AC 2008-1732: TECHNOLOGY IN CONTEXT: INTEGRATING TECHNOLOGICAL "LITERACY" WITH SCIENCE REQUIREMENTS FOR NON-MAJORS

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Technology in Context: Integrating Technological "Literacy"[1] with Science Requirements for Non-Majors

Introduction

Although the technological "literacy" (TL) movement has been under way since the 1980s, it was only in the late 1990s that TL became a priority for the National Academy of Engineering (NAE). The NAE's involvement lends prestige to technological literacy efforts. More importantly, the NAE has been able to engage an impressive group of scholars and practitioners who possess the broad range of perspectives required to (1) understand why technological literacy is important, (2) define the traits a technologically literate person possesses, and (3) outline the key steps that various stakeholders can take to promote technological literacy at all levels of our system of formal education and in informal educational settings as well. In March of 2007, the National Science Foundation (NSF) sponsored and the NAE hosted a workshop aimed at developing successful models for technological literacy courses at the college level. The approach advocated in this paper arose in one of the breakout groups at that workshop.

The name "Technology in Context" captures the central idea behind the approach: courses that combine specific engineering or scientific knowledge with an understanding of the historical, social, and ethical context in which the technology is arises and is implemented. Three key features define the approach:

1. Start with existing courses and modify them so that they explicitly pursue TL outcomes and help students develop TL traits. *This aspect leverages existing faculty expertise and interests and requires less faculty investment than new courses.*

2. Design these courses so that they justify dual credit as both humanities and social science courses and as science for non-majors (SNM) courses. *This feature integrates courses that promote TL into the existing requirements structure of most colleges and universities without creating a new and separate TL requirement; it would make TL courses attractive to a broader range of students.*

3. Recruit and train interdisciplinary faculty teams with the complementary expertise necessary to qualify the course as both an HSS and an SNM course. *This feature helps*

[1] "Technological literacy" is the conventional terminology used to denote the capacity to think critically about and make well considered decisions about technology. The word "literacy" is put in quotation marks here because it is strongly associated with the basic ability to read and write and is not accurately use to describe the complex set of traits, knowledge, ways of thinking and acting, and capabilities defined in the various NAE publications and elsewhere. The word "literacy" is put in quotation marks here because it is strongly associated with the basic ability to read and write, rather than with sophisticated skills.

the individuals who are interested in interdisciplinary work to identify each other and supports them through the process of developing a successful collaboration.

Motivation and Inspiration as Central Issues

Although *Technically Speaking* (2002) and many other publications excel at making the case for TL in terms of its importance for democracy, citizenship, and the general welfare of society, they say little that would inspire most faculty to create courses that achieve TL outcomes. These publications are directed more to administrators and policy-makers than they are to faculty or students. Thus, they do little or nothing to motivate students to incorporate one or more TL courses into a curriculum that often seems over-filled with requirements already. Integrating TL courses into the existing system of requirements should contribute significantly to solving the student motivation problem. Inspiring faculty will require connecting TL to existing faculty interests and approaching the design of the new courses in a way that makes them seem do-able, an incremental but meaningful extension of what they are already doing.

The approach that we propose would draw on the impressive body of scholarly work that has already been done to help us understand the connection between technology and its contexts. It would also make use of courses designed for purposes other than developing TL that could readily be modified to serve TL goals.

Although our approach resembles that of the Alfred P. Sloan Foundation's New Liberal Arts Program (1980-1992), it builds on what was learned through that effort by recognizing that "Innovative courses are not easily transportable or transferable. When new faculty are asked to take on these courses, they are more likely to create their own than to pick up on the course created by the pioneers" (Steen, 1999, p. 5). Instead of seeking to create a series of courses designed to be exported to other faculty institutions, our approach focuses on enhancing substantive interdisciplinary interaction among faculty and tapping into faculty professional and scholarly interests—areas in which the New Liberal Arts projects often succeeded (Steen, 1999, p. 5).

Specifying the Knowledge and Abilities Required to Achieve TL Outcomes

Thinking about course designs requires specifying the things that a person who has completed the course successfully will know or be able to do. The traits identified in *Technically Speaking* seem unlikely to elicit opposition or objection, but they are also so generic that they do not clearly relate to particular academic disciplines. To overcome this difficulty, we began by fleshing out the list of "knowledge" characteristics of a technologically literate person that appears on p. 4 of *Technically Speaking*. We did this by translating the characteristics into the terms that would ordinarily be used in the HSS, especially the field of Science, Technology, and Society (STS). This strategy is based on the recognition that engaging STS faculty is critical to actually achieving the broad goals for TL articulated by NAE.

Some of the outcomes we list below also indicate the presence of "ways of thinking and acting." The statements in bold come from *Technically Speaking*. The material in the bullet points that appear after the numbered items was developed by our group.

1. **Recognizes the pervasiveness of technology in everyday life.**
    - Analyzes the social dimensions of a particular sociotechnical system (that is, recognizes that technology is more than just artifacts) and articulates the specific ways in which that system reflects choices.
    - Describes the various sociotechnical systems in which his/her life is embedded.
2. **Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.**
    - Defines and gives examples of sociotechnical systems
    - Contrasts sociotechnical systems thinking with at least one other way of thinking about technology.
3. **Is familiar with the nature and limitations of the engineering design process.**
    - Describes the ways that organizational and cultural constraints shape engineering design.
    - Describes the non-scientific ways in which engineers compensate for lack of certain knowledge.
    - Selects the appropriate way to analyze a sociotechnical system.
4. **Knows some of the ways technology shapes human history and people shape technology.**
    - Discusses specific ways in which individuals and groups influence technology and make meaningful choices about technology (that is, shows an understanding of the limits of technological determinism).
    - Articulates the social and cultural values embodied in a particular artifact or sociotechnical system and describes the ways that artifact or system both facilitates and constrains human activity.
5. **Knows that all technologies entail risk, some that can be anticipated and some that cannot.**

- Describes the ways that engineers conceptualize, communicate, and manage risk and contrasts those with the ways non-experts conceptualize, manage, and judge the acceptability of risk.

- Describes the ways in which unanticipated consequences emerge in sociotechnical systems.

6. **Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits.**

    - Enumerates specific trade-offs in the development and use of particular new technology; compares and contrasts its costs and benefits, especially compared with other alternatives.

    - Describes the ways that the level of technology possessed by a particular group affects and is affected by resource allocation, availability of goods and services to society in general.

    - Describes the ways that technology can create or eliminate social, political, environmental, or economic inequities.

7. **Understands that technology reflects the values and culture of society.**

    - Identifies and describes the key features of sociotechnical systems and identifies the choices and resources that went into them

    - Analyzes a particular discourse on technology (such as the Unabomber's manifestoes or a newspaper editorial) by (a) identifying the values being advocated and questioned in that discourse and (b) identifying the alternative positions to the one being offered in the discourse.

Although the bullet points listed above would likely be immediately meaningful to audiences trained in STS, concrete examples would be required to make these outcomes to clear to non-STS audiences. For example, audiences with a background in English or communication might articulate the aims in this area as "the ability and willingness to engage in technologically literate discourse." It would probably also be necessary to distinguish contemplative vs. action-oriented STS. Taken as a group, these outcomes focus on process rather than answers, and they seem to require multidisciplinary, team-based teaching. They could be fruitfully developed through the technological literacy equivalent of Harvard Business School Cases, where a key to success would be illuminating the multidimensionality of the case in question. Such cases would be a resource in course design but should leave room for the creativity of the faculty who would actually teach a particular course.

A Proposal to Leverage and Develop Faculty Expertise

The model and approach address two opportunities that grow out of existing problems:

1. Science requirements for non-majors, which can be legitimately viewed as an attempt to promote technological literacy (TL), have not been successful in many contexts from both the student and faculty points of view. To the extent that these requirements are still in place at colleges and universities, they provide the potential for integrating TL courses into the structure of requirements in college curricula.

2. Technological literacy courses also seem relevant to solving the problem usually referred to as bridging the "two cultures" of the humanities and social sciences (HSS) and science, technology, engineering, and mathematics (STEM).The disciplinary and curricular structures of universities contribute substantially to the gap between the HSS and STEM disciplines. Real team teaching (as opposed to "tag team" teaching) and truly collaborative course design involving HSS and STEM faculty have the potential to expand faculty expertise and transform faculty perspectives in ways that are sustainable outside of the team teaching/course design context and both benefit students and influence the future teaching and research of the faculty in question.

We propose to develop a system for recruiting and training interdisciplinary faculty teams to teach courses that would help students understand technology in context and help develop technological literacy among undergraduates. The system we develop would guide and sustain the teams through the process of designing and implementing an interdisciplinary course in the general area of "technology in context." These courses would be designed to (1) draw on the disciplinary expertise of the team members and (2) justify dual credit as both HSS and science for non-majors (SNM) courses.

We envision three broad categories of courses:

1.) HSS/STS courses with relevant STEM content added
2.) STEM courses with relevant HSS/STS content added
3.) New interdisciplinary courses

Examples of possible course topics include:

Technology and Democracy
Technology and the Family
Nazi Science and Technology
Nuclear Waste Disposal Policy and Native American Perspectives

The main criteria for an appropriate topic would be that it is (1) one to which several different disciplines can speak and (2) not viewed as the exclusive territory of any one discipline. Such courses could be taught at any level of the curriculum. The basic approach behind the courses would be to say: *Here's a big problem. What would you need to learn to be part of the solution to it?*

As part of the collaboration and course design process, the participants would be encouraged to articulate the robust big ideas that are central to their particular fields of expertise while at the same time demonstrating for the students how different perspectives can be fruitfully integrated. The goal would be to articulate these ideas in a way that is at once rigorous and accessible to non-experts in the discipline. Students should come away from such a course with a sense of what makes the disciplines distinctive as well as of how they can enrich understanding of the course topic. Faculty who have participated in such a collaboration should come away from the experience having articulated the tacit knowledge that is central to their fields.

The program would be modeled on the National Project on Philosophy and Engineering Ethics (1978-1980), which paired engineer-philosopher teams to develop integrated perspectives on engineering ethics. One of the most notable successes of this program is the collaboration of Mike W. Martin and Roland Schinzinger, authors of the widely used texts *Ethics in Engineering* (1985) and *Introduction to Engineering Ethics* (2000) and originators of the powerful concept of "engineering as social experimentation."

Beyond personal compatibility. . .

To recruit team members, we would draw on our own extensive networks of colleagues in the HSS and STEM who are interested in interdisciplinary work. We would also develop an academic equivalent of match.com, which would help potential participants identify and articulate the range of their own interests and expertise and find areas of compatibility with other faculty. We envision a one week workshop in the summer followed by on-going contact and support.

Evaluating the Outcomes

In evaluating the outcomes from this process, we would look not only at the learning of the students who take these courses but also at ways in which the attitudes and behaviors of teachers and students changed over time. How would their course designs and decisions about which courses to take be affected? How would faculty research be changed? What changes might be observed in the institution as a whole once several such collaborations were in place?

Research Questions

Beyond the research questions related to success in interdisciplinary collaboration, we would investigate a perception that undermines the intellectual credibility of many TL courses: the belief that there is a qualitative difference between the way the big ideas of the discipline are articulated for majors vs. non-majors, with the version of non-majors usually being designated as "watered down." Our hypothesis is that master teaching in any domain conveys the big ideas of that domain while retaining appropriate accuracy and rigor. We also hypothesize that the typical majors approach of beginning instruction with the lowest level of physical detail is detrimental to many students majoring in the subject and may create an unnecessary divide between majors and non-majors at the introductory course level.

A second research question that needs to be answered is how much HSS or STEM content a particular course would need to have before it could legitimately be considered as satisfying both social science and natural science distribution requirements. This would require an interesting inquiry into the rationale underlying both sets of requirements, including a critical examination of the ways in which we expect students to draw on the knowledge gained through distribution requirements in their later education and careers. The answers to both these questions have roots deep within academic culture. Changing that culture is a significant challenge, but one that seems clearly worth making.

A third possible area of research would focus on service learning and community-based student research, another area where multiple forms of expertise are required for effective course design and meaningful research.

Conclusion

Technology in Context offers an incremental approach to integrating courses that achieve the aims of TL into undergraduate curricula. With a relatively small investment of faculty time, the approach should result in a much larger number of courses that both function as and are explicitly recognized as TL courses. Perhaps more importantly, designing the courses so that they can justifiably be used to satisfy either HSS or STEM distribution requirements should ensure adequate demand for the courses without requiring the restructuring of the distribution requirements themselves. This should mean that significantly more students take a TL course as part of their undergraduate curriculum. While we do not envision the model we propose as the only or the dominant model for TL courses for university undergraduates, but we do believe that it holds great potential.

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