

AC 2008-285: TECHNOLOGY ASSESSMENT: A GRADUATE COURSE TO BUILD DECISION-MAKING SKILLS

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Technology Assessment: A Graduate Course To Build Decision-Making Skills

Abstract

The decision to adopt and use a technological innovation is often accompanied with a broad range of undesirable impacts upon the health and welfare of individuals, society, and the environment. As innovations become more complex, it becomes increasingly important that engineers, consumers, and citizens build assessment skills which will enable them to make better informed, sound decisions regarding the choice to adopt, use, and dispose of innovations. For almost a decade, *Technology Use and Assessment*, a graduate online course, has provided opportunities for technology educators to develop skills in assessing and predicting the possible impacts of technological innovations. This course serves as a model for building technology assessment skills for non-engineers. It combines a problem-based, collaborative pedagogy with the examination of contemporary problems, such as energy opportunities of the American roof, impacts of the American lawn, non-occupational hearing protection, and residential heating in the next fifty years. Students build data-gathering, data-analysis, and decision-making skills by developing alternative action scenarios based upon trends and other predictive models.

Introduction

There are inextricable links among technology, society, and the environment. Technology—the knowledge, process, tools, and artifacts by which humans modify nature to meet their needs and desires [1]—enables efficient economic productivity and a very comfortable standard of living for U.S. citizens. However, with each new technological innovation, humans, deliberately or inadvertently, alter the balance of biotic and abiotic systems in the environment which often degrades the ability of ecosystems to persevere. In addition, the adoption of technological innovation necessitates changes within our social systems (e.g., educational, legal, political, and economic systems) as individuals and communities coordinate their efforts to design, manage, use, and dispose of these technological products and by-products.

As technology grows more complex and ubiquitous, it is increasingly important that all members of our society become better, more-informed assessors and decision-makers about technology. In essence, the challenges of our modern age demand that future citizens become technologically literate, i.e., able “to use, manage, assess and understand technology” [2](p.7), in order to approach and, hopefully, achieve sustainability.

Within U.S. public schools, technology education (TE) is a curricular program dedicated to enhancing the technological literacy of students in grades K-12. As articulated by the fairly recent *Standards for Technological Literacy* (STL) [2], twenty content standards and their associated benchmarks “prescribe the content knowledge and abilities of what students should know and be able to do in order to be technologically literate” (p. 12). Among these standards are three which directly relate to the interrelationships among technology, society, and the environment, including:

4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

5. Students will develop an understanding of the effects of technology on the environment.
13. Students will develop the abilities to assess the impact of products and systems.

The inclusion of these three standards formally marked new content for technology curriculum which had previously (pre -1980s) emphasized the development of skills in using tools and machines [3]. However, Ball State University was ahead of this national initiative; preceding the release of the STLs, technology faculty developed both undergraduate and graduate courses for pre-service and practicing teachers to address these content goals. For almost a decade, *Technology: Use and Assessment*, a graduate online course, has provided opportunities for practicing technology educators from across the nation to develop skills in assessing and predicting the possible impacts of technological decisions. The purpose of this paper is to describe the content, pedagogical strategies, activities, and lessons-learned from 12 implementations of the technology assessment portion of this course. The hope is that this course may serve as a curriculum model for others who seek to build technology assessment skills for non-engineers.

Contextualizing the Course

With the support and guidance of the graduate program committee within the Department of Industry and Technology at Ball State University, the *Technology: Use and Assessment* course was developed in 1999 by Jim Flowers. The rationale for the development of this 3-credit, graduate-level course included two arguments: (1) to provide practicing technology teachers with an opportunity to build their knowledge of usability and technology assessment; and (2) to pilot the delivery of an online graduate course. Since the fall of 2000, this course has been offered 100% online to on- and off-campus students using the Blackboard Course Management System as its primary delivery and collaborative venue.

With the successful implementation of this online course and the results of a national needs assessment which demonstrated a perceived need for and interest in an online masters degree program in technology education [4], the department received approval to transition two graduate programs to complete online delivery, including the Master of Arts in Technology Education and the Master of Arts in Career and Technical Education. Since 2000, *Technology: Use and Assessment* has served both technical and technology teachers from these programs, as well as graduate students from audiology, wellness and gerontology, computer science, policy studies, and school administration. After 12 implementations, the course serves an average of 15 students per class and generates consistently desirable outcomes, including favorable reviews and learning gains.

Course Goals and Content

As suggested by the title, the mission of the course “is to analyze 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” [5]. Although goals vary slightly with faculty teaching different sections of the course, all sections provide content and activities which enable completers to:

1. Develop inquiry skills which support technological decision-making and policy development, including planning, collecting, analyzing, interpreting, and presenting empirical data.
2. Analyze product usability and perform usability research.
3. Develop proficiencies in planning, implementing, and reporting a technology assessment.
4. Identify and forecast the risks and impacts of technological decisions upon society and the environment.
5. Make informed, sound decisions regarding technology based upon empirical evidence and sustainability principles.

Essentially, the course is organized around two themes with approximately six weeks of the 16-week course dedicated to a study of use and eight weeks dedicated to a study of technology assessment. The content for the study of "using technology" includes adoption theory, trends of technological adoption, historical methods, clinical experiments, surveys of users or potential users, usability testing, the design of environments and devices to promote "userfriendliness" [6]. A sampling of information resources for this section of the course include Rogers’[7] treatment of adoption theory and Rubin’s [8] examination of usability testing.

Technology Assessment. As defined within course materials [9], technology assessment (TA)

refers to the process of measuring and gathering evidence on the effects, risks, or costs of adopting or using a technology. Individuals may conduct informal technology assessments when making purchase decisions from a variety of heating systems for their new home or a variety of vision correction options for their aging eyes. More commonly, however, technology assessment is a formal process conducted for the purpose of informing policy decisions. According to Lawless (1977)...

A "technology assessment" may be defined as a systematic study of the effects on all sectors of society that may occur when a technology is introduced, extended or modified, with special emphasis on any impacts that are unintended, indirect, or delayed. In other words, a technology assessment is a search for the ways in which a technology might exert influences outside itself; the results can be used in the identification and evaluation of public policy options, in reaching wise decisions in the legislative and regulatory area, and in the expenditure of research funds. Ideally the concept of technology assessment will be used in all the important decision-making levels in the public and private sectors (p. 5-6)."

The purpose of technology assessment is to help individuals, organizations, and policy makers make better-informed decisions in dealing with technological problems or in courses of action that involve technological innovation or adoption.

The content for the study of technology assessment includes a generalized overview of the mission, levels, process and methods that are common to the analytical work which informs

technological decisions. In particular, students examine and apply methods for identifying and analyzing impacts and risks (e.g., life cycle analysis), methods for weighing costs, benefits, and trade-offs, and for decision-making (e.g., force field analysis), and methods for forecasting (e.g., Delphi technique, weighted averages, and simple mathematical extrapolation).

The course incorporates information from a broad range of sources. For example, Porter et al. [10] provides guidance on process and methods, as do multiple articles from the *Technological Forecasting and Social Change* journal. Rich examples of technology assessment reports generated by the Office of Technology Assessment (closed 1995) can be found in the archives stored at Princeton University (<http://www.princeton.edu/~ota/>). Additionally, there are abundant examples and resources from government agencies which support examination of specific social and environmental issues, as well as technology assessment methods, including the U.S. Environmental Protection Agency and Technology Administration (closed 8/2007). However, since the primary learning activities for this course revolves around a contemporary issue, there is a concerted effort by instructor and students alike to locate and secure timely information from a wide variety of sources. Therefore, the information base which supports a study of technology assessment is quite changeable from semester to semester.

A Problem-Based Learning Approach

Within this online class, numerous teaching and learning strategies are employed to capitalize upon the diverse expertise and learning needs of mature learners. During the introduction of the two units, students encounter new concepts, principles, and methods during Web-based lectures and diverse readings. Students summarize their new understandings and self-assess their progress through asynchronous group discussions and formative tests. Typically, the introductory portion of each unit of the course concludes with an application activity where students apply a specific analytical methods, e.g., developing a user survey or a cross-effect matrix.

Both units of the course conclude by requiring students to integrate their growing understandings of their respective content and skills into an extensive synthesis project. For the unit in technology use, an inquiry approach is adopted to enable students to hone their data gathering and analysis skills. In this approach, students individually plan, implement, analyze and report an original usability test of a technological product, process, or system. For an overview of this project see Flowers [11].

During the technology assessment unit, the dominant pedagogy is best described as problem-based learning (PBL). PBL is a student-driven inquiry strategy where a central problem serves as both a content organizer and as a stimulus for learning. As a content organizer, the statement of the problem raises the concepts and principles relevant to the content domain [12] and identifies key parameters for the scope or depth of coverage in that domain. In PBL, authentic contemporary problems are deliberately selected because they require students to examine real-world data and engage in professional practices. The authenticity and relevance of this problem serves as a powerful stimulus for initiating and sustaining self-directed and collaborative learning.

In the PBL approach taken to examine technology assessment, the instructor selects an authentic, ill-structured problem which: (1) has multiple technological, social and environmental concerns with regional, national or global relevance; (2) uses data that is accessible to distributed students; (3) hinges on debatable issues; (4) has not been the subject of a published technology assessment; and (5) requires students to apply complex reasoning, inquiry and decision-making skills. It is hoped that each student will find personal or professional relevance in the issue under study.

After development of the problem, the instructor presents the problem to students in a fictitious “Contract Award Letter” originating from a government office, national organization, or business. The contract letter requires delivery of a technology assessment report which includes a literature review providing background on the topic, followed by chapters that outline alternative policies, including as one alternative the policy of taking no action. Within each of these chapters a different student author selects and uses several technology assessment methods to describe the estimated economic and non-economic costs and benefits.

Over the 12 iterations of this course, numerous scenarios have served as the focus of these technology assessment problems. For example, during the fall of 2005, the contract fictitiously originated from the U.S. Senate Committee on Energy and Natural Resources and requested a well-researched technology assessment of the energy opportunities presented by American roofs. The assessment of this issue sparked inquiry into the green-house effect, energy efficiency, micro-climates, electric power grid, battery technology, housing design, rain water run-off, solid waste, photovoltaic and solar thermal technology, and green roof technology. Other problem scenarios [13] included:

- Impacts of the American Lawn
- Residential Heating in the next Fifty Years
- Minimizing Exposure to Toxins in Schools
- The Use of Biometrics in Education
- E-Waste: Policy Alternatives for Ball State and Beyond
- Controlling the West Nile Virus within the United States
- Non-occupational Hearing Protection
- Digital Content Development and Delivery at Ball State University: 2004 to 2010
- Health and Wellness Implications of Computer Use by Children

As the problem scenario is presented, the instructor assigns students to small groups of 3 to 5 individuals. Over a six-week period, these cooperative groups engage in a cycle of planning, self-directed study, collaborative analysis and debate, self-reflection, and cooperative decision-making and writing. In essence, these learning groups collaboratively select and apply the technology assessment process and analytical methods they discovered earlier in the class to the exigencies of this issue. Eventually, the results of their analytical work enable them to propose four policy options. Accompanying each is a future scenario that might result if these policies were adopted.

Although groups may interact using a variety of communication tools, students are urged to document their work in their group’s private asynchronous discussion board within Blackboard.

These archived postings provide extensive evidence of group process, individual and group reasoning, and learning progress. As the primary role of the instructor in PBL is facilitative, the discussion board enables the instructor to monitor group progress, model critical thinking (e.g., questioning assumptions), and offer learning guidance when students exhibit superficial thinking and faulty reasoning.

For the technology assessment project, student achievement is evaluated from both an individual and group perspective. A group grade is determined by an evaluation of the technology assessment report, although only 40% of the activity grade is based on the report in an attempt to emphasize learning outcomes rather than report preparation. Criteria of evaluation include wise use of technology assessment methods, thorough literature review, identification and analyses of impacts, and reasonable policy options. An individual score is derived from a self-reflection activity (20%) and the instructor's quantitative and qualitative analyses of students' contributions to the discussion board (40%). This qualitative evaluation seeks evidence of critical thinking in the dialog, such as questioning assumptions, presenting multiple perspectives, supporting propositions with evidence, or providing constructive feedback.

Lesson Learned

The continued demand for this elective course and the host of positive reviews offered by completing students strongly suggests that *Technology Use and Assessment* course fulfills an important professional development need of technology teachers and other professionals. It is not uncommon for a student to mention, "I'll never look at [residential heating / hearing protection / etc.] the same way again." In addition, the technology assessment reports and online transcripts generated by students during the analytical work include extensive evidence that students develop meaningful understandings of the value, process, methods, and outcomes of technology assessment.

Organizing Learning. However, the combined complexities of employing a problem-based learning approach in a distributed learning environment has been a challenging and initially intimidating task for graduate students. The nature of online group work creates competing priorities for coordinating group effort and pursuing learning goals [14]. For instructors, the subtleties of organizing group experiences to optimize critical thinking, learning, and productive interactions among group members was quite demanding. Evidence from two separate research studies not only revealed these challenges, but also provided valuable insights for managing and alleviating other difficulties.

During the first (2000) and second (2001) implementations of this course, two research studies were conducted to examine the influence that different small-group structures or role assignment played upon the productive discussions of students. In the first quasi-experimental study [14, 15], students were assigned to six groups of 3 to 5 individuals while controlling for group process skill, degree program, sex, and location. Groups were randomly assigned to either a cooperative learning structure or a collaborative learning structure. For the cooperative structure, the instructor assigned specialist roles (e.g, school, economics, health and wellness) to individuals within each group and frequently monitored the group discussions (every 2 to 3

days). For the collaborative structure, the instructor encouraged the group to engage in critical dialogue and provided sporadic monitoring and scaffolding (every 4 days).

Over a six-week period, all groups conducted a technology assessment entitled “Health and Wellness Implications of Computer Use by Children: Recommendations for School Districts to Promote Lifelong Wellness”. Group interactions were documented in separate forums of the asynchronous discussion board. These transcripts (625 student and 70 instructor messages) and the results of a perception survey were the primary data of the study. Using the frameworks of Henri [16] and Henri and Rigault [17], all student transcripts were unitized and coded by at least two independent coders in terms of the function (cognitive, organization, social, and metacognitive), cognitive skill, and level of processing (surface vs. deep). Cohesion (interconnectedness) was also measured. A perception survey administered at the end of the third and sixth week generated information about students’ perceptions of interdependence (mutual dependence upon each other) and intersubjectivity (mutually shared understanding).

A global analysis of all transcripts indicated extensive engagement throughout the PBL activity with an average of 5.3 messages per student per week. Between-group comparisons were conducted on all variables using the Mann Whitney U. Results indicated that the cooperative groups generated more cohesive (interconnected) discussions and higher levels of deep processing than the collaborative groups. Deep processing is evidenced by higher-order and critical thinking skills, e.g., questioning assumptions, offering multiple perspectives, speculating on possibilities, reserving judgments, and supporting propositions with evidence. At the end of the third week, perceptions of intersubjectivity were also higher for the cooperative groups. However, there was little evidence to suggest that these different group structures had a differential effect upon participation levels, function of the dialogue, cognitive skill, or perceptions of interdependence.

One interpretation of these results suggest that there are learning efficiencies to be gained by taking a more structured approach to group organization, i.e., role assignment and close monitoring. This may be explained by the effect this approach has upon students’ perceptions of intersubjectivity during the initial stages of the activity.

Four specific concerns were also revealed by these analyses. First, the amount of student dialogue serving a cognitive or learning function (41%) and a managerial function (36%) were appreciably different than other instructional strategies reported in the literature, e.g., the 70% of cognitive function reported for weekly discussions of readings [18]. Second, the percentages of deep processing (35% of cognitive units) and indepth clarification skills (9%) evident in student dialogue [15] were deemed low because PBL theorists argue that this strategy enhances reasoning and critical thinking skills [12]. Third, students were initially intimidated by the activity. Finally, there was a tendency for groups to distribute technology assessment tasks among themselves to promote production efficiency; this resulted in isolated and narrow thinking while reducing the learning potential of PBL.

To address these issues, the researcher and instructor implemented a second quasi-experimental study in the fall of 2001 [19]. In this study, all PBL groups were structured using an adaptation of a jigsaw cooperative learning strategy [20] and learning roles, rather than the previous

performance roles. Specifically in this jigsaw strategy, the instructor devised a two-tier system of discussion forums which served different functions. To begin, students within each group were assigned a specific role either as a summarizer, possibility generator, inferencer, or strategist. In one set of forums, each group worked together to conduct a technology assessment titled “Non-Occupational Hearing Protection”. In a second set of forums, individuals with the same learning role discussed learning issues, methods, and sources of information which supported the responsibilities of their learning role.

At the conclusion of the class, similar content analysis methods were used to analyze the group transcripts. Statistical comparisons of between-role differences indicated only a single statistical difference between the summarizer and strategies role on elementary clarification skills. However, global analyses of the data indicated that over 52% of the dialogue served a cognitive or learning function, 14% of the cognitive units were evident of indepth clarification skills, and 34% were evident of deep processing, i.e., critical thinking[19]. Compared to the first study, these were all desirable increases and support the contention that learning role assignment and learning role support enhance the use of critical thinking skills.

As a result of these two studies, the primary instructor of this course has consistently employed the jigsaw method with learning role assignment when class size permitted. In addition, the instructor is convinced that the use of a discussion forum to support learning roles helps learners overcome initial intimidation of the activity, enhances motivation throughout the activity, and helps learners direct their cognitive resources on learning goals, rather than production goals. Furthermore, the use of learning forums has had the unexpected benefit of promoting intergroup collaborative learning. For example, summarizers in each group share a summary of their group’s work with other summarizers who, in turn, share this information with their technology assessment group. Even though groups still work on parallel reports, the use of learning role forums has allowed students throughout the class to support each other.

However, the jigsaw method with learning role assignment does not appear to reduce the tendency of groups to opt for production efficiency (task specialization) over learning goals. Ideally, each assessment task would be addressed by multiple group members to capitalize upon the diverse perspectives, collaborative ideation and reasoning checks that a learning partnership could afford. To minimize the isolating effect of task specialization, the instructor now requires learners to post and review drafts of their progress to the learning role forum.

Observations. Anecdotal observations from students and the instructor also suggest valuable lessons and positive outcomes of conducting a technology assessment.

- **Policy.** For some students, engaging in a formal technology assessment has reportedly made it easier to see their own connection to governmental decision-making, with an increased understanding about those decision-making processes.
- **Narrow Thinking.** After two weeks working on the “Biometrics in Education” assessment, student groups were unanimously suggesting the increased use of biometrics in schools, with different policy options distinguished by different technologies. The instructor crafted a fictitious letter from the American Civil Liberties Union beseeching these technology assessors to reject the assumptions in their award letter and to protect children from this invasive technology. This forced students to question the assignment

they were given, with the result of a more balanced and critical examination of the impacts that biometric technology might have upon individual's privacy.

- **Diverse Knowledge and Skills.** Both the content and methods of technology assessment tend to intimidate students, in some cases due to the fear of mathematical analytical procedures or the unfamiliarity with the impact sectors or methods. To overcome this intimidation and enhance collaborative learning, the instructor has found it beneficial to populate technology assessment groups with individuals who possess diverse skills and knowledge. In addition to considering learners' preexisting differences, the instructor deliberately populates groups with students who had previously practiced different technology assessment methods.

Conclusion

As technologies become more complex, ubiquitous, and risk-laden, it becomes increasingly important that citizens make more informed, sound decisions regarding the choice to adopt, use, and dispose of innovations. The *Technology Use and Assessment* course provides practicing technology educators and others with the information and guidance to develop a valuable set of analytical skills with which to predict impacts of technological decisions. The problem-based learning approach taken in this course offers an in-depth opportunity for students to collaboratively identify, analyze, and forecast impacts of contemporary innovations upon real ecosystems, individuals, economies, and other social systems. While the use of distributed PBL has its challenges, the selection of an authentic problem situation and the combination of jigsaw, learning role assignment, and close monitoring provides a manageable teaching and learning structure for distributed learners. It is the hope that this builds technological literacy and empowers students to apply lessons learned to other aspects of their professional and personal lives where decision-making skills are so critical. The need to build technological literacy and informed decision-making suggests that educational institutions should expand opportunities for students from all disciplines to develop these skills. This online distributed course serves as one model.

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