented as evidence that engineering faculty can develop and teach courses that advance the understanding of technology by all Americans. For widespread impact however, standard classes must be taught at many institutions around the country. To accomplish this, standard easily adopted technological literacy courses must be developed.

A workshop will be conducted to bring educators and related professionals together to facilitate collaboration and focus future efforts. The goal of the workshop will be to bring these efforts close to an implementation resulting in collaborations and future course development. At the workshop, groups will define and discuss several models of technological literacy courses. These models will then become candidates for further development. The objective will be to create materials for both students and instructors with the intention of easy adoption and widespread use. The primary outcomes will be materials describing several models for technological literacy courses, a community focused on developing these models, and dissemination of these results to a broader audience.

3. Session Discussion Questions

These questions are intended to lead the groups toward concrete results. Groups should not feel compelled to address the entire list of questions at the expense of allowing sufficient time for meaningful discussion and dialogue.

Input is not confined to the formal reporting out sessions. Participants who have ideas or comments about any of these issues may also communicate them directly to the organizing committee. Every effort will be made to incorporate all contributions into the final report.

Session 1: Candidate Standard Models

- Do the models effectively include the body of work represented by existing courses?
- Is each model specific enough to allow well-defined course outlines and objectives to be developed?
- Do the models include themes represented by existing courses while being larger in scope than any one particular preexisting course?
- Do these models promote the benefits of standardization while preserving individual instructor flexibility?
- Is this set of standard models sufficient? Should there be more or less?
- Are the models an appropriate framework for future work leading to standard and easily adopted courses? Can the scholarly community move forward with these models?

Session 2: Model Learning Outcomes

All Groups (1-4)

- What are the major student learning outcomes expected for this model?
- What are the major topics, issues, concepts that should be included in a course outline?
- Is there anything that should be specifically excluded from this course model?
- Can any of the *Technically Speaking*, *Tech Tally* Content Areas and Cognitive Dimensions be used to help define model learning outcomes?
- Can any of the ITEA Standards be used to help define model learning outcomes?

Group 2: Technology Focus Course

- Is it possible to define a course model and learning outcomes that transcend the specific technological topic?
    - Is there a generic model for this type of course?
    - Can learning outcomes be identified that are independent of a specific topic?

Session 3: Assessment

- What are the means to assess the major student learning outcomes?
- Do any appropriate assessment methods exist?
- Should any of the outcomes identified by the group in the previous session be rewritten in terms of measurable verbs?

Session 4: Cross Cutting Issues

- How can the standard models make effective use of these activities?
- Should these particular activities be associated with specific course models?
- Do any of these cross cutting issues support the *Tech Tally* Content Areas and Cognitive Dimensions or ITEA Standards?

    - Mechanical Dissection
    - Design Projects
    - Lego Mindstorms-based activities.
    - Make-and-take projects
    - Investigative Laboratories (scientific method, hypothesis testing)
    - Course formats: lecture/lab, lecture/demo, multidiscipline team teaching

Session 5: Proposals and Areas Needing Future Work

- What are the research and development needs of the model?
- What might be an outline for an NSF CCLI proposal(s) that would address one or more of these needs?

4. Defining and Assessing Technological Literacy

Technically Speaking (2002)

To minimize the problems caused by local definitions of technological literacy it is suggested that the workshop should adopt the NAE's *Technically Speaking* as a common reference for this concept.

In *Technically Speaking*, the NAE describes three dimensions of technological literacy:

1. Knowledge
2. Capabilities
3. Ways of Thinking and Acting

Tech Tally (2006)

Tech Tally (2006) follows *Technically Speaking* (2002) with an emphasis on assessment. In *Tech Tally* the three dimensions described in *Technically Speaking* are considered to be three cognitive levels relevant for assessment. The "Ways of Thinking and Acting," has been rephrased to "Critical Thinking and Decision Making." In addition, four content areas are defined: technology and society; design; products and systems; and characteristics, concepts, and connections. This is summarized in Figure 1, adapted from Figure ES-2 from *Tech Tally*.

COGNITIVE DIMENSIONS

CONTENT AREAS

	Knowledge	Capabilities	Critical Thinking & Decision Making
Technology & Society			
Design			
Products & Systems			
Characteristics, Core Concepts, & Connections			

Figure 1: Proposed assessment matrix for technological literacy in *Tech Tally*.

This assessment matrix from *Tech Tally* may serve as a way to classify and organize pre-existing courses or to help define the scope of new courses.

ITEA Standards for Technological Literacy

The International Technology Education Association has developed a set of standards (ITEA 2000) *Standards for Technological Literacy: Content for the Study of Technology*, http://www.iteaconnect.org/TAA/Publications/TAA_Publications.html. While the ITEA standards address K-12 students, the detail of these standards may be helpful in categorizing or classifying the content areas that appear in courses for undergraduates. The standards consist of five areas that are subdivided into 20 standards. The five main areas are:

1. Understanding the Nature of Technology
2. Understanding of Technology and Society
3. Understanding of Design
4. Abilities for a Technological World
5. Understanding of the Designed World.

Table 1: Listing of the ITEA Technological Literacy Standards.

	The Nature of Technology
1	The characteristics and scope of technology.
2	The core concepts of technology.
3	The relationships among technologies and the connections between technology and other fields.
	Technology and Society
4	The cultural, social, economics, and political effects of technology.
5	The effects of technology on the environment.
6	The role of society in the development and use of technology.
7	The influence of technology on history.
	Design
8	The attributes of design.
9	Engineering design.
10	The role of troubleshooting, research and development, invention and innovation, and experimentation and problem solving.
	Abilities for a Technological World
11	Apply the design process.
12	Use and maintain technological products and systems.
13	Assess the impact of products and systems.
	The Designed World
14	Medical technologies
15	Agricultural and related biotechnologies.
16	Energy and power technologies.
17	Information and communication technologies.
18	Transportation technologies.
19	Manufacturing technologies.
20	Construction technologies.

5. Candidates Models for Standardized Technological Literacy Courses.

Based on the published descriptions, most of the existing courses can be organized into four categories. There are a few existing courses that appear in more than one category. The four candidate standard models are:

1. The Technology Survey Course.
2. The Technology Focus or Topics Course.
3. The Technology Creation Course (Engineering Design Course).
4. The Technology Critique, Assess, Reflect, or Connect Course.

The technology survey courses offer a broad overview of a number of areas of engineering and technology. The technology or topics or focus course is narrower in scope and develops one well-defined area. The engineering design course (or technology creation) places an emphasis on the engineering design process in developing technological solutions to problems. The last model to emerge from existing courses is concerned with assessing technological impacts, connecting technological developments to other areas of society, history and culture, or reflecting on engineering in a broader context. This last course model was tentatively called technology: critique, assess, connect, or reflect.

<u>1. Technology Survey Courses.</u>
Address a range of technologies.
May include social and historical dimensions.
May include lectures, demonstrations, laboratories.
Scientific principles usually a major component.
Includes "How Things Work" courses
Includes Physics courses that emphasize everyday technology.
Could include some introduction to engineering courses.

Examples:

Bloomfield[+] et. al. ....How Things Work: Physics of Everyday Life
DeGoode* ....How Things Work
Disney[+,*] ....Science at Work: Technology in the Modern World
Hammack[+]..............................The Hidden World of Engineering
Kim ....Introduction to Electro-Technology
Krupczak[+,*]............................Science and Technology of Everyday Life
Lienhard[+]................................Engines of our Ingenuity
Oakley* ....Everyday Engineering
Ollis[+,*]....................................How Things Work
Vedula[+] ....Technology and the Human-Build World.

* = 2007 workshop participant
+ = 2005 workshop participant

2. Technology Focus or Topics Courses

These courses tend to address a single technological topic or issue.
Subject matter is intentionally focused rather than intentionally broad.
May have a substantial technical or quantitative component.
May include laboratories or projects.
May include some social and historical aspects of the topic.

Examples:

Klein* and Balmer+: ....Converging Technologies at Union
Billington, Littman+ et. al ....Civil Infrastructure.
George+,* ....Fuel Cells
Mechtel+,* Korzeniowksi et al. ....Electrical Engineering for Non-Engineers
Kuc+: ....Information Technology
Norton,* and Bahr ....Materials
Orr, Cyganski, and Vaz: ....Information Technology
Pisupati, Mathews, and Scaroni ....Energy Conservation
Walsh, Demmons, and Gibbs.............Materials
Shraibati* ....Intro to Computer Graphics Tools.

* = 2007 workshop participant
+ = 2005 workshop participant

In developing and teaching these courses, instructors are often working from their area of research expertise. Topical courses focused on one area of technology were characteristic of many of the courses developed under the Sloan Foundation New Liberal Arts Program (Steen 1999).

3. Engineering Design for Everyone (Technology Creation or Application Courses)

These courses focus on the engineering design process.
May include engineering majors along with non-engineering majors
Also includes some of the work being done with K-12 teachers.
Includes some introduction to engineering courses.

Examples:

Baish+ ....Designing People, Form and Function
DeGoode* ....How Things Work
Mahajan. and McDonald....................Exploring Technology
Mikic and Voss ....Engineering for Everyone
Nocito-Gobel*....................................Project-based Introduction to Engineering
Whitman+,* ....Engineering for Non-Engineers
J. Young* ....Introduction to Engineering.

* = 2007 workshop participant
+ = 2005 workshop participant

4. Technological Impacts, Assessment, and History Courses.
(Critique, Assess, Reflect, and Connect Courses)

These courses emphasize the relation between technology and culture, society, history. May include technological policy assessment or analysis.
Probably well-represented in STS programs but not many examples offered by engineers or jointly taught.

Examples:

Carlson[+,]* and Gorman: ....Invention and Innovation
Cutcliffe[+,]* ....Technology and Human Values
Herkert ....Engineering Disasters
Klein* and Balmer[+,] ....Converging Technologies Courses at Union.
Neeley[+,]* ....Engineering in Context.
Rosa[+,] ....Technology 21

* = 2007 workshop participant
+ = 2005 workshop participant

Comparison to of Course Formats Across Disciplines.

All of the existing courses on technology for non-engineers were developed in the absence of any formal organizational scheme. However, the four standard models appear to be in a consistent format that can be applied to other disciplines. A comparison of the technology course models with a sampling of other disciplines is given in Table 2. Also included in the table are some example courses names in each category.

Table 2: Comparison of Technology Literacy Courses to Other Disciplines Including Example Course Names.

Activity	**Engineering for Everyone (Technology Literacy)**	**English**	**Psychology**	**Music**
Survey	Technology Survey Courses	English 101: *Intro to Literature*	Psychology 101: *Intro to Psych*	Music 101: *Intro to Music*
Focus	Technology Focus Courses *Fuel Cell Systems* *Materials: Foundation of Soc.*	Focus or Topics Courses *British Literature* *American Literature*	Focus or Topics Courses *Developmental Psych* *Organizational Psych*	Focus or Topics Courses *Jazz Styles and Analysis* *Music of 18th Century*
Create Apply	Technology Creation Courses (Engineering Design) *Intro. to Engineering Design* *Designing People*	Writing Courses *Creative Writing: Nonfiction* *Creative Writing: Poetry*	Creation or Application Courses *Research Methods in Psych* *Clinical Assessment*	Music Performance Music Composition
Critique Assess ***Reflect Connect***	Technology Critique Courses *Converging Technologies* *Engineering in Context*	Critique Course Examples: *Literature and Cultural Difference* *Literary Forms and Reformulations*	Critique, Assess, History Ex: *History of Modern Psychology* *The Psychology of Everyday Things*	Critique, Assess, History Ex: *History of Music Theory* *Aesthetic Theory and Modernism*

Basic similarity in course models exists across disciplines. All disciplines have survey courses that are open to all undergraduate students with limited or no prerequisites. Theses courses help to define the scope and breadth of the discipline. All areas also have a focus or topics course model. Courses of this model are of narrower scope but greater in depth than survey courses. The third category of engineering design courses are analogous to English courses focusing on writing or Music courses in composition or performance.

The fourth category is the broadest in scope and possibly the most difficult to define. However all disciplines have a course model that examines activity in some type of context external to itself. This model includes discipline-specific history courses and courses focusing on critique or assessment.

One notable difference between the engineering for everyone courses and the other disciplines listed in Table 2, is that courses in each of the other disciplines are mostly located in on one department. The technology courses can be dispersed through a range of departments including: chemical engineering, civil engineering, electrical engineering, physics, history, or STS departments.

While the boundaries between categories are by no means rigid, these four standard models appear to approximate the organization of courses that has persisted in other disciplines. This provides some confidence that these models of technology courses could endure into later eras of course development.

6. Cross Cutting Issues Of Course Formats And Pedagogy.

There are curricular elements and methods of pedagogy that different instructors use to cut across the different content areas. Methods of instruction could be considered as a third dimension to the Content Areas and Cognitive Dimensions given in the *Tech Tally* assessment matrix. This third dimension of curriculum and pedagogy may be a direction along which standard materials can be developed.

Mechanical Dissection
    Ollis[+,]*, Sheppard et al., T. Simpson*

Design Projects
    Baish[+], DeGoede*, J. Young*

Lego Mind Storms
    L. Whitman[+,]*, C. Rogers, J. Young*,

Make-and-take
    DeGoode,* Krupczak[+,]*, George[+,]*

Investigative Labs
    Disney[+,]*, M. Littman[+], Weiss

Course Formats
    Format 1: Lecture/Demonstration
        Example: Bloomfield[+] et al.

    Format 2: Lecture/Lab
        Example: DeGoode*

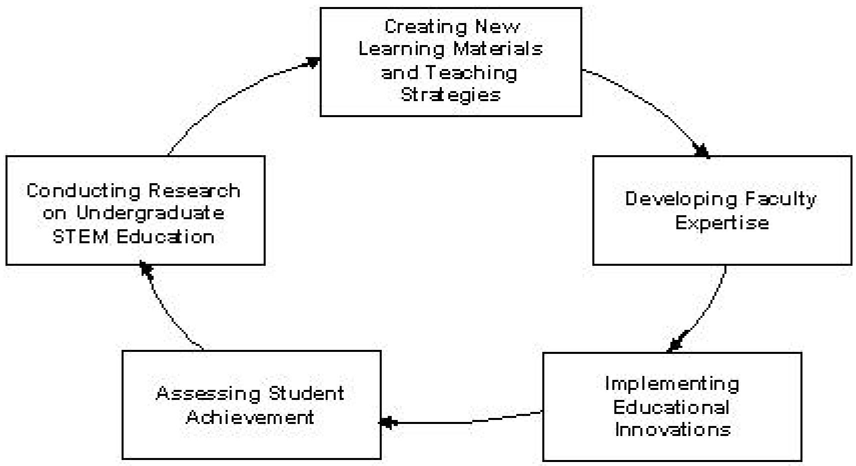
    Format 3: Integrative: Multidisciplinary Engineering + Other Disciplines,
        May include laboratories or projects.
        Example: Ollis[+,]*

* = 2007 workshop participant
+ = 2005 workshop participant

7. NSF Course Curriculum and Laboratory Improvement (CCLI) Program.

The NSF CCLI Program was substantially revised in 2005. Proposal should address one or more components of this cycle. Details can be found in Program Solicitation NSF 07-543 http://www.nsf.gov/pubs/2007/nsf07543/nsf07543.pdf. The general structure of the CCLI program is summarized below.

(Taken from NSF 07-543)



A. Project Components

All proposals must contribute to the development of exemplary undergraduate STEM education. Proposals may focus on one or more of the components of this cycle.

- **Creating Learning Materials and Teaching Strategies.** Guided by research on teaching and learning, by evaluations of previous efforts, and by advances within the disciplines, projects should develop new learning materials and tools, or create new and innovative teaching methods and strategies. Projects may also revise or enhance existing educational materials and teaching strategies, based on prior results. All projects should lead to exemplary models that address the varied needs of the Nation's diverse undergraduate student population. They may include activities that help faculty develop expertise in adapting these innovations and incorporating them effectively into their courses, the next step in the cycle.
- **Developing Faculty Expertise**. Using new learning materials and teaching strategies often requires faculty to acquire new knowledge and skills and to revise their curricula and teaching practices. Projects should design and implement methods that enable faculty to gain such expertise. These can range from short-term workshops to sustained activities that foster new communities or networks of practicing educators. Successful projects should provide professional development for a diverse group of faculty so that new materials and teaching strategies can be widely implemented.
- **Implementing Educational Innovations**. To ensure their broad based adoption, successful educational innovations (such as learning materials, teaching strategies, faculty development materials, assessment and evaluation tools) and the research relating to them should be widely disseminated. These innovations may come from CCLI projects or from other sources in the STEM community. Funds may be requested for local adaptation and implementation projects, including instrumentation to support such projects. Results from implementation projects should illuminate the challenges to and opportunities for adapting innovations in diverse educational settings, and may provide a foundation for the development of new tools and processes for dissemination. They also may provide a foundation for assessments of learning and teaching.

- **Assessing Student Achievement**. Implementing educational innovations will create new needs to assess student learning. Projects for designing tools to measure the effectiveness of new materials and instructional methods are appropriate. Some projects may develop and share valid and reliable tests of STEM knowledge; other projects may collect, synthesize, and interpret information about student reasoning, practical skills, interests, or other valued outcomes. Projects that apply new and existing tools to conduct broad-based evaluations of educational programs or practices are appropriate if they span multiple institutions and are of general interest. Projects should carefully document population characteristics and context for abstracting what can be generalized. Results obtained using these tools and processes should provide a foundation that leads to new questions for conducting research on teaching and learning. Assessment projects likely to have only a local impact are discouraged.
- **Conducting Research on Undergraduate STEM Education.** Results from assessments of learning and teaching as well as from projects emphasizing other components in the cyclic model provide a foundation for developing new and revised models of how undergraduate STEM students learn. Research to explore how effective teaching strategies and curricula enhance learning is appropriate. Some research results may compel faculty to rethink STEM education for the future. Other projects will have a practical focus. All projects should lead to testable new ideas for creating learning materials and teaching strategies that have the potential for a direct impact on STEM educational practices.

8. Standards for Evaluating Scholarly Work

Charles E. Glassick, Mary Taylor Huber, and Gene I. Maeroff
Scholarship Assessed: Evaluation of the Professoriate.

Exhibit 2.1. Summary of Standards

Clear Goals

Does the scholar state the basic purposes of his or her work clearly? Does the scholar define objectives that are realistic and achievable? Does the scholar identify important questions in the field?

Adequate Preparation

Does the scholar show an understanding of existing scholarship in the field? Does the scholar bring the necessary skills to his or her work? Does the scholar bring together the resources necessary to move the project forward?

Appropriate Methods

Does the scholar use methods appropriate to the goals? Does the scholar apply effectively the methods selected? Does the scholar modify procedures in response to changing circumstances?

Significant Results

Does the scholar achieve the goals? Does the scholar's work add consequentially to the field? Does the scholar's work open additional areas for further exploration?

Effective Presentation

Does the scholar use a suitable style and effective organization to present his or her work? Does the scholar use appropriate forums for communicating work to its intended audiences? Does the scholar present his or her message with clarity and integrity?

Reflective Critique

Does the scholar critically evaluate his or her own work? Does the scholar bring an appropriate breadth of evidence to his or her critique? Does the scholar use evaluation to improve the quality of future work?

Source: *Glassick,* C.*E., Huber, M.T., and Maeroff, G.I.*
Exhibit 2.1 in Scholarship Assessed: Evaluation of the Professoriate.
San Francisco: Jossey-Bass, 1997, p.36.

9. Review of Recommendations of 2005 Workshop and Actions Taken

2005 WORKSHOP RECOMMENDATIONS

1. 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.

Actions:
Neeley, Kathryn, “From "How Stuff Works" to "How STUFF Works": A Systems Approach to The Relationship Of STS and "Technological Literacy".” Proceedings of the 2006 American Society for Engineering Education Annual Conference (2006).

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

Actions:
Technically Speaking is a reasonable starting point which was not explored in much detail during the first workshop.

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.

Actions:
Ollis, David, “Cross-College Collaboration of Engineering with Industrial Design.” *Proceedings of the 2005 American Society for Engineering Education Annual Conference* (2005).

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.

Actions:
Design process and quantitative thinking included in *Technically Speaking* and ITEA Standards.

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.

Actions:

1. Technology and Society identified as content areas in *Tech Tally* and ITEA Standards
2. Carlson, W. Bernard, "Technological Literacy and Empowerment: Exemplars from the History of Technology," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006).

<u>Develop Links to Other Competency Criteria</u>
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.

Actions:
Advocated in Tech *Tally.*

2. 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.

Actions: None specifically.

3. 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.

Actions:
Tech Tally identifies Content Areas and Cognitive Dimensions as a starting point.

4. 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.

Actions:
Tech Tally (Ch 5) has provided an overview of existing methods.

<u>Specific Assessment Needs</u>
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

Actions:

1. *Tech Tally* (Ch 5) has provided an overview of existing methods.
2. Use of MSLQ to measure attitudes, Krupczak, J.J., et. al, "Work in Progress: Case Study of a Technological Literacy and Non-majors Engineering Course," *Proceeding of the 35th ASEE/IEEE Frontiers in Education Conference*, October 19 – 22, 2005,

5. 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.

Actions:

1. ASEE Technological Literacy Constituent Committee created June 2005, currently 87 members.
2. ITEA and ASEE K-12 Collaboration
3. ITEA members: Mark Sanders and M. Annette Rose participants in 2007 Workshop

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.

Actions: None

6. 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.

Actions: 2007 Workshop to identify course models.

7. 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.

Actions:
Ollis, D. and J. J. Krupczak, "Hands-On Activities For Technological Literacy," Workshop held at the *2006 American Society for Engineering Education Annual Conference*.

Mikic, Borjana and Susan Voss, "Engineering For Everyone: Charging Students With The Task Of Designing Creative Solutions To The Problem Of Technology Literacy," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006)

Mississippi Valley Technology Teacher Education Conference
93rd Conference
Nashville, TN

Perceptions of *Technological Literacy* Among the Science, Technology, Engineering, and Mathematics Leaders

SESSION IV: Issues in STEM Education

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Abstract

This paper presents a story about the many appropriated meanings the science, technology, engineering, and mathematics (STEM or SMET) communities have for *technological literacy*. This story-telling is complicated by a U.S. national fervor for economic competitiveness (domination) that has been directly linked to national education programs in the STEM fields.

This story is a re-telling of perspectives and experiences garnered through interviews with 13 leaders of national professional organizations, as well as a review of key documents referenced by those informants. The interviews sought to reveal the informants' personal characterizations of *technological literacy,* as well as their perceptions of the professional educational communities in which they worked.

This story is tinted by the researcher's professional history within the technology community and personal beliefs of *technological literacy*. This history consists of formal education within industrial education, technology education, and instructional technology, as well as fulltime teaching responsibilities within public schools (≈10 years) and undergraduate and graduate education (>5 years). To minimize interpretive bias within the story, the researcher recorded verbatim conversations with informants and confirmed key propositions through the triangulation of data sources.

Background

The use of the term *literacy* has a deep history within the United States as it relates to efforts to improve the human abilities to speak, read, and write using a specific language within a specific culture. As such, literacy movements have employed formal and informal educational strategies with the express intent to help individuals build the core knowledge and skills of communication which will enable them to achieve the full rights and benefits of citizenship within their society. Over time, the term has been appropriated by numerous communities to describe a broader range of human qualities related to socio-cultural phenomena (e.g., cultural literacy), technological innovations (e.g., media, computer, and digital literacy), workplace skills, competency domains (e.g., Microsoft-literate), educational goals, and curricular programs.

As early as the 1950's, the term *scientific literacy* was used in discussions of science in general education when Paul DeHart Hurd drew connections between society and scientific and technological innovation (Bybee, 1997). The term *technological literacy* was employed by C. Dale Lemons at the 1972 Mississippi Valley Industrial Teacher Education Conference (Bouhdili, in Cajas, 2001) and by James A. Hale (Hale, 1972) as a fundamental focus of his dissertation research at West Virginia University. In both instances, *technological literacy* referred to the idea that the knowledge and skills needed to function in a society dominated by technological innovation included core understandings about technology and its impact upon society. The use of this term heralded the philosophical and curriculum debates (for overview, see Zuga, 1989) where various factions struggled over the mission, goals, and content of an educational program that eventually emerged as technology education.

Since the early 1990's, national leaders within technology education—William Dugger, Kendall Starkweather, and Tom Hughes—have long fought to position *technological literacy* as the fundamental goal of technology education. Under the auspices of the *Technology for All Americans Project (TfAAP), technological literacy* became the embodiment of a vision for the study of technology as a general education goal for all students. The TfAAP was an 11-year, $4.2 million project (W. E. Dugger, personal communication, February 20, 2006) administered by the International Technology Education Association (ITEA) and funded by the National Science Foundation and the National Aeronautics and Space Administration. In the premier document produced by the TfAAP, a rationale for the study of technology was presented to a national audience (ITEA, 1996). Then, after several years of consensus-building strategies, the TfAAP released the *Standards for technological literacy: Content for the study of technology (ITEA, 2000)*. These content standards were meant "to build the case for *technological literacy* by setting forth precisely what the outcomes of the study of technology should be" (p. 3). Within this document, *technological literacy* is defined as "the ability to use, manage, assess and understand technology" (p. 7).

The T*fAAP* has been one of the most far-reaching curriculum reform projects to occur within technology education. Its national impact can be attributed, in part, to the efficacy of its comprehensive approach to curriculum change, its multi-disciplinary perspectives, infrastructure for dissemination, and the consensus-building methods used for decision-making. For example, the TfAAP purposefully populated the TfAAP Advisory Board with individuals who brought cross-disciplinary perspectives to the group, including representatives from science, engineering, mathematics, and the National Research Council.

After more than a decade of advocacy for the goal of *technological literacy*, there is evidence to suggest that this vision has diffused throughout certain sectors of the technology education profession. For instance, Daughtery's (2005) study of technology teacher educators indicates widespread support for 18 of the 20 content standards.

However, the extent to which other educational communities share common values and definitions for *technological literacy* has not been established. For as Lewis and Gagel (1992) point out, "advocacy for the goal of technological literacy originates from philosophically diverse quarters (e.g., the scientific community, business and industry, politicians) and it cannot, therefore be assumed that the concept has a stable, unambiguous meaning" (p. 117).

There have been urgent political voices and significant financial investments—$2.8 billion in fiscal year 2004 for 207 education programs (Government Accounting Office, 2005)—to improve opportunities for all students to attain high standards of achievement in mathematics, science, engineering, and technology. These efforts are driven by a desire to maintain the technological competitiveness of the U.S. into the future. These efforts have generated a significant need for teachers to build deep understandings of mutually-relevant concepts and processes. Therefore, it could be argued that achieving common ground among key stakeholders--teachers, teacher educators, curriculum developers, administrators, and professional organizations-- embedded within STEM education is arguably a precondition to envisioning and restructuring general curricular programs which could positively impact the *technological literacy* of their students and possibly the competitive strength of the U.S. workforce.

Purpose and Research Questions

The purpose of this inquiry is to characterize and compare the STEM communities' perceptions of *technological literacy* and thereby gauge the extent to which the vision of *technological literacy* is shared among these communities. Specifically, the following questions guided the inquiry:

> What are the perspectives of technological literacy in each of the four STEM education areas?
>
> To what extent is technological literacy an important goal in each of the STEM education areas?
>
> To what extent can technology education lead STEM education in delivering on the goal of general technological literacy?

Methods

This paper presents findings of a descriptive research study conducted in the fall of 2006. The goal was to characterize and compare perceptions of *technological literacy* among STEM communities. Interviews were conducted with a small group of leaders who serve in strategic positions within STEM-related national organizations and a review of key documents referenced by these informants.

Interviews with Informants

This report is a re-telling of perspectives and experiences garnered through interviews with 13 leaders of national educational organizations, including the National Science Teachers Association (NSTA, N=2), National Science Education Leadership Association (NCELA, N=3), the National Council of Teachers of Mathematics (NCTM, N=3), and the American Society for Engineering Education (ASEE, N=5). These organizations were deemed exemplars of professional organizations supporting educators within the STEM disciplines because of the size of their membership, their charge to support undergraduate teacher education, their leadership in developing national educational standards, or their involvement in STEM programs. The technology education community was purposefully excluded from this sampling frame because both the researcher and the target audience are professionally embedded within the technology professional community.

Potential participants were purposefully selected from each organization because of the leadership position individuals held within the organization. Specifically, members of the board of directors, committee chairs, and officers of committees related to technological literacy, standards, curriculum, teacher education, professional development, or K-12 education were invited to participate in the study through a personal telephone invitation.

After an explanation of the purpose of the study and assurances of confidentiality, those volunteering to participate engaged in telephone interviews lasting from 25 to 75 minutes. A set of 20 questions guided each interview (Appendix A), however additional probes were extended to better explore unique propositions and unexpected issues. During the interview, the responses were immediately recorded into an electronic database.

Document Reviews

To discover and characterize perspectives of technological literacy among educators within the STEM disciplines, I have reviewed the documents recommended by the informants. These documents consisted of national standards, frameworks documents, and key reports embedded within parallel professional organizations of the STEM disciplines. These works of literature included:

Principles and Standards for School Mathematics (NCTM, 2000)
National Science Education Standards (NRC, 1996)
Science for All Americans (AAAS, 1993)
Science and Technology/Engineering Curriculum Framework (Massachusetts Department of Education, 2001)
Standards for Technological Literacy (ITEA, 2000)
Technically Speaking: Why All Americans Need to Know More About Technology (NAE & NRC, 2002)
Improving the Technological Literacy of Undergraduates: Identifying the Research Issues (Krupczak & Ollis, 2005)

Findings and Interpretation

The results of these interviews and document reviews are presented as they relate to the guiding questions. These retellings are represented as only perspectives and impressions drawn from the inquiry. Clearly the limited number of informants, the methods of data gathering, and the analytical lens employed by the researcher limits the external validity and usefulness of these results.

What are the perspectives of technological literacy in each of the four STEM education areas?

To gain insight into the various perspectives of technological literacy, informants were asked a variety of questions to uncover the unique and common perspectives of the STEM areas, including those items which addressed definitions (#1-4), sources of information, and examples of how technology is addressed within the area (#7). Examples of how technology is addressed within STEM curriculum and references to key documents are woven into the narrative.

In Table 1, key phrases have been extracted from the responses of the informants when asked about the definition of technology common to their STEM area (#1 & 3). As a result of the analysis of these responses, phrases were placed into a row which best typified the emergent themes. These themes included: knowledge of technology, technology as the object of assessment, technology and society, technological processes (design and problem solving), technology for teaching and learning, and technology as artifacts or outcomes.

The second question asked informants to forward their own definition for *technological literacy*. Key responses are offered in Table 2. Once again, key phrases have been selected to represent the open-ended responses of the informants. To more easily compare these perspectives to those of the technology area, the phrases in each row have been categorized into the common themes extracted from the *Standards for Technological Literacy* (STL; ITEA, 2000).

A multiple-answer question (#4) was posed to informants; this item encouraged informants to select any combination of definitions which spoke to their own understanding of *technological literacy*. Column 1 of Table 3 represents the distribution of selections by STEM discipline.

Science. The science informants offered the most multifaceted and complex definitions for *technology* and *technological literacy*. The initial definition offered by majority of informants was technology as tool use, especially as it related to teaching, learning, or doing inquiry. For example, one informant offered this example:

> We use technology for monitoring environmental conditions. Without the instrumentation, we could not track environmental conditions in an effective manner.

In addition to defining technology as a tool, science informants offered numerous definitions of technology to include connections to the individual and society, design and problem solving processes, as well as technology as an object of assessment. These connections were evidenced in thoughts about *human need, retrofitting, problem solving, engineering design, and evaluation and wise selection.* An informant's reference to the *Science for All Americans* (AAAS, 1989) document further elaborates this theme. Essential propositions in the Nature of Technology section note that technologies always have side effects, risks, and can fail, therefore decisions about the use of technology are complex at both the societal and personal levels (p. 44). Furthermore, this perspective places the analytical (e.g., risk analysis) and decision-making acts prior to the introduction of the innovation or instantiation of the design. This chronological placement may also differentiate the science definition of technology from that portrayed within the technology education literature where the emphasis is upon assessment of an innovation after its implementation. Assessment that precedes technological implementation, unlike assessment after implementation, can inform implementation decisions.

Informants also offered examples of the interdependencies between science and technology and the parallels between science as inquiry and technology as problem solving. An informant explained that biotechnology is being adopted by many larger districts in Arizona. However, within biotechnology the boundaries between science and technology are blurred. The technology enables scientists to do the research on gene slicing and stem cell research, but the tools and processes required to do this research often have to be developed for this research to continue. The aforementioned exemplifies the strong connection that science informants made to technology as problem solving and engineering design process.

Table 1. Perspectives on the meaning of *technology* from STEM informants.

	Science	Engineering	Mathematics
Knowledge about Technology		• Understanding, handling, and properly using anything that humans synthesize	
Technology as Object of Assessment	• Actual physical stuff, how to use it, and evaluate it • Evaluating and selecting tools and materials		
Technology, Society, & Environment	• If a human need is to know and understand and explore, then technology certainly meets that human need. It would be defined by human need		
Processes Engineering Design Troubleshooting R&D Problem Solving	• Retrofitting modern concepts into structures [and systems] • A way of problem solving. A way of logically thinking through a problem to find a solution. • Design engineering	• Habits of mind, processes, tools, materials, and ways we approach the human-built world ….design under constraint and optimization	
Technology for Teaching Learning	• The use of tools as it applies to science teaching • Technologies enhance classroom instruction • Enable students to do experiments, manipulate variables and find information • Technology enables long distance learning • Instructional technology		• Tool for the study of math • Visual tools that open doors to mathematics at higher levels • Application of technology to teaching • Appropriate use of technology for doing math
Technology as Artifact or Outcome	• Technology is a tool • The software and hardware of technology • That which grows out of science • Monitoring environmental conditions	• The systems that are designed, engineered, or created to achieve a purpose • Outcomes of the engineering process • Computational technology, software for computers, graphic calculators • The human built environment • Products of the engineering profession	• Any kind of device that aids you in doing something: a calculator. • Handheld technologies

Table 2. Perspectives on the meaning of *technology literacy* among STEM informants.

<table>
<tr><th>Technology</th><th>Science</th><th>Engineering</th><th>Mathematics</th></tr>
<tr><td>STL #1-3
• Characteristics
• Core concepts
• Relationships</td><td>• Understanding the manmade world from the natural world</td><td></td><td>• Minimal level of knowledge about tools and systems
• Read, write, and comprehend text</td></tr>
<tr><td>STL #4-7
• Effects
• Environment
• Role of society
• Influence on history</td><td>• The safety piece, the technology that we need to ensure the safety of students and the students in the broad society
• Science, technology, and society</td><td></td><td></td></tr>
<tr><td>STL #8-10
• Attributes of design
• Engineering design
• Role of troubleshooting, R&D…. problem solving</td><td rowspan="2">• Applying that knowledge [conceptual science] to address a problem whether it is a medical, physical, or environmental problem Important in using technology and as consumers telling the difference between hype and what it is actually doing
• Using technology to solve everyday problems
• Experiencing low-tech and high-tech tools</td><td rowspan="2">• Understanding the important underlying principles that engineers use to create technology. Would know key principles that engineers use, including both design principles and engineering science.
• Every individual needs to have habits of mind, knowledge and the ability to solve problems.
• Ability to effectively use technology either in the workplace or for personal benefit
• Being comfortable with technology, understanding, handling, and properly using anything that humans synthesize</td><td></td></tr>
<tr><td>STL 11-13
• Apply design process
• Use & maintain
• Assess</td><td>• The ability to solve [problems] and do one's work
• Understand and use basic technology</td></tr>
<tr><td></td><td>• A teacher would understand the use of a wide variety of tools, when to apply, and how to apply.
• Teachers know how to integrate technology and enhance their teaching.
• Students are technologically literate.
• Meeting the ISTE standards</td><td></td><td></td></tr>
<tr><td>Meeting the ITEA standards</td><td>Meeting the ITEA standards</td><td>I don't know</td><td>I don't know. We don't talk about it.</td></tr>
</table>

Table 3. Results of STEM informants selection of definitions for *technological literacy*.

	I'm going to read four definitions. Which of these describes your understanding of a "technologically literate" person? (multiple answer)
SEEE	a. A person who is able to read and interpret literature about technology.
SSSEEE	b. A person who is able to design, build, install, and troubleshoot products and systems.
SSSEEEEEM	c. A person who critically examines technological innovation in order to make informed decisions.
SSSSSEEEEM	d. A person who understands linkages among the individual, technology, environment, and society.
M	e. Other (Using technology to solve everyday problems)

Key: S=Science, E=Engineering, M=Mathematics

Among the science informants, there were strong parallels between definitions of *technology* and *technological literacy*. As indicated in Table 2, the range of responses addressed:

- understandings of the manmade world;
- connections among and between science, society, the environment, and technology;
- abilities to use technology, especially in learning and teaching science and conducting inquiry;
- abilities to evaluate and make informed decisions; and
- standards for technological literacy, including both those produced by the ITEA and the International Society for Technology in Education (ISTE; NETS Project Staff, 1998).

Agreement was also unanimous among the science informants that a technologically literate person was one who understands linkages among the individual, technology, environment, and society (Table 3). However, the majority of respondents also insisted that a single statement could not encapsulate the full range of knowledge and abilities that they associated with the term. One informant proposed that it takes both the *Standards for Technological Literacy* (ITEA, 2000) and the *National Educational Technology Standards for Students* (NETS Project Staff, 1998) to elaborate what it means to be technologically literate in K-12. Certainly, it must be concluded that the science community holds a broad perspective of *technological literacy* which emphasizes a knowledge base, assessment, decision-making, problem solving, and its interconnected nature to society.

Engineering. As shown in Table 1, engineering informants defined technology along several facets: technology as artifact or outcome, knowledge about technology, and processes. However, it is important to note that the latter two definitions were offered by single informants. The strongest sentiment was that technology was an outcome, artifact, or creation of an engineering process, rather than as a tool to accomplish engineering design or as the process of engineering. Explanations offered by two informants may help clarify this perspective:

> Tool use makes me think of technology and not engineering. It's engineering if there is a direct linkage from the knowledge base to the solution of a problem.

> I've heard people from technology education speak about a technological design process or a technological problem solving process. This is never mentioned in engineering. Engineers would reject the notion that you do technology.

In addition, two informants reacted to this definition of technology--modifying our natural world to meet human needs (Item # 3). One rejected this definition of technology because of its engineering orientation; he explained that this “definition seems to be the creation of technology” not a definition of its meaning. Another informant spoke to the inadequacy of the definition: “this definition is lacking because, it doesn’t focus upon constraints and optimization.” At the very least, this line of evidence suggests that the language employed by the technology and engineering education communities may present obstacles to developing mutual understandings.

Perspectives of technological literacy among the engineering informants were fairly consistent with clear connections to the framework of “knowledge, capabilities, and ways of thinking and acting” that the Committee on Technological Literacy presented in *Technically Speaking* (NAE & NRC, 2002). In addition, all informants agreed that a technologically literate person may be described as one who has the ability to critically examine technological innovation in order to make informed decisions. This emphasis upon critical thinking and decision-making is mirrored in the Academies recent effort to examine approaches to assess *technological literacy*. In *Tech Tally* (NAE & NRC, 2006), the Committee on Assessing Technological Literacy renamed the “ways of thinking and acting” dimension to “critical thinking and decision making” to better represent one’s approach to technological issues (p. 2).

These informants were also quick to indicate that “engineers are far more technologically literate than the average citizen. However, their technological literacy is not equally balanced across all the aspects.” A second informant explained:

> There is a difference between a professional [engineer] and technologically literate citizen; the professional has more advanced skills. But it’s also important that a citizen has similar literacy especially as it applies to medical technologies and communication systems. Just because you are an engineer does not mean that you could lay claim to a domain outside your specialized area. I wouldn't expect an electrical engineering to be more literate than an average citizen in regards to cloning.

Mathematics. All mathematics informants indicated that technology is important within mathematics education. However, as shown by Table 1, the mathematics community restricts its definition of technology to the tools used to teach, learn, and do mathematics. When offered a broad definition of technology—modifying our natural world to meet human needs—one mathematics informant explained:

> We don’t use those phrases. We talk about the appropriate use and application of technology [as it applies to mathematics], not the technology itself….Mathematics is used as a tool to modify the natural world. Technology is a tool within that tool set…. We have three principles which are outlined in our standards.

A review of the *Principles and Standards for School Mathematics* (NCTM, 2000) confirms this perspective. In this national standards document, a principle states:

> Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. (Principles for School Mathematics section)

Additionally, informants indicated that technology is also woven into mathematics through the communication, representation, and connections threads of their content standards. Although a review indicated that explicit references to technology were scarce within these threads, one infers that technology is valued as a tool for developing, sharing, visualizing, and demonstrating mathematical understandings. For example, one respondent explained [Technology] "represents ideas using different forms, such as physical forms, graphs, data, and symbolic forms."

In contrast to their narrow definition of technology, mathematics informants' perspectives on *technological literacy* were much broader and more encompassing. As evidence by Table 2 and 3, it appeared that the literacy connection spoke to the development of "minimal skills" that enabled people to make informed decisions about both the problems encountered in everyday life, as well as future "opportunities and challenges" encountered by society. An informative elaborated this point:

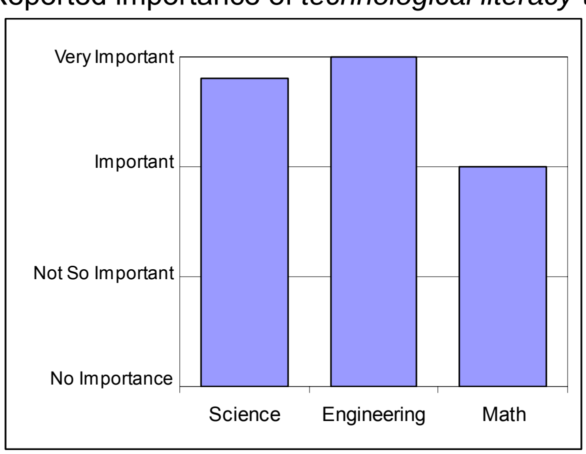
> For us, the ability to simulate future scenarios (see Illuminations on our Web site) allows students to explore and control future pandemics, population, the possibility of catching a disease, and the number of days a person is contagious and quarantined…. I contend this is technology.

Given these insights into the mathematics area, one can conclude that *technological literacy* refers to integrated knowledge and abilities to use a tool set to make informed decisions and solve personal and societal problems.

To what extent is technological literacy an important goal in each of the STEM education areas?

In addition to more general discussions about technological literacy, informants were asked to indicate how important technological literacy was within their STEM area. Figure 1 presents those responses to Item #6 using a 4-position scale, ranging from Very Important to No Importance. These responses cannot be interpreted on an equal interval scale because there were qualitative differences in their definitions of technological literacy and the examples offered to exemplify its position within their educational area. Further discussion will be offered for each STEM area below.

Figure 1. Reported importance of *technological literacy* to STEM informants.



Science. Most evidence from this inquiry supports the conclusion that the science community inextricably links *technological literacy* to science literacy. Informants' numerous references to *Science for All Americans* and the *National Standards for Science Education* further clarified these connections. There is a clear and redundant message within these documents that building both science literacy and *technological literacy* among all people is urgent national concern for health and well-being of citizens, the environment, and the economy. Therefore, a conclusion must be drawn that the goal of *technological literacy* is essential to the study of science. As one informant emphatically stated:

> Technological literacy is critical…The whole notion of learning science conceptually is to apply that knowledge to a model that will address a problem whether it is a medical, physical, or environmental problem.

Engineering. Although all engineering informants indicated that *technological literacy* was very important to engineering education (see Figure 1), three of five informants cautioned that their views were probably not representative of engineering educators. One informant conceded "engineering students need to develop *technological literacy*. But they are not necessarily getting it from the engineering curriculum." For instance, when asked where an undergraduate engineering curriculum would provide experiences for students to make connections between engineering and societal concerns, a second informant positioned within a prominent engineering institution stated that these connections were limited to two experiences within the undergraduate curriculum. These connections are made within a seminar and a senior design project where ethical considerations of the project must be taken into consideration.

However, informants enthusiastically reported that there are significant efforts within the ASEE to raise the consciousness of its members toward technological literacy, including the technological literacy strands of the 2005 and 2006 ASEE National Conferences, and the Technological Literacy Constituency Committee. One informant explains:

> The Technological Literacy Constituency Committee has been in existence for less than 2 years. One of our goals is to define technological literacy relative to engineering education. Our goal is to become a full Professional Interest Council within the ASEE. To do that, our committee needs active members. We invite involvement from technology educators and the ITEA.

In addition, there was a common sentiment that children should engage in engineering design activities throughout their public school career. Informants spoke enthusiastically about current efforts to infuse engineering into the K-12 environment, especially through access to resources provided by the ASEE K12Engineering Center (accessible at http://www.engineeringk12.org/).

Mathematics. As already discussed, the mathematics informants' narrow definitions for technological literacy—skills and abilities related to teaching, learning, and doing mathematics—tempers the weight we should place on their contention that *technological literacy* is an important goal within their area. An informant's reaction to definitions of *technological literacy* clarifies this point:

> I don't see this as math education. I don't believe that building technology literacy, the way you have defined it, is a part of mathematics education.

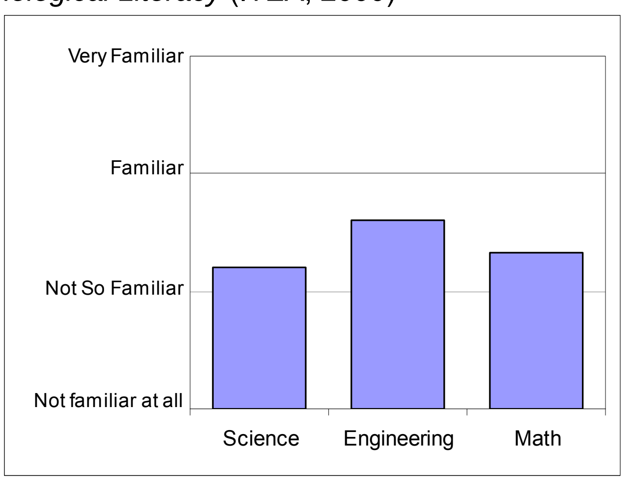
Therefore, we must conclude that building *technological literacy* is not as high a priority within mathematics as Figure 1 suggests.

To what extent can technology education lead STEM education in delivering on the goal of general technological literacy?

To approach this highly-speculative, politically-charged question, several assumptions had to be made. First, it was assumed that familiarity with technology education as a school subject, the STLs, and professional organizations for technology educators (e.g., the ITEA) would be a necessary precondition for members of the other STEM areas to accept leadership from the technology area. Second, it was also assumed that confidence in a potential leader could be inferred from recommendations informants make about how public schools should build *technological literacy* among students and about what entities should lead a national effort.

Familiarity. To assess familiarity, a specific question was raised concerning informants' level of familiarity with the STLs (Item #10). Figure 2 indicates that the all communities had awareness-level familiarity of the STLs; in other words, informants knew this document existed but could not discuss its general themes or attributes. In addition to this direct question, a phrase count of the occurrences of technology education or any technology professional organization within the informant's responses was conducted. The results indicated that references to technology education as an area of study were negligible, with only one reference made by science, and five made by engineering informants. References to a technology education professional organization, only the ITEA, occurred more frequently within two from science and six references from engineering informants.

Figure 2. STEM informants' familiarity with *Standards for Technological Literacy* (ITEA, 2000)



Confidence in School Curriculum. To assess levels of confidence that STEM informants might have in technology education as a curricular program, informants were asked to make recommendation about how public schools could best build technological literacy (Item

#9). Six of thirteen informants recommended that public schools make it a responsibility of all subject areas within a school. Not one informant suggested that the appropriate placement of *technological literacy* goals should be embedded within technology education or a technical subject area. Two engineering informants provide some insight into this reasoning:

> I would like to say that all students would take an interdisciplinary course in technological literacy. But, that's not going to happen. Schools should integrate the study of technology into science and math because all students must take science and math. Then in high school, students can take specific explorations of technology and engineering in their electives.

> The focus of my high school experience was a college prep orientation. This program [technology education] sounds more like a vocational orientation. I do think that some courses that are directly oriented toward understanding or using technologies can be a useful thing. But I suspect that there isn't that much linkage between the more traditional math and science courses. Engineering is a linkage between the two.

Confidence in Leaders. Finally, informants were asked to make recommendations as to who should best lead a national effort to deliver on the goal of technological literacy. Twenty-one recommendations were offered; the most frequently mentioned organizations are mentioned below with first letter codes representing each community, (e.g., S=Science):

SSSSE	National Science Teachers Association
EEEE	American Association of Engineering Education
EEE	International Technology Education Association
SE	National Academy of Engineering

Leadership Conclusion: Given the science and mathematics informants' (1) low level of awareness of the STL and the technology profession, (2) their lack of confidence in technology education's power to build technological literacy in public schools, and (3) their recommendations for desirable national leaders, one must conclude that any entity or professional organization embedded within the technology community will have a significant struggle in positioning itself as a national leader within science and mathematics. In contrast, there appears to be an opportunity for mutual cooperation with the engineering community.

Conclusion

This descriptive research study characterized and compared the perceptions of *technological literacy* among 13 leaders of professional organizations representing science, engineering and mathematics communities. The evidence suggests that the STEM communities conceptualize it in subtly different ways and place priority upon different dimensions. The science informants tend to value the knowledge and abilities that enable them to solve problems, evaluate, and make wise decisions about technology within a larger social context. The engineering informants valued the knowledge and abilities that enable them to apply engineering design in a human-synthesized world. The mathematics informants speak to minimal level of knowledge that enables them to understand and use technology to do one's work.

The importance of *technological literacy* as a goal varies greatly across the STEM education areas. The interdependencies between the knowledge, abilities, and habits of mind expressed within science literacy and *technological literacy*, as well as the multiple, explicit connections made within the Benchmarks (AAAS, 1994) and content standards indicate that the science community places high priority upon *technological literacy*. The engineering community also values *technological literacy*, especially as it relates to the knowledge and abilities which enable them to engage in their fundamental professional act of engineering design. However, their interest in making *technological literacy* a goal is still emerging and appears to parallel a movement to infuse engineering into K-12 education. The mathematics community places high priority upon building only a subset of *technological literacy*, i.e., the abilities and knowledge required to teach, learn, and do mathematics. This evidence is in clear agreement with Lewis and Gagel's (1992) conclusion that "technological literacy as a general educational goal cannot be claimed by any one sector or discipline within the curriculum. The sum of the conceptions of technological literacy we see results in an amalgam which suggests a whole-school approach to the problem" (p.135).

This inquiry suggests that STEM leaders outside the technology education discipline do not readily associate the "T" in STEM with a curricular program known as technology education. Among those who were aware of technology curricular programs, there was lack or confidence in its power to positively effect *technological literacy* among students. There was a prevailing sense that technology education was not an equal partner in efforts to build interdisciplinary knowledge and skills at the public school level in order to increase numbers of students pursuing undergraduate studies in STEM disciplines. Therefore, it must be concluded that science, engineering, and mathematics communities will not look toward the technology community for leadership.

Although there have been significant political, economic, and educational efforts to promote a common understanding of *technological literacy* among STEM educators, the goal still remains illusive and the costs of achieving common ground may be great. The current nationalist trend for standardization (common standards, curriculum, assessments, and outcomes) as a quest for efficiency, economic gain, and international superiority threatens many values held within our multicultural society. Those holding values for self-sufficiency, individual freedom, local control of public education, decision-making based on sustainability principles and ethical, moral, and religious grounds have convincing arguments for promoting diversity and flexibility within our educational systems. Fundamentally, technology proponents may be wise to embrace diverse representations of *technological literacy,* applaud the significant efforts of other communities to enhance this goal, and focus their attention on the unique contributions they make in building *technological literacy* within general education.

References

AAAS (American Association for the Advancement of Sciences). (1989). *Science for All Americans: A Project 2061 report on literacy goals in science, mathematics and technology*. Washington DC.

AAAS (American Association for the Advancement of Sciences). (1993). *Benchmarks for science literacy*. New York: Oxford University Press.

Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Cajas, F. (2001). The science/technology interaction: Implications for science literacy. *Journal of Research in Science Teaching, 38*(7). 715-729.

Daughtery, M. (2005). A changing role for technology teacher education. *Journal of Industrial Teacher Education, 42*(1), 41-53.

Dugger, W.E. (2006, February 20). Personal communication.

Government Accounting Office, U.S. (2005). *Federal science, technology, engineering, and mathematics programs and related trends* (No. GAO-06-114).

Hale, J. A. (1972). *Essential determinants of technological literacy for high school graduates.* West Virginia University, Morgantown, WV.

ISTE (International Society for Technology in Education). (1998). *National educational technology standards for students*. Eugene, OR: Author.

ITEA (International Technology Education Association, Technology for All Americans Project). (2000). *Standards for technological literacy: Content for the study of technology*. Reston, Virginia: Author.

ITEA (International Technology Education Association, Technology for All Americans Project). (1996). *Technology for all Americans: A rationale and structure for the study of technology.* Reston, Virginia: Author.

Krupczak, Jr., J., & Ollis, D. F. (2005). Improving the technological literacy of undergraduates: Identifying the research issues. A workshop sponsored by The National Science Foundation. National Academy of Engineering, Washington, DC.

Lewis, T., & Gagel, C. (1992). Technological literacy: A critical analysis. *Journal of Curriculum Studies, 24*(117-138).

Massachusetts Department of Education. (2001). *Science and Technology/Engineering Curriculum Framework*, from http://www.doe.mass.edu/frameworks/scitech/2001/standards/strand4.html

NAE & NRC (National Academy of Engineering & National Research Council). (2006). *Tech Tally: Approaches to assessing technological literacy.* Washington, D.C.: National Academies Press.

NAE & NRC (National Academy of Engineering & National Research Council). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, D.C.: National Academy Press.

NCTM (National Council of Teachers of Mathematics). (2000). *Principles and Standards for School Mathematics*. Reston, VA: Author.

NRC (National Research Council). (1996). *National science education standards*. Washington, DC: National Academy Press.

Zuga, K. F. (1989). Relating technology education goals to curriculum planning. *Journal of Technology Education, 1*(1).

APPENDIX A

Guiding Questions for Telephone Interview with Leaders of Professional Organizations

A. What is your professional role and title at _[insert organization]_?

B. What documents best characterize what it means to teach and learn _[insert STEM]_?

TECHNOLOGY

1. In the context of _[insert STEM]_ education, what does “technology” mean?

2. In the context of _[insert STEM]_ education, what does “technological literacy” mean?

3. Using a broad definition of technology as “modifying our natural world to meet human needs”, does _[insert STEM]_education address the study of technology?

4. If so, how does _[insert STEM]_education address the study of technology?

5. I’m going to read four definitions. Which of these describes your understanding of a “technologically literate” person?
    a. A person who is able to read and interpret literature about technology.
    b. A person who is able to design, build, install, and troubleshoot products and systems.
    c. A person who critically examines and questions technological progress and innovation in order to make informed decisions.
    d. A person who understands the links among the individual, technology, environment, and society.

6. Technological literacy is sometimes defined as “one’s ability to use, manage, assess, and understand technology.” In light of this definition, is developing technological literacy among students an important element in _[insert STEM]_ education?

7. If so, could you offer some examples of standards or curriculum content which illustrate this importance?

8. If not, do you believe technological literacy should be emphasized within _[insert STEM]_ education? If yes, how might this occur?

9. Now direct your imagination to public schools, how should the school curriculum build “technological literacy” among students?

10. To what extent are you familiar with the *Standards for Technological Literacy* published by the International Technology Education Association (2000)?

11. To what extent do the *Standards for Technological Literacy* clarify what it means for students in K-12 to be technologically literate?

12. To what extent do the standards for __[insert STEM field]_ education share common elements with the *Standards for Technological Literacy*? Are there…

13. Could you identify an example where the overlaps are strong?

14. Has the __[insert organization name]_ planned or implemented any efforts, projects, or services to inform its membership about technological literacy or the *Standards for Technological Literacy*?

15. Could you identify these efforts?

STEM

STEM or SMET often refer to educational projects and curricular programs which integrate the study of science, technology, engineering, and mathematics content for the purposes of strengthening students' skills to eventually contribute to the STEM-related workforce.

16. From the perspective of _[insert organization]_, how important is integration within __[insert STEM]_ education ?

17. How has _[organization name]_ participated in STEM or SMET integration?

18. What entity, organization, or STEM field or should lead the national effort in delivering on the goal of general technological literacy?

19. What recommendations do you have to those working to promote technological literacy?

20. In light of these questions, have you any thoughts, concerns, or suggestions about the relationship of technological literacy and STEM to _[insert STEM] education that you would like to share with me?

11. Pre-Workshop Survey Course Information

Courses are listed alphabetically by instructor. As working document, some of the character formatting errors caused by the online survey software have not yet been corrected.
Some references entered via the survey are not yet included in the overall bibliography.

Steve Cutcliffe
Course 1

Course Title: Science, Technology and Human Values

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	
	Construction technologies	

Steve Cutcliffe
Course 1

Course description:

Technology can inspire great wonder or great fear, and sometimes do so at the same time. It can entail grand social goals or the most mundane of consumer products, but the interrelationship between technology and the society that creates it is always dynamic and inherently value-laden. Cultural, political, and economic values help to shape and direct technological development, which in turn can have a profound effect on those same social values and the society that holds them. In this course we will examine technology as a “social process,” exploring social and ethical questions raised by the exploitation of technological innovations and discussing how society channels the work of scientists and engineers through institutions characteristic of the society: governmental, economic, corporate, educational, cultural. We will pursue this understanding through assigned readings, discussion, selected films, and a “technology journal.” By the end of the course you should be better informed about both the innovation of technology and its implications for society.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

syllabus

Course website:

NA

References about your course or technological literacy work:

<u>Course Title</u>: Nanotechnology and Society

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Steve Cutcliffe
Course 2

Course description:

Course Overview Nanotechnology involves the development of tiny amounts of material far smaller than the human eye can detect. A nanometer is 1 billionth of a meter, and a single human hair is approximately 80,000 nanometers wide. Engineered atom by atom to give them unique properties, nanoparticles do not behave like solids, liquids or gases. Instead, they have special properties that include different colors and electronic, magnetic and mechanical properties, which can all be altered at the nanoscale. Because of these unique properties, nanotechnology is supposed to drive a "new industrial revolution," according to U.S. government officials. One official estimates that by 2015, nanotechnology will play a key role in products that will spur the economy by $1 trillion per year, requiring two million workers. Besides its impacts on industry, nanotechnology is projected to influence many societal factors including privacy, military and security issues, health and environmental risks, medical technologies, socioeconomic and global concerns..   This course will introduce students to both the societal and technological dimensions of nanoscale science and nanotechnology. It will explore some of the potential benefits expected from this new field including smaller but more powerful computers, internal medical monitoring, new foods, lighter and stronger materials, and new methods of cleaning up environmental pollution. It also will explore some potential risks various groups foresee including health and environmental risks, radically changed warfare because of nanotechnology-based military weapons, and repetition of costly past technological mistakes such as asbestos. Additionally it will help enhance student awareness of potential career opportunities.   Emerging applications of nanotechnology along with opportunities and challenges will be discussed weekly. Specific nano applications will include electronics, medicine and health, consumer products, and the environment. Other dimensions of nanotechnology and society will also be a focus of the course including business opportunities, entrepreneurship, intellectual property, government issues, public perceptions and the future of nanotechnology. A tour of Lehigh's Nano-characterization Lab will be a highlight of the course activities.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

syllabus

Course website:

NA

References about your course or technological literacy work:

Kurt DeGoede
Course 1

<u>Course Title</u>: PHY105 How Things Work

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	
	Capabilities	✓
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	
	Construction technologies	

Kurt DeGoede
Course 1

Course description:
Based on activities experienced in daily life, students will learn several physical concepts. By experiencing science at work students will become more comfortable with it and will understand the predictable nature of the universe and dispel the "magic" of science and technology. Students learn how various technologies work and will develop their physical intuition of the world. Topics may include: amusement park rides, bicycles, baseball, human movement, automobiles, clocks, musical instruments, audio amplifiers, radio, lasers, cameras, computers, copiers, power generation and distribution, and nuclear reactors. Course will include a two-hour laboratory component each week. Hours: lecture 3, laboratory 1.5.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
Lab instructions, Lecture materials (based on Louis Bloomfield's text), design problem statements

Course website:
NA (I use Blackboard)

References about your course or technological literacy work:
ASEE paper included in collection assembled by John. I have the presentation materials which could also be made available (pdf of the presentation slides).

Kate Disney
Course 1

Course Title: Engr 3 - Science at Work: Technology in the Modern World

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	
	Construction technologies	✓

Kate Disney
Course 1

Course description:

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; Faradayâ€™s Law of induction; electromagnetics and radiation; atomic mass energy conversion; and materials science. Students will dissect an engineering system after the instructor provides a presentation and/or demonstration of the related scientific theory. Experiments will enable students to verify or disprove their initial hypothesis as to how the system functions and employs science. Credit / No Credit option

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course website:

References about your course or technological literacy work:

Principal Investigator, NSF - CCD Program "Designing a Portable Technical Literacy Course for Use in California", Award #9254172 1993-1994

Camille George
Course 1

Course Title: Fuel Cell Systems

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	
	The role of society in the development and use of technology	✓
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Course description:
A discovery-oriented pedagogy focused on fuel cell technology. Fuel cells types, their chemistry, physics, design, safety, cost and operation are examined. Considerable time will be spent on hydrogen generation, storage & distribution.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
Notes on the following Topics: History, Industry Terms, Basic Principals, and Comparison Review the history of fuel cell technology. Define the common terms used in the fuel cell industry. Understand the basic principals of fuel cell systems. Compare fuel cell systems to traditional combustion systems for generating electricity. Liquid and Gaseous Fuels Identify the variety of liquid and gaseous fuels used in fuel cell systems. Review the benefits and limitations of the different fuels used by fuel cells. Safety Requirements and Hazards Understand the need for safety requirements when working with fuel cell systems. Describe the hazards and precautions for each liquid and gaseous fuel: hydrogen, methane, propane, methanol. Hydrogen as an energy source Describe hydrogen as an energy resource. Understand the hazards and benefits of hydrogen as an energy resource. Thermodynamics & Electrochemical Kinetics Introduce 1st and 2nd Law, enthalpy and entropy. Introduce Gibbs Free Energy & chemical thermodynamics. Discuss efficiency and losses. Explain electrode kinetics and reaction rates. Types of Fuel Cells Identify the five types of fuel cells. Discuss the advantages and disadvantages of the different types of fuel cells. Identify the present applications of each type of fuel cell. Discuss the operational theory of each of the fuel cell systems. Explain the major components of each of the fuel cell systems. Fuel Cell Stacks Describe the operation theory of the fuel cell stack. Identify the typical arrangement of the fuel cell stack for the different fuel cell systems. Identify and describe the functions of the fuel cell system subcomponents (mechanical, electrical and electronic subsystems). Discuss the manufacturing challenges of system subcomponents. Electric Conversion Equipment Describe the operation theory of the conversion of the fuel cell produced electricity to become useful to the electric power grid. Identify the components of the electric conversion equipment. Combined Heat and Power Describe the methods of heat generation and heat rejection in a fuel cell system. Compare the efficiency of a fuel cell system with and without heat recovery. Identify typical applications of the waste heat from the different fuel cell systems. Economics and Politics Explore the current status of codes and standards. Discuss the status of infrastructure investment. Examine recent congressional bills and policy. Discuss the barriers to societal change.

Course website:
I have an extensive blackboard page but it is restricted to the university.

References about your course or technological literacy work:
C. George, “Fuel Cells and Discovery-Oriented Teaching”, Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Session 2233, Salt Lake City, Utah, June 2004.

Camille George
Course 2

<u>*Course Title:*</u> SMEE (science & math for elementary education) Seminar

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	
	Assess the impact of products and systems	
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

<u>*Course description:*</u>
This is a seminar for education majors. A seminar which includes the science division (biology, physics, chemistry and geology) and engineering. Each week a different faculty person teaches the seminar which must include a hands-on activity. I teach one week of the seminar every semester.

<u>*List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)*</u>
I have compiled several teaching modules for the SMEE seminar. The modules are documented the website listed below.

<u>*Course website:*</u>
http://www.stkate.edu/~ysng/PROJECTS/METoo/index.html

<u>*References about your course or technological literacy work:*</u>
C. George, E. Amel and C. Greene, "'Lessons with Lunch' Using a Common Technology with a Global Impact to Address Technology and Data Literacy", Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition, Honolulu, H

Course Title: I did a seminar course on engineering topics for non-engineers while a visiting professor at Sweet Briar College.

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	
	Assess the impact of products and systems	
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	✓
	Construction technologies	

Mary Kasarda
Course 1

Course description:
This one-hour seminar course covers an overview of engineering topics including research, design, and historical and societal issues.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
N/A the course was taught once and was pretty ad-hoc. I used a lot of guest speakers including a humanist who gave a historical/social lecture on impact of coal production and advent of other technology (like canned goods) on a small community in rural Virginia

Course website:
N/A

References about your course or technological literacy work:

Mary Kasarda
Course 2

Course Title: ME4015/16 Senior Capstone Design: Design of Educational Tools to Support FIRST robotics

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	
Technology and Society	The cultural, social, economic, and political effects of technology	
	The effects of technology on the environment	
	The role of society in the development and use of technology	
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Mary Kasarda
Course 2

Course description:

The ultimate design goal of this project is to design and build one or more educational tools (such as an experiment, hands-on demonstration board, mini design competition, etc) to help high school teachers who are working with FIRST Robotics teams communicate to the students the essential elements of the engineering design process, and the understanding and utilization of engineering tools. You will be working with students and teachers from Montgomery County Public Schools (MCPS) in order to facilitate successful design(s). The first semester (ME4015) will initially begin with your orientation to the program, and in that context, you will be given the assignment to redesign a robot from a previous year. This "mini-goal" will require you to immediately apply the design approach to a technical problem, while at the same time allowing you to familiarize yourself with the students, teachers, and First robotics competition. By mid-semester, you will begin to also utilize the design process to achieve your project goal of developing one or more educational tools. You will be completing the process, including building the final product(s), during the spring semester (ME4016).

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course policy Assignment List

Course website:

N/A

References about your course or technological literacy work:

Kasarda, M., Brown, E., and Brand, B., "Teaching Capstone Design in a Service Learning Setting," Proceedings of 114th Annual ASEE Conference and Exhibition, Honolulu, Hawaii, June 24-27, 2007. Accepted pending revisions for presentation and publication.

Doug Klein
Course 1

Course Title: Technology, Culture and Society

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Doug Klein
Course 1

Course description:

Course Description: Technology has always had an enormous effect on society, from the kinds of work we do, to how long we live, to the values we hold, and which humans are prosperous or poor. Many predict that we are now entering an era of stunning technological change, an era in which we will be called on to redefine our very notion of humanity. Indeed, some are beginning to refer to a near future as a "posthuman" world. Those in college today will be the leaders in addressing these issues and making the many momentous choices that technological change will pose. Unfortunately, many of these same students have little opportunity to understand science and technology and even less chance to think systematically about the implications of technological change.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Syllabus (will send as attachment)

Course website:

Being developed under Blackboard; will provide contents when ready.

References about your course or technological literacy work:

I will provide info about #1 below, which I will be involved with, and #2 and #3 which were taught this year for the first time by colleagues. 1. Technology, Society and Culture -- will provide syllabus 2. Designing as if People Mattered – (taught as a Sophomore Research Seminar to non-engineers) http://cs.union.edu/~fernandc/srs200/   3. Impossible Missions Design Teams – (taught as a Sophomore Research Seminar to non-engineers) -- will provide syllabus

John Krupczak
Course 1

Course Title: Science and Technology of Everyday Life

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	
	The role of society in the development and use of technology	✓
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	✓
	Construction technologies	

John Krupczak
Course 1

Course description:
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.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
Laboratories: Automobile Engine - Disassemble/Reassemble Basic Electricity Wiring a Lamp Basic Magnetism and Electromagnetism Building an Electric Motor Building a Speaker Building a Radio Building an Amplifier Making a Pinhole Camera Building a one-octave musical keyboard Telephone - Disassemble/Reassemble Computer - Disassemble/Reassemble Paper Assignments Investigating a Problem with Your Car. Savvy Consumer Analyzing an Appliance to Purchase Impacts: Analysis of How a New Technological Device Has Changed Everyday Life

Course website:
http://www.hope.edu/academic/engineering/labs/index.htm

References about your course or technological literacy work:
Krupczak J.J., “Science and Technology of Everyday Life: A course in technology for liberal arts students,” Proceedings of the1996 American Society for Engineering Education Annual Conference (1996) American Society for Engineering Education. <http://www.asee.org/acPapers/01535.pdf>. Krupczak, J.J "Demystifying Technology," American Society for Engineering Education, PRISM, October (1997) 30-34. Krupczak, J.J and C. Green “The Perspective of Non-Engineers on Technological Literacy," Proceedings of the1999 American Society for Engineering Education Annual Conference (1999) American Society for Engineering Education. <http://www.asee.org/acPapers/99conf409.PDF>. Krupczak, J.J., N. Bair, T.Benson, P.Berke, D.Corlew, K. Lantz, D.Lappenga, M. Scholtens, and D. Woessner, “Hands-on Laboratory Projects for Non-Science Majors: Learning Principles of Physics in the Context of Everyday Technology,” Proceedings of the 2000 American Society for Engineering Education Annual Conference. (2000). American Society for Engineering Education. <http://www.asee.org/acPapers/20276.pdf>. Krupczak, J.J "Reaching Out Across Campus: Engineers as Champions of Technological Literacy,” Liberal Education in 21stCentury Engineering, Worcester Polytechnic Institute Series on Studies in Science, Technology, and Culture, H. Luegengbil, K. Neeley, and D. Ollis, editors, Peter Lang Publishers, New York, (2004). Krupczak, J.J., S. VanderStoep, L. Wessman, N. Makowski, C. Otto, K. Van Dyk, “Work in Progress: Case Study of a Technological Literacy and Non-majors Engineering Course,” Proceeding of the 35th ASEE/IEEE Frontiers in Education Conference, October 19 – 22, 2005, Indianapolis, IN. Frontiers in Education. < http://fie.engrng.pitt.edu/fie2005/papers/1469.pdf>. Krupczak, J.J., D. Ollis, R. Pimmel, R. Seals, G. Pearson, and N. Fortenberry, “The Technological Literacy of Undergraduates: Identifying the

Research Issues," Proceedings of the 35th ASEE/IEEE Frontiers in Education Conference, October 19 – 22, 2005, Indianapolis, IN. <http://fie.engrng.pitt.edu/fie2005/papers/1238.pdf>.
Krupczak, J.J., D. Ollis, "Technological Literacy and Engineering for Non-Engineers: Lessons from Successful Courses," Proceedings of the 2006 American Society for Engineering Education Annual Conference (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11081&pdf=2006Full744.pdf>.

Course Title: EAS107P Intro to Engineering - Project-Based

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	✓

Course description:
Overview of the problems, perspectives, and methods of the engineering profession. Modeling of real-world problems for purposes of optimization, decision-making, and design. Practical techniques of problem formulation and analysis.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
UNIVERSITY OF NEW HAVEN Tagliatela College of Engineering and Applied Science EAS107P ¡V Introduction to Engineering (Project-Based) Spring Semester, 2007 Instructors Required Text Holtzapple, Reece, Foundations of Engineering, 2nd edition, McGraw-Hill, 2003 Course Objectives ƒá Introduce students to the disciplines of engineering. ƒá Develop a foundation of professional skills for future engineering work. ƒá Develop a basic understanding of engineering design from a multi-disciplinary perspective. ƒá Develop a basic understanding of the engineering foundation topics. Course Outcomes By the end of EAS107P, students will have attained measurable skills in the following areas: Professional Skills 1. Demonstrate an understanding of the common and unique attributes of the major engineering disciplines. (Civil, Mechanical, Electrical, Industrial, Chemical and Computer Engineering). 2. Understand and demonstrate the attributes of an effective team member. 3. Be able to communicate technical information with engineering graphics, drawings and written documents. 4. Understand the engineering design process as applied to multi-disciplinary projects. Technical Skills 5. Demonstrate a basic understanding of engineering concepts in the following areas: a. Material Balances: Conservation of mass, power, and energy for simple systems. (ex: fuel cell project) b. Electrical Circuits: Voltage, current, resistance, power relationships. Able to use Ohm¡¦s law and power-energy relations to solve simple problems (robotics-fuel cell). c. Thermodynamics & Fluids: Buoyancy, Energy conservation & conversion. Able to determine the buoyant force for a given geometry and mass. Able to convert units from USC to SI as part of a computation given the conversion factors. d. Mechanics: Resolving forces, Compressive & tensile forces, yield strength, torque, moments. Able to determine reactions and member forces for simply supported 3-7 member trusses. e. Systems: Computer Programming, focus on logic, flow chart style understanding. Able to interpret and organize graphical programming elements for simple task completion. Able to anticipate the consequences of multitasking programs. Able to use Boolean logic based structures in graphical programming. 6. Have a basic understanding of engineering terminology. Able to define the basic terminology related to the engineering pillars and engineering professionalism. Grading (tentative) Students are evaluated based on (a) 4 design projects; (b) individual design notebooks/portfolios; (c) homework, quizzes and (d) class preparedness and participation. It is expected that students attend all classes. The assigned weights for each component of the grade are listed below. Homework/Other Assignments 10% Quizzes and Final exam 30% Project work (reports & presentations) 40% Class Preparedness & Participation 10% Portfolio 10% (required to pass the course) Teams will be assigne

Course website:
Listed on BlackBoard - You need to be enrolled in class or teach the course in order to access course information.

References about your course or technological literacy work:

Nocito-Gobel, J., S. Daniels, M. Collura, and B. Aliane, 2004, ¡§Project-Based Introduction to Engineering ¡V a University Core Course¡¨, Proceedings, 2004 American Society for Engineering Education Annual Conference and Exposition, Salt Lake City, Utah, June 20 ¡V 23.

M. Grant Norton
Course 1

Course Title: MSE 440 Materials: The Foundations of Society and Technology

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	✓
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	✓
	Construction technologies	✓

Course description:
History of materials; role that materials have played in human development; modern societal, technological, and economic impact of materials.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
A new textbook for our course: M. Grant Norton and David F. Bahr, "Materials: The Foundation of Society and Technology" Princeton: Princeton University Press (under contract - final manuscript due Summer 2007)

Course website:
N/A

References about your course or technological literacy work:
M.G. Norton and D.F. Bahr, â€œAn Upper-Division General Education Course on Materials for Non-Engineering Studentsâ€ , Proceedings of the 2002 American Society for Engineering Education Annual Conference & Exposition, MontrÃ©al, Canada (2002). D.F. Bahr and M.G. Norton, â€œIntroducing Upper Division Non-Engineering Students to Materials,â€ Journal of Materials Education 25, 71 (2003) M.G. Norton and D.F. Bahr, â€œA General Education Course on Materials,â€ Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, Utah, (2004). M.G. Norton and D.F. Bahr, â€œA General Education Course in Materials,â€ Journal of Materials Education 28, 239 (2006)

Barbara Oakley
Course 1

<u>*Course Title:*</u> "How Things Work"
(based on Louis Bloomfield's book by that name. Dr. Bloomfield teaches from a physics perspective, emphasizing the principles. I teach it from an engineering perspective--emphasizing engineering design.

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	✓
	Transportation technologies	✓
	Manufacturing technologies	✓
	Construction technologies	✓

Barbara Oakley
Course 1

Course description:
For non-science majors: a practical introduction to engineering and science in everyday life. This course considers objects from our daily environment and focuses on their principles of operation, histories, and relationships to one another.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
1. Syllabus 2. Conference paper, "The Untapped Student Goldmine," that describes some of the different technological literacy courses that have proven successful nationally, (that is, have large enrollments). This paper will be presented at the American Society of Engineering Education Annual Conference in Hawaii in June, 2007.

Course website:
http://www2.oakland.edu/users/oakley/Teachingfiles/ISE%20150/ISE150.htm

References about your course or technological literacy work:
Paper to be presented at the ASEE 2007 Annual Conference as mentioned above.

Sarah Pfatteicher
Course 1

Course Title: History of Technology (survey course)

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Products & Systems	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	✓
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	
	Transportation technologies	✓
	Manufacturing technologies	
	Construction technologies	✓

Sarah Pfatteicher
Course 1

Course description:
It's been 10 years since I taught the course, so details are sketchy, but it was an introductory level overview of the history of technology for undergraduates, most of whom were non-science, non-engineering majors.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
N/A

Course website:
N/A

References about your course or technological literacy work:
N/A

Course Title: ITDPT 204: Energy Processing

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	✓
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Course description:
Examines sources and types of energy and common energy processing techniques. Emphasizes controlling and transmitting energy and the operation of energy conversion systems. Includes laboratory activities.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course website:
Resource list at http://arose.iweb.bsu.edu/BSUCourses/ITDPT204/resources.htm

References about your course or technological literacy work:
Rose, M.A. (2007). Infusing sustainability principles into technology curriculum. Presentation at the International Technology Education Association Annual Conference, March 2007, San Antonio, TX. Rose, M.A. (2006). Perceptions of technological literacy among science, technology, engineering, and mathematics leaders. Paper presented at the 93rd Mississippi Valley Technology Teacher Education Conference, Nashville, TN, November 3, 2006. Rose, M.A. (2006). Emergency preparedness: Balancing electrical supply and demand. The Technology Teacher, 65(8), 6-9. Rose, M.A. (2006). Signals, transducers, and modulation: A wireless design challenge. The Technology Teacher, 65(6), 21-24. Rose, M.A. Griffis, K.*, & Frazier, E.* (2005). Building literacy and efficacy through service-learning. Presentation at the International Technology Education Association Annual Conference, April 4, 2005, Kansas City, KS. Rose, M.A. (2004). Use and consequences: An energy decision. Presentation at the International Technology Education Association Annual Conference, March, 2004, Albuquerque, NM. Rose, M.A. (2002). The productive interactions and perceptions of distributed groups interacting in an asynchronous computer conference. Presentation at the Association for Educational Communications and Technology International Conference, November, 2002, Dallas, TX. Rose, M. A., & Flowers, J. (2002). Problem-based learning in an online course on technology assessment. Presentation at the International Technology Education Association Annual Conference, March, 2002, Columbus, OH.

Mary Annette Rose
Course 2

Course Title: ITEDU 205: Information Processing

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Mary Annette Rose
Course 2

Course description:
Presents the technological processes used in encoding, transmitting, and decoding information. Laboratory experiences introduce many forms of information; the processing of electronic and graphic images or data; and various types of storage systems. Includes laboratory activities.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course website:
http://arose.iweb.bsu.edu/BSUCourses/ITEDU205/resources.htm

References about your course or technological literacy work:

Course Title: ITEDU 510: Technology Use and Assessment

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Mary Annette Rose
Course 3

Course description:
Analyzes the use and assessment of technology. Topics include: decision-making in adopting technologies, design for use, usability testing, user surveying, technology assessment techniques, environmental impact assessment, and forecasting.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course website:
Syllabus: http://arose.iweb.bsu.edu/BSUCourses/ITEDU510/syllabus.htm Resources: http://arose.iweb.bsu.edu/BSUCourses/ITEDU510/resources.htm

References about your course or technological literacy work:

Mary Annette Rose
Course 4

Course Title: ITEDU 305: Communication Systems

Which Tech Tally content and cognitive areas (approximately) were addressed in your course? (Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Course description:
Includes a study of communication processes and systems. Laboratory experiences involve developing, producing, and delivering electronic and graphic media. How this technology is applied and its effect on individuals, society, and the environment is examined. Includes laboratory activities.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course website:
http://arose.iweb.bsu.edu/BSUCourses/ITEDU205/resources.htm

References about your course or technological literacy work:

<u>*Course Title:*</u>

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	✓
	The role of society in the development and use of technology	✓
	The influence of technology on history	✓
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

Mark Sanders
Course 1

Course description:
Course Description The Standards for Technological Literacy (ITEA 2000) organize the field of technology education into 7 major areas: information/communication, energy/power, transportation, manufacturing, construction, agriculture/bio-related, and medical technologies. Information/communication technology content, in turn, may be organized into five subcategories: Graphic Production Systems (Print); Digital Communication Systems (Computing, Networks, etc.); Technical Design Systems (CAD); Audio/Video Systems (Radio/TV); and Optic Systems (Photo Imaging). This course incorporates and integrates elements of each of these five systems of information/communication technology. EDTE 4444: Communication Technology encourages students to apply many of the concepts, processes, tools, and materials used in EDTE 3475 and 3476 in a group problem-solving context. Much of the course focuses on the design and production of a promotional campaign for a non-profit client. Students work in small groups to produce components of this campaign, including a logo design, two-color screen printed T-shirt, promotional hologram, digital audio advertisement, and a digital video advertisement. Students also work individually on logo designs and a Web-based Portfolio. Course Objectives Upon completion of this course, students will be able to: 1. explain various communication systems models and curriculum structures for a communication technology course; 2. use sketching as an effective graphic design tool; 3. apply fundamental design principles in the development of print/media messages; 4. effectively engage in collaborative (group) activities and employ group organizational strategies to optimize group productivity; 5. design and produce the following “deliverables” for a non-profit agency/client: logo/symbol; brochure; digital video ad/PSA; digital audio ad/PSA; 2-color T-shirt; hologram; and Web pages 6. use current tools to research a communication technology and present an overview of said technology to peers using a self-developed Web/PowerPoint/multimedia presentation; 7. develop and present a software demonstration, with a student assignment and handout; 8. update/enhance the Web-based Technology Education Portfolio begun in EDTE 3475 and 3476; 9. describe interactions between information/communication systems and society/culture; and 10. effectively use information/communication technology vocabulary.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
I haven't taught communication technology courses since Fall 2004... so my resources are already dated.

Course website:
NA (see previous comment).

References about your course or technological literacy work:
Note: Because the goal of my field is "technological literacy for all," much of my work is "technological literacy work." I have listed some of that work below. Feel free to omit whatever you feel isn't relevant for the purposes of this survey. Sanders, M. E. (1997-present). Developer/Project Director. GRAPHIC COMM CENTRAL: The Web portal for graphic communication education. Available: http://teched.vt.edu/GCC/ Sanders, M. E. (2006, March). Technology teacher education in the United States. In J. Williams. (Ed.). International technology teacher education. Yearbook #56 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill, 241-270. Sanders, M. E. (2005). Portals for technology education. In W.

Havice (Ed). Distributed learning environments: New challenges and opportunities for technology educators. Yearbook #54 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill, 210-220. Sanders, M. E. , et al. (2004). Ethics and the design and development of technological systems: Information and communication technology. In R. Hill (Ed). Ethics for citizenship in a technological world. Selecting instructional strategies for technology education. Yearbook #53 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill, 87-96. Sanders, M. E. , et al. (2004). Ethics and the study of the designed world: Information and communication technology. In R. Hill (Ed). Ethics for citizenship in a technological world. Selecting instructional strategies for technology education. Yearbook #53 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill, 210-220. Sanders, M. E. (2003). Interdisciplinary approaches to teaching technology education. In K. Helguson & A. Schwaller. (Eds.), Selecting instructional strategies for technology education: Yearbook #52 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill. Sanders, M. E. & Litowitz, L. (2002). The Implications of Standards for Technological Literacy for Teacher Licensure in Technology Education. In J. M. Ritz, W. E. Dugger, & E. N. Israel (Eds.), Standards for Technological Literacy—The role of teacher education: Yearbook #51 of the Council on Technology Teacher Education (pp. 141-164). Peoria, IL: G

Tim Simpson
Course 1

<u>Course Title:</u> Product Dissection

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	
Technology and Society	The cultural, social, economic, and political effects of technology	
	The effects of technology on the environment	
	The role of society in the development and use of technology	
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	
	Transportation technologies	
	Manufacturing technologies	✓
	Construction technologies	

Tim Simpson
Course 1

Course description:

This course examines the way in which products and machines work: their physical operation, the manner in which they are constructed, and the design and societal considerations that determine the difference between success and failure in the marketplace. The primary objectives in this course are to develop a basic aptitude for engineering and engineering design and to develop mental visualization skills by examination of design and manufacture of consumer and industrial products. Heavy emphasis is placed on hands-on laboratory experience and the development of team and communication skills.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Product dissection laboratory exercises; powerpoint slides relating to dissected products; Wiki reports and multimedia technology for dissected products; podcasts of products being dissected.

Course website:

http://www.mne.psu.edu/simpson/courses/me288/

References about your course or technological literacy work:

Learning Engineering by Product Dissection, J. S. Lamancusa, M. Torres, V. Kumar, J. Jorgensen, 1996 ASEE Conference Proceedings, June 23-26, 1996, Washington DC. Product Dissection - A Tool for Benchmarking in the Process of Teaching Design, Jens E. Jorgensen, James Fridley, and John S. Lamancusa, Proceedings of 1996 Frontiers in Education Conference , Salt Lake city, UT, November, 1996. Benchmarking: A Process for Teaching Design, James Fridley, Jens Jorgensen, and John Lamancusa, Proceedings of the Frontiers in Education Conference, Pittsburgh, PA, November 1997.

Lawrence E. Whitman
Course 1

Course Title: Engineering for non-engineers

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	
Design	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	
	The relationship among technologies and the connections between technology and other fields	
Technology and Society	The cultural, social, economic, and political effects of technology	
	The effects of technology on the environment	
	The role of society in the development and use of technology	✓
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	✓
	Construction technologies	

Lawrence E. Whitman
Course 1

Course description:
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.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)
LEGO MINDSTORMS modules (building instructions and powerpoints) Powerpoint presentations

Course website:
http://www.wichita.edu/techlit

References about your course or technological literacy work:

James F. Young
Course 1

<u>Course Title:</u> Introduction to Engineering Design

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?
(Mark each that applies.)

Technology & Society	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Design	Knowledge	
	Capabilities	✓
	Critical Thinking & Decision Making	✓
Products & Systems	Knowledge	✓
	Capabilities	✓
	Critical Thinking & Decision Making	

Which of the 20 ITEA standards do you address in your course to any extent?

The Nature of Technology	The characteristics and scope of technology	✓
	The core concepts of technology	✓
	The relationship among technologies and the connections between technology and other fields	✓
Technology and Society	The cultural, social, economic, and political effects of technology	✓
	The effects of technology on the environment	
	The role of society in the development and use of technology	
	The influence of technology on history	
Abilities for a Technological World	Apply the design process	✓
	Use and maintain technological products and systems	✓
	Assess the impact of products and systems	✓
The Designed World	Medical technologies	
	Agricultural and related biotechnologies	
	Energy and power technologies	
	Information and communication technologies	✓
	Transportation technologies	
	Manufacturing technologies	
	Construction technologies	

James F. Young
Course 1

Course description:

This hands-on course immerses students in an engineering design and problem solving team process that exposes them to the challenges and rewards of practicing engineers. The course targets two groups. First, freshmen and sophomores who are considering an engineering major but who want more information on the principles of engineering design and the profession. Second, non-engineering majors who want to experience and understand the design process that creates the technology that permeates today's economy, society, and political decisions. Teams of three students design, construct, and program a small autonomous robot to engage in a competition at the end of the semester. The course is completely self-contained, assumes no prerequisites, and is intended for all majors.

List of course materials you currently have available that you would consider contributing to a resource collection of curriculum material. (They need not be in final form.)

Course notes; game ideas.

Course website:

http://www.owlnet.rice.edu/legolab

References about your course or technological literacy work:

"Engineering for Everyone," ASEE Prism, December 2004, p22. "The General Education Bridge," Rice University Sallyport magazine, Fall 2003, p 21.

Summary Statistics for Courses

Total number of courses = 22

Which Tech Tally content and cognitive areas (approximately) were addressed in your course?

Area		**Number of courses which address**
Technology & Society	Knowledge	19
	Capabilities	9
	Critical Thinking & Decision Making	12
Design	Knowledge	10
	Capabilities	10
	Critical Thinking & Decision Making	13
Products & Systems	Knowledge	15
	Capabilities	13
	Critical Thinking & Decision Making	9

Which of the 20 ITEA standards do you address in your course to any extent?

Area		**Number of courses which address**
The Nature of Technology	The characteristics and scope of technology	17
	The core concepts of technology	13
	The relationship among technologies and the connections between technology and other fields	17
Technology and Society	The cultural, social, economic, and political effects of technology	17
	The effects of technology on the environment	14
	The role of society in the development and use of technology	15
	The influence of technology on history	13
Abilities for a Technological World	Apply the design process	12
	Use and maintain technological products and systems	12
	Assess the impact of products and systems	14
The Designed World	Medical technologies	8
	Agricultural and related biotechnologies	1
	Energy and power technologies	12
	Information and communication technologies	13
	Transportation technologies	7
	Manufacturing technologies	6
	Construction technologies	5

Summary Statistics for Participants

Total number of responses = 19
Which Tech Tally content and cognitive areas (approximately) were addressed in your course?

Area		**Number of instructors who address**
Technology & Society	Knowledge	14
	Capabilities	5
	Critical Thinking & Decision Making	9
Design	Knowledge	7
	Capabilities	7
	Critical Thinking & Decision Making	8
Products & Systems	Knowledge	11
	Capabilities	9
	Critical Thinking & Decision Making	5

Which of the 20 ITEA standards do you address in your course to any extent?

Area		**Number of instructors who address**
The Nature of Technology	The characteristics and scope of technology	13
	The core concepts of technology	10
	The relationship among technologies and the connections between technology and other fields	14
Technology and Society	The cultural, social, economic, and political effects of technology	12
	The effects of technology on the environment	10
	The role of society in the development and use of technology	10
	The influence of technology on history	10
Abilities for a Technological World	Apply the design process	9
	Use and maintain technological products and systems	10
	Assess the impact of products and systems	10
The Designed World	Medical technologies	7
	Agricultural and related biotechnologies	1
	Energy and power technologies	11
	Information and communication technologies	11
	Transportation technologies	7
	Manufacturing technologies	6
	Construction technologies	5

12. Pre-Workshop Survey Participant Views

Participant Survey Questions:

OBSTACLES: What is your view of the impediments to creating standard technological literacy courses? What are some suggestions for helping to achieve readily transportable technological literacy courses.

NEEDS: Specific types of materials you currently do not have that you think would be most useful.

BRAINSTORMING: Please provide a brief description or list of attributes of the ideal technological literacy course for undergraduates that might serve as a standard model.

PROPOSAL INTERESTS: Specific areas you might be interested in collaborating on CCLI proposals (not a commitment)

OTHER: Any other comments relevant to workshop goals.

Obstacles & Suggestions for Transportable Courses

What are some suggestions for helping to achieve readily transportable technological literacy courses for undergraduates?

James F. Young	Developed modules on specific subjects, at varying levels. Class notes and sources of materials. Examples of projects and activities. Learning objectives and assessment means.
Sarah Pfatteicher	The biggest obstacle on our campus has to do with engineering faculty not feeling they have the freedom or time or incentive to develop courses that would be primarily of service to the rest of campus rather than internally with the College of Engineering. One technique we're beginning to try is to open up selected engineering courses to non-engineers, to encourage more cross-talk between disciplines. For example, we're creating a new engineering ethics sequence of courses, all of which are designed to be part of the engineering curriculum but which will be open to non-engineers as well. We hope this will benefit both groups of students while enabling us to "sell" the courses as serving our home college.
Barbara Oakley	Use Lou Bloomfield's "How Things Work" textbook! The survey we conducted nationally showed that those schools that taught a course using the "How Things Work" textbook had very large enrollments. Technological literacy is easy and fun when it's taught from the perspective of gizmos and devices!
Lawrence E. Whitman	Faculty in other colleges not wanting to accept credit for a "professional" college course.
Mary Annette Rose	Support an online, searchable repository for educational resources.
M. Grant Norton	Need high quality materials that can be readily adopted and adapted by different institutions Need funding source focused on supporting this type of curriculum/course/materials development Need workshops/forums to share approaches and develop effective/best practices
Tim Simpson	Making course materials (PPT slides, handouts, activities, lab assignments, readings, etc.) readily available online, preferably free of charge.
Renee Lerche	Create modularized templates that can be easily tailored
Camille George	Sharing websites between practitioners and encouraging more websites to be created.
Mary Kasarda	Workbooks on existing successful courses including syllabus, course policy, text book references, assignments, and some general guidelines for teaching the course. Also, guidelines for getting institutional support/approval would be helpful.
Marie Dahleh	Make sure that the subjects and texts are broad and not related to very specialized areas
Kurt DeGoede	A larger collection of recommended texts. I have not seen a viable alternative to using Bloomfield's text for my course (our general ed requirements require this course to be a "physics" course). Transfer of insights/experiences/module development between schools with similar courses.

Obstacles & Suggestions for Transportable Courses

What are some suggestions for helping to achieve readily transportable technological literacy courses for undergraduates?

Kate Disney	A set of canonical/fundamental freshman laboratory experiments or activities in Engineering. Textbooks that cover the underlying science while giving good coverage to the engineering and technology.
Jean Nocito-Gobel,	Use a modular format for course content.
John Krupczak	Materials in a modular format from which individual instructors could pick and choose would be helpful. Courses for non-majors generally must meet some type of graduation requirement perhaps some type of blog or discussion group to share experience and advice would be helpful.
Doug Klein	Each course will need a clear statement of expected pre-requisites (if any), and clear and inexpensive “parts list” for hands-on components. Students (and administrators) must acknowledge that technological literacy is an essential component of being generally educated. It seems so obvious to some, but cracking open already ossified curricula is a challenge. I think that promoting "engineering as a liberal art" is a very powerful idea in this day and age.

Needs for Specific Types of Course Materials

What specific types of course materials, which you currently do NOT have, would be most useful to you?

Barbara Oakley	Short movies about engineers and their problems. Some material is available at the National Association of Manufacturers website-- www.Coolstuffbeingmade.com. I'd like to see a wider variety of topics covered. (What they already have, however, is fabulous!)
Lawrence E. Whitman	Instructional materials for modules (like how John Krupzak does the engine lab).
Mary Annette Rose	Interactive tutorials and examples of life cycle analysis, impact identification, impact analysis, and other techniques for technology assessment.
M. Grant Norton	We have all the materials we need for our current course
Tim Simpson	Case studies and lecture materials on reverse engineering in practice and global product development.
Renee Lerche	hands on scenario based
Steve Cutcliffe	I would like to see a good nanotechnology and society text that includes understandable technic as well as serious analysis of the societal implications.
Camille George	Perhaps a text book that one could pick and choose the chapters based on one's expertise.
Mary Kasarda	Examples of course policies, assignments, and insights for getting institutional support/approval.
Marie Dahleh	text book and web materials newspaper articles
Kurt DeGoede	Database of interactive figures, animations, and schematics of systems and their "real-time" operation for use in class. Database of questions/problems/cases at all levels of Bloom's Taxonomy suitable for the types of students taking these courses.
Kate Disney	A reasonable budget would be the most useful, so that the course can be continuously improved. A repository of resources would be helpful to allow sharing of course materials. Resources could be either electronic or physical equipment.
John Krupczak	Tools to help assess knowledge, capabilities, and critical thinking in the context of technological literacy that are somewhat generic would be helpful. Something similar to the physics force concept inventory.
Doug Klein	Modular “case studies” that could be mixed and matched as appropriate; materials suitable for one class period; one week; one lab session; etc. with associated background reading materials. Such modules could be adopted and adapted into existing non-engineering courses so that technology is not relegated to whatever the engineering equivalent of "Rocks for Jocks" is called.

Brainstorming – Ideal Course

Please provide a brief description or list of attributes of the ideal technological literacy course for undergraduates that might serve as a standard model.

James F. Young	I don't see a single course model, but a suggested list of topics and focus areas, with supporting modules at different levels. There is too much variability in situations, goals and student bodies to have a single solution. Also, modules can be incorporated into other courses, even technical courses, to enhance them.
Sarah Pfatteicher	It would focus as much on scientific/engineering thinking as on specific technologies. It would provide experiences that students could use immediately in their non-school lives -- for example, it would give them practice reading and analyzing news articles on scientific concepts or issues, or investigating a technology public policy issue that might be on the ballot. In short, it would help them become more informed and confident citizens.
Barbara Oakley	Teaches students that many of the devices they use without thinking have an extraordinary complexity behind their design, with many considerations they never knew existed. At the same time, shows students that the key ideas behind how those devices work is often easy to understand.
Lawrence E. Whitman	Provides hands-on to keep students interested, but enough theory in an overview to make it general.
Mary Annette Rose	Action-oriented, empowering, robust, interdisciplinary, personally and globally relevant. Addresses the following concepts -Impact analysis -Sustainability principles -Energy efficiency -Responsible Consumerism -Safe Use -Pollution Reduction -Problem-solving, trouble-shooting, engineering
M. Grant Norton	Need to develop critical-thinking and decision-making skills in areas of technology that are of critical importance (i.e., the "Grand Challenges") and in emerging areas (e.g., Nanotechnology) Have wide range of students (different majors) participate Have technological literacy in all parts of the curriculum (freshman through senior) Integrate these courses with the general education curriculum
Tim Simpson	Design and technology in society; engineering in a global environment; global product realization
Steve Cutcliffe	A standard model should have both a basic understanding of technology as a field of endeavor but one that grounds it in the societal context at the same time. The two cannot be divorced in my mind.
Camille George	A technology literacy course should address basic engineering principles, have some design exercises, have a hands-on component, relate to societal issues, and have a historical context.
Mary Kasarda	I think hands-on assignments that empower students are critical. Also, assignments that relate to every day life to get students to think critically about technology in their actual lives.
Marie Dahleh	Connected to the real world (current events) combines some tech information and some policy, law, societal impacts

Brainstorming – Ideal Course

Please provide a brief description or list of attributes of the ideal technological literacy course for undergraduates that might serve as a standard model.

Kurt DeGoede	It seems it would be difficult to fully address the 20 standards (although I have trouble saying any are not important). For my institution, the course must fit under the guidelines of Physical and Natural Sciences. I would want to establish a sound conceptual understanding of the physical principles behind the technology. Then convince them they can understand and contribute to any discussion of a technological issue. I also strongly believe in using open ended design problems to (1) serve as a vehicle for understanding the fundamental concepts being taught (2) teaching student how to break down and iteratively solve complex problems, regardless of the context, and (3) convince the students they can figure out how a device works, think about what would make a device better. My students come into the course afraid of and uninterested in "Physics". They also do not know how to solve open ended problems. I want the course to teach the students: (1) some fundamentals of mechanics and electronics, (2) how those fundamentals cam be applied to understanding a wide range of technologies, (3) to use "engineering problem solving" and think a little like an engineer. This should be done in the context of societal and environmental impact.
Kate Disney	After completing the ideal Tech Lit course, students would feel confident enough to conduct their own research and make their own findings on new technologies. Students would have sufficient background in basic science to distinguish facts and theories from propaganda and fallacies. The students would be able to explain "how" and "why" everyday technology functions. The course would also cover some history, politics, as well as environmental and social issues. The course would be memorable because every lecture/lab would have some hands-on component. The ideal course would be developmentally appropriate such that both the typical college freshman and the student with MESA experience would feel challenged. Lastly the ideal course should be something that the majority of teachers can teach.
Jean Nocito-Gobel,	- Has a modular format. - Uses hands-on activities/projects.
John Krupczak	Introduction to Modern Technology. This would be a survey course on technology similar to broad-based survey courses in other fields such as Art, Music, or History. The course would be open to all students. The emphasis of the course would be on major themes and ways of knowing specific to engineering and technology.
Doug Klein	Promoting conversation/collaboration between engineers and non-engineers. See below. With regard to the 20 ITEA standards, I would say any one or two of the last list would be fine; does not matter which one(s).

Ideal Course – Based on Tech Tally

Which Tech Tally areas would be addressed in this ideal course?

Area		**Number who would address**
Technology & Society	Knowledge	14
	Capabilities	9
	Critical Thinking & Decision Making	16
Design	Knowledge	10
	Capabilities	11
	Critical Thinking & Decision Making	13
Products & Systems	Knowledge	16
	Capabilities	10
	Critical Thinking & Decision Making	10
Characteristics, Core Concepts & Connections	Knowledge	12
	Capabilities	12
	Critical Thinking & Decision Making	12

Ideal Course – Based on ITEA Standards

Which of the 20 ITEA standards would you address in your course to any extent?

Area		**Number who would address**
The Nature of Technology	The characteristics and scope of technology	15
	The core concepts of technology	17
	The relationship among technologies and the connections between technology and other fields	18
Technology and Society	The cultural, social, economic, and political effects of technology	17
	The effects of technology on the environment	16
	The role of society in the development and use of technology	14
	The influence of technology on history	9
Abilities for a Technological World	Apply the design process	13
	Use and maintain technological products and systems	10
	Assess the impact of products and systems	16
The Designed World	Medical technologies	9
	Agricultural and related biotechnologies	9
	Energy and power technologies	14
	Information and communication technologies	11
	Transportation technologies	9
	Manufacturing technologies	10
	Construction technologies	8

Proposal Interests

What specific areas might you be interested in collaborating on NSF CCLI proposals? (This is not a commitment.)

Ron Miller	Assessment/evaluation of new course models.
James F. Young	Design, engineering failure, professional ethics.
Sarah Pfatteicher	I'm a historian who teaches ethics and design in an engineering college, so my specialty is in collaborating and translating across disciplinary boundaries. Not sure how that would fit into a specific CCLI proposal, but am interested in exploring possibilities with folks.
Barbara Oakley	Programs involving the encouragement of technological literacy "gen ed" outreach courses provided to general student communities from Schools of Engineering. Why should the sciences and humanities get all the fun--and students--in teaching outreach courses? :)
Lawrence E. Whitman	Design for non-designers. Societal impacts of engineering
Mark Sanders	Assessment/evaluation of new course models.
Mary Annette Rose	Collaborative, distributed models for enhancing technological literacy especially as it relates to curriculum which addresses energy, technology assessment, and hazards/risks/toxics.
M. Grant Norton	Assessing current technological literacy of non-STEM undergraduates -- maybe a multi-institutional approach using a series of standard questions Developing modules/course materials on materials/energy/nanotechnology that might form part of a multi-institution approach involving all aspects of engineering and technology -- possibly web-based modules
Tim Simpson	Product dissection/reverse engineering; global product design, development, manufacturing, and outsourcing.
Camille George	Assessing student learning, examining how engineering stereotypes can be changed. Creating engaging modules.
Mary Kasarda	To expand our work with engineering students and FIRST robotics teams. Also, work to develop tech lit courses for liberal arts majors with significant design components.
Marie Dahleh	technology and policy
Kurt DeGoede	I do not know at this point.
Kate Disney	Developing a system that enables teachers to get course material and equipment. Creating a set of fundamental engineering labs appropriate for college freshmen.
Jean Nocito-Gobel,	Assessment of technological literacy courses
John Krupczak	I would be interested in contributing to work on developing or testing assessment methods specific to the non-engineering audience. I would also be interested in providing materials to other people or serving as a test site for other people's materials.

Proposal Interests

What specific areas might you be interested in collaborating on NSF CCLI proposals? (This is not a commitment.)

Doug Klein	Opportunities to develop mid- to upper-level courses/projects/research opportunities that would involve interdisciplinary teams of engineers and non-engineers, both in specific design projects (including the process of identifying social needs, and of successfully implementing new design ideas – I hesitate to use the phrase "bring new design ideas to the market" because design projects need not be market-oriented), and in the assessment of technology on society. I think that what is needed even more than a rudimentary technological literacy on the part of non-engineers is the ability for engineers and non-engineers to communicate with one another. In the process of such communication activities each will become more literate in the world of the other.

Other Comments

Do you have any other suggestions or comments relevant to the goal of developing standardized technological literacy courses for undergraduates?

James F. Young	Need a flexible framework with options.
Sarah Pfatteicher	As I think I noted last year, many of our engineering students are not technologically literate (by the ITEA standards listed above, for example), so I would not assume that tech lit courses are necessarily just for non-science/engineering types.
Barbara Oakley	Yes, talk to the engineering accreditation (ABET) folks. Ask them if there is a way they can make having successful technological outreach courses (that is, gen ed courses) from schools of engineering be part of what schools of engineering are graded on for accreditation purposes. ABET could also help standardize such courses.
Lawrence E. Whitman	We really need to address the obstacles from Liberal Arts faculty at traditional universities. If the course is not toward someone's degree, then it is difficult to get enrollment.
Mary Annette Rose	Diversity breeds innovation.
Tim Simpson	Publicize availability of course materials.
Renee Lerche	I would like to see such courses developed that can be modified for secondary school usage
Mary Kasarda	Some strategies for getting institutional support/approval for this type of course.
Kate Disney	1. Get input from instructors of many disciplines. 2. There needs to be both standards and some outlines for course content. 3. We need to determine what is developmentally appropriate at the college level given that so many students have MESA experience at the K-12 levels.
Doug Klein	See above; I think that these standardized courses are just one part of a larger problem. Perhaps they could be a pre-requisite for participation in one of the team-based courses or design projects described above.

13. Bibliography and Reference Information

This is a compilation of publications on technological literacy of undergraduates and courses about engineering topics for non-engineering students appearing in the engineering education literature over approximately the last ten years. An effort was made to make this a comprehensive list however, as working document; there is the possibility that some articles have been missed.

Ames, O., A Program for Technological Literacy in the Liberal Arts, *Journal of College Science Teaching*, March/April. 286-288, (1994).

Baish, J.W., and T.P. Rich, "Design as a Liberal Art," *Proceedings of the 2001 American Society for Engineering Education Annual Conference* (2001). American Society for Engineering Education. <http://www.asee.org/acPapers/00208_2001.PDF>.

Balmer, R.T., "Converging Technologies: The New Frontier in Engineering Education, *Proceedings of the 2002 American Society for Engineering Education Annual Conference* (2002). American Society for Engineering Education. <http://www.asee.org/acPapers/2002-777_Final.pdf>.

Billington D., *The Innovators: The Engineering Pioneers Who Made America Modern*," Wiley (1996).

Bloomfield, L., *How Things Work: The Physics of Everyday Life, 2nd Edition* (Wiley, New York, 2001).

Bloomfield, L., Explaining the Physics of Everyday Life. University of Virginia. <http://howthingswork.virginia.edu/>

Brereton, M., S. Sheppard, L. Leifer, "Students Connecting Engineering Fundamentals and Hardware Design: Observations and Implications for the Design of Curriculum and Assessment Methods," *The 25th ASEE/IEEE Frontiers in Education Conference*, 1995, Atlanta, GA. Frontiers in Education. < http://fie.engrng.pitt.edu/fie95/4d3/4d31/4d31.htm >.

Brown, A., and D. Ollis, "Team Teaching: A Freshman Engineering Rhetoric and Laboratory," *Proceedings of the 1996 American Society for Engineering Education Annual Conference* (1996). American Society for Engineering Education. <http://www.asee.org/acPapers/01597.pdf>.

Byars, N.A., "Technology Literacy Classes: The State of the Art", *Journal of Engineering Education*, Jan, (1998), pp. 53-61. <http://www.asee.org/publications/jee/PAPERS/display.cfm?pdf=536.pdf>

Carlson, W. Bernard, "Technological Literacy And Empowerment: Exemplars From The History Of Technology," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11088&pdf=2006Full1182.pdf>.

Converging Technologies at Union College, Union College, <http://www.union.edu/CT>.

Daniels, S., M. Collura, B. Aliane, J. Nocito-Gobel, "Project-Based Introduction to Engineering – Course Assessment, *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-1969_Final.pdf>.

DeGoede, K., "Synthesizing Liberal Arts Physics," *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-1542_Final.pdf>.

Disney, Katy, Vitkovits, S, Pam, R., "Designing a Portable Technical Literacy Course for Use in California," *The 25th ASEE/IEEE Frontiers in Education Conference*, 1995, Atlanta, GA. Frontiers in Education. <http://fie.engrng.pitt.edu/fie95/4a6/4a62/4a62.htm>.

Disney, K. and K. Kawamoto, Engineering 3: How Everyday Technology Works, Mission College, Santa Clara, CA http://salsa.missioncollege.org/kawamoto.

Drake, R. L., "Society and Technology for Non-Engineering Majors, "*Proceedings of the1996 American Society for Engineering Education Annual Conference* (1996) American Society for Engineering Education. < http://www.asee.org/acPapers/code/getPaper.cfm?paperID=303&pdf=01545.pdf>

Ettouney, O., "A New Model for Integrating Engineering Into the Liberal Education of Non-Engineering Undergraduate Students," *Journal of Engineering Education*, October, (1994) http://www.asee.org/publications/jee/PAPERS/display.cfm?pdf=448.pdf

Garmire, Elsa, and Greg Pearson, editors, *Tech Tally: Approaches to Assessing Technological Literacy*, Committee on Assessing Technological Literacy in the United States, National Academy of Engineering, National Academy Press (2006).

George, C., "Fuel Cells and Discovery-Oriented Teaching," *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-1861_Final.pdf>.

George, C., E. Amel, K. Mueller, "A Solar-Powered Decorative Water Fountain Hands-On Build To Expose Engineering Concepts To Non-Majors," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11193&pdf=2006Full655.pdf>.

Hammack, W., Bill Hammack's Engineering and Life. http://www.engineerguy.com/

Hanford, Bethany, "Engineering for Everyone," American Society for Engineering Education, *PRISM*, December 2004. American Society for Engineering Education. < http://www.prism-magazine.org/dec04/feature_engineering.cfm>

International Technology Education Association. *Standards for Technological Literacy*, International Technology Education Association, Reston, VA (2000). <http://www.iteaconnect.org/TAA/Publications/TAA_Publications.html>.

Kasarda, Mary, "The Last Word: Paper or Plastic?...Why all students must become more technologically literate." American Society for Engineering Education, *PRISM*, October 2004. American Society for Engineering Education. <http://www.prism-magazine.org/oct04/last_word.htm>

Kennedy, Ana, Ollis, David Ollis, David , Rebecca Brent, "Cross-College Collaboration to Enhance Spanish Instruction and Learning." Proceedings of the 2005 American Society for Engineering Education Annual Conference (2005). American Society for Engineering Education. <http://www.asee.org/acPapers/2005-1301_Final.pdf>.

Kim, Ernest M, "A Engineering Course Which Fulfills a Non-Major General Physical Science Requirement," *Proceedings of the1999 American Society for Engineering Education Annual Conference* (1999) American Society for Engineering Education. <http://www.asee.org/acPapers/99conf181.PDF >.

Kim, Tae Yu; Lee, Byung Gee; Lee, Ki-Jun; Yoo, Young Je, “Understanding Engineering and Technology for Liberal Education,” *Proceedings of the1997 American Society for Engineering Education Annual Conference* (1997) American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=771&pdf=01081.pdf>

Klein, D., and R. Balmer, “Liberal Arts and Technological Literacy,” *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006) American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11082&pdf=2006Full912.pdf>.

Korzeniowksi, K.A. and D. Mechtel, “Teaching Engineering to Non-Electrical Engineering Majors,” *Proceedings of the 1998 American Society for Engineering Education Annual Conference* (1998). American Society for Engineering Education. <http://www.asee.org/acPapers/00552.pdf>.

Krupczak J.J., “Science and Technology of Everyday Life: A course in technology for liberal arts students,” *Proceedings of the1996 American Society for Engineering Education Annual Conference* (1996) American Society for Engineering Education. <http://www.asee.org/acPapers/01535.pdf>.

Krupczak, J.J "Demystifying Technology," American Society for Engineering Education, *PRISM*, October (1997) 30-34.

Krupczak, J.J and C. Green “The Perspective of Non-Engineers on Technological Literacy," *Proceedings of the1999 American Society for Engineering Education Annual Conference* (1999) American Society for Engineering Education. <http://www.asee.org/acPapers/99conf409.PDF>.

Krupczak, J.J., N. Bair, T.Benson, P.Berke, D.Corlew, K. Lantz, D.Lappenga, M. Scholtens, and D. Woessner, “Hands-on Laboratory Projects for Non-Science Majors: Learning Principles of Physics in the Context of Everyday Technology,” *Proceedings of the 2000 American Society for Engineering Education Annual Conference. (2000).* American Society for Engineering Education. <http://www.asee.org/acPapers/20276.pdf>.

Krupczak, J.J "Reaching Out Across Campus: Engineers as Champions of Technological Literacy,” *Liberal Education in 21st Century Engineering*, Worcester Polytechnic Institute Series on Studies in Science, Technology, and Culture, H. Luegengbil, K. Neeley, and D. Ollis, editors, Peter Lang Publishers, New York, (2004).

Krupczak, J.J., S. VanderStoep, L. Wessman, N. Makowski, C. Otto, K. Van Dyk, “Work in Progress: Case Study of a Technological Literacy and Non-majors Engineering Course,” *Proceeding of the 35th ASEE/IEEE Frontiers in Education Conference*, October 19 – 22, 2005, Indianapolis, IN. Frontiers in Education. < http://fie.engrng.pitt.edu/fie2005/papers/1469.pdf>.

Krupczak, J.J., D. Ollis, R. Pimmel, R. Seals, G. Pearson, and N. Fortenberry, “The Technological Literacy of Undergraduates: Identifying the Research Issues,” *Proceedings of the 35th ASEE/IEEE Frontiers in Education Conference*, October 19 – 22, 2005, Indianapolis, IN. <http://fie.engrng.pitt.edu/fie2005/papers/1238.pdf>.

Krupczak, J.J., D. Ollis, “The Technological Literacy of Undergraduates: Identifying the Research Issues,” A Workshop Sponsored by the National Science Foundation, (2005). <http://faculty.hope.edu/krupczak/Technological_Literacy_Report.pdf>

Krupczak, J.J., D. Ollis, “Technological Literacy and Engineering for Non-Engineers: Lessons from Successful Courses,” *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11081&pdf=2006Full744.pdf>.

Kuc, R.," Teaching the non-science major: EE101 - The most popular course at Yale." *Proceedings of the 1997 American Society for Engineering Education Annual Conference* (1997). American Society for Engineering Education. <http://www.asee.org/acPapers/01056.pdf>.

Kuc, R, "Teaching the Non-science Major: EE 101-The Digital Information Age," *IEEE Transactions on Education*, **44**(2), 158-164 (2001).

Lienhard, J.H, The Engines of Our Ingenuity, www.uh.edu/engines .

Lienhard, J.H, *The Engines of Our Ingenuity: An Engineer Looks at Technology and Culture*, Oxford University Press (2001).

Lienhard, J.H, *Inventing Modern: Growing up with X-Rays, Skyscrapers, and Tailfins*, Oxford University Press. (2003).

Mahajan, A. and D.McDonald, "Engineering and Technology Experience for Liberal Arts Students at Lake Superior State University," *Proceedings of the1996 American Society for Engineering Education Annual Conference* (1996) American Society for Engineering Education. <http://www.asee.org/acPapers/01280.pdf >.

Mikic, Borjana and Susan Voss, "Engineering For Everyone: Charging Students With The Task Of Designing Creative Solutions To The Problem Of Technology Literacy," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11191&pdf=2006Full575.pdf >

Neeley, Kathryn, "From "How Stuff Works" to "How STUFF Works": A Systems Approach to The Relationship Of STS and "Technological Literacy"." *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11079&pdf=2006Full426.pdf>.

Nocito-Gobel J., S. Daniels, M. Collura, B. Aliane, "Project-Based Introduction to Engineering – A University Core Course," *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. < http://www.asee.org/acPapers/2004-907_Final.pdf>.

Norton, M.G., and D. Bahr, "Student Response to a General Education Course on Materials, *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-873_Final.pdf>.

Norton, M.G., and D. Bahr, "An Upper Division Course on Materials for Non-Engineering Students, *Proceedings of the 2002 American Society for Engineering Education Annual Conference* (2002). available: http://www.asee.org/acPapers/2002-2356_Final.pdf

Oakley, B., L. Smith, Y. Chang, "The Untapped Student Goldmine," *Proceedings of the 2007 American Society for Engineering Education Annual Conference* (2007). preprint

Ohland, Matthew, "First-Year Engineering Programs and Technological Literacy," *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11200&pdf=2006Full1282.pdf>.

Ollis, David, and David Kondratowicz, "Device Dissection for Eleven Hundred Engineering Students," SUCCEED Southeastern University and College Coalition for Engineering Educations (1999) <http://www.succeed.ufl.edu/papers/DDEleven.pdf>

Ollis, David, “A Lab for All Seasons, A Lab for All Reasons.” *Proceedings of the 2000 American Society for Engineering Education Annual Conference. (2000).* American Society for Engineering Education. <http://www.asee.org/acPapers/20381.pdf>

Ollis, David, “Installing A New "Technology Literacy" Course: Trials and Tribulations, *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-441_Final.pdf>.

Ollis, David, Ana Kennedy, Bryan Laffitte, Rebecca Brent, “Cross-College Collaboration of Engineering with Languages, Education, and Design.” *Proceedings of the 2005 American Society for Engineering Education Annual Conference* (2005). American Society for Engineering Education. <http://www.asee.org/acPapers/2005-1308_Final.pdf>

Ollis, David., “Technology Literacy: Connecting through Context, Content, and Contraption,” *Proceedings of the 2005 American Society for Engineering Education Annual Conference* (2005). American Society for Engineering Education. < http://www.asee.org/acPapers/2005-1313_Final.pdf >.

Ollis, David, “Cross-College Collaboration Of Engineering With Industrial Design.” *Proceedings of the 2005 American Society for Engineering Education Annual Conference* (2005). American Society for Engineering Education. <http://www.asee.org/acPapers/2005-2191_Final.pdf >.

Ollis, David and J.J. Krupczak, “Teaching Technology Literacy: An Opportunity For Design Faculty?” *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11197&pdf=2006Full620.pdf>.

Ollis, D., and J.J. Krupczak, “Teaching Technology Literacy: An Opportunity for Design Faculty,” *International Journal of Engineering Education*, vol. 22, no. 3 (2006) 665-670.

Ollis, David, Teaching Technological Literacy As A Quest, Or "Searching For Self In The Engineering Cosmos." *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. http://www.asee.org/acPapers/code/getPaper.cfm?paperID=10896&pdf=2006Full647.pdf

Ollis, David, and G. Pearson, “What Is Technological Literacy And Why Does It Matter?” *Proceedings of the 2006 American Society for Engineering Education Annual Conference* (2006). American Society for Engineering Education. < http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11080&pdf=2006Full695.pdf >.

Orr, J.A., D. Cyganski, R. Vaz, “A Course in Information Engineering Across the Professions,” *The 26th ASEE/IEEE Frontiers in Education Conference*, 1996, Salt Lake City, UT. Frontiers in Education. <http://fie.engrng.pitt.edu/fie96/papers/122.pdf>

Orr, J.A., D. Cyganski, R. Vaz, “Teaching Information Engineering to Everyone,” *Proceedings of the 1997 American Society for Engineering Education Annual Conference* (1997). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=823&pdf=01050.pdf>.

Pearson, G., and A.T.Young, editors, *Technically Speaking: Why all Americans Need to Know More About Technology*. Washington, D.C. National Academy Press, (2002).

Pearson, G., J.J. Krupczak, D. Ollis, “Assessing Technological Literacy in the United States,” *Proceedings of the American Society for Engineering Education Annual Conference*, June 18-21, 2006, Chicago, IL. American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=11194&pdf=2006Full701.pdf>

Pisupati, S. Jonathan P. Mathews and Alan W. Scaroni, "Energy Conservation Education for Non-Engineering Students: Effectiveness of Active Learning Components," *Proceedings of the 2003 American Society for Engineering Education Annual Conference* (2003). American Society for Engineering Education. <http://www.asee.org/acPapers/code/getPaper.cfm?paperID=6240&pdf=2003-2358_Final.pdf>.

Rosa A.J., P.K. Predecki, and G. Edwards, "Technology 21 – A Course on Technology for Non-Technologists," *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). American Society for Engineering Education. <http://www.asee.org/acPapers/2004-604_Final.pdf>

Rose, Mary Annette, "Perceptions of Technological Literacy Among the Science, Technology, Engineering, and Mathematics Leaders," Mississippi Valley Technology Teacher Education Conference 93rd Conference, Nashville, TN (2006).

Sarfaraz, A.R., and T.A. Shraibati, "Responding to the Expectations of Non-Technical Students," *Proceedings of the 2004 American Society for Engineering Education Annual Conference* (2004). < http://www.asee.org/acPapers/2004-1387_Final.pdf>.

Sheppard, S., "Mechanical Dissection: An Experience in How Things Work," Proceedings of the Engineering Education Curriculum Innovation & Integration Conference, Jan 6-10, 1992, Santa Barbara, CA. Stanford University. < http://www-cdr.stanford.edu/images/Dissection/dissphil.pdf >.

Sheppard, S., "Mechanical Dissection Course (ME99): Students Projects," Stanford University. (1993) <http://bits.me.berkeley.edu/cw/00/01/38/1/ME99Projects.sea.hqx>.

Steen, Lynn Arthur, "The New Liberal Arts Program: Alfred P. Sloan Foundation, 1980-1992." St. Olaf College, 1520 St. Olaf Avenue, Northfield, Minnesota. (1999) <http://www.stolaf.edu/other/ql/nla.html >

Walsh, D., A. Demmons, D. Gibbs, "It's a Material World: An Engineering Experience for Non-Engineers," *Proceedings of the 1998 American Society for Engineering Education Annual Conference* (1998). American Society for Engineering Education. <http://www.asee.org/acPapers/00348.pdf>.

Wankat, P., Frank Oreovicz, "Teaching: A Nation of Techies," American Society for Engineering Education, *PRISM*, October 2004. American Society for Engineering Education. <http://www.prism-magazine.org/mar06/tt_04.cfm>.

Weiss, P.T, and D. J. Weiss, "Hands-on Projects to Engage Non-engineering Students," *Proceedings of the 2001 American Society for Engineering Education Annual Conference* (2001). American Society for Engineering Education. < http://www.asee.org/acPapers/00454_2001.PDF >.

Whitman, L., Robotics in the Classroom: Shocker Mindstorms, Wichita State University http://education.wichita.edu/mindstorms/.

Young, T.A., J. R. Cole, D. Denton, "Improving Technological Literacy," *Issues in Science and Technology*, Summer (2002). < http://www.issues.org/18.4/young.htm >

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