AC 2010-2115: ASET 101: SCIENCE, TECHNOLOGY AND PUBLIC POLICY: INCREASING TECHNOLOGICAL LITERACY AMONG COMMUNITY COLLEGE STUDENTS

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ASET 101: Science, Technology and Public Policy
Increasing Technological Literacy
Among Community College Students

Introduction

A new course, Science, Technology and Public Policy (ASET 101), has been initiated at Community College of Philadelphia. The course is designed to introduce students to basic scientific principles in Biology, Chemistry and Physics, to show how these principles are applied in areas such as biotechnology, process technology, and nanotechnology, and to explore societal issues related to these technologies. One of the hoped for goals of the course in examining these current technologies is that students will start to develop "technological literacy."

In a paper discussing an NSF sponsored workshop on technological literacy for undergraduates, Krupczak and Ollis report on efforts to "to identify and define several models of technological literacy courses. Based on a review of courses already developed and comparisons to other disciplines, four candidate standard models were identified: The Technology Survey Course, The Technology Focus or Topics Course, The Technology Creation Course (Design Course), The Technology Critique, Assess, Reflect, or Connect Course."[1]

ASET 101 has elements in common with the Technology Focus category in that the course incorporates scientific principles focused on a limited range of technological applications. ASET 101 also shares elements of The Technology Critique, Assess, Reflect, or Connect Course, helping students see the connections between technology and public policy questions.

Technological literacy has been defined as "an understanding of the nature and history of technology, a basic-hands-on capability related to technology, and an ability to think critically about technological development."[2] Providing an explanation and developing an understanding of the basic science and scientific techniques employed in the application of these technologies touches upon the first part of this definition. Using that background to make and support a personal decision regarding the use of these technologies would address the third part and what is probably the most critical part of the definition. It is essential that "ordinary citizens [are able] to make thoughtful decisions on issues that affect, or are affected by, technology."[3] "Science and technology are so pervasive in modern society that students increasingly need a sound education in the core concepts, applications and implications of science"[4] in order to function as citizens in a democratic society charged with making long-term decisions on these emerging technologies.

While the technological literacy focus of this course is critical, greater impact is achieved if the content is effectively communicated, can reach a broad audience and is easily sustainable over time. Thus, in addition to discussing the content of ASET 101, we will also discuss the active learning pedagogy utilized. Moreover, we will discuss how issues of reaching a broad audience and sustainability were dealt with by addressing issues of institutional context in the design of the course. Finally, we consider possible measures to determine the success of the course's goals.

Course Description

The content of ASET 101 is organized into 4 modules. The first module is designed to provide an overview of the scientific method. Being grounded in how problems and issues are approached, examined and addressed from a "scientific perspective" is the foundation for appreciating all the other technology modules to be presented. Students need to understand this approach in order to decide if (and/or assure that) the information they are examining on a particular technology is rooted in experimentation and shared published results versus conjecture or personal opinions and feelings. After a presentation on the general terminology and techniques of *the scientific method*, the students apply this approach as a group to solving an historical case on Childbed Fever.[5]

The second, third and fourth modules were each themed on a current technology not only to be found in the news but tied to curricula offered by the College. Linking the modules to current College offerings was recognized as an opportunity to expose and attract students to these scientifically–based careers. In addition, the modular structure of the course allows the content to be swiftly altered should another scientific technology offering become more of a focus within the institution.

Each of these subsequent modules followed the same methodology. First, the basic scientific concepts of biology, physics or chemistry (including important terms and math concepts) underlying the technology are presented. Building upon that base, one or more technological applications based upon that science are presented and discussed. Lastly, the societal implications of utilizing that technology are examined from multiple perspectives. The current modules are Biotechnology, Nanotechnology and general Process Technology.

In Biotechnology, basic terminology (for example, codon, enzyme, plasmid) is introduced, and basic biology, including the process of gene expression and protein synthesis, are explained. Building on this foundation, basic techniques of introducing genetic modifications into an organism are discussed. The implications of biotechnology in agribusiness to produce foods are then examined from the perspectives of the industry, a consumer, an environmentalist, a government regulator and other stakeholders.

For Process Technology, the chemistry of energy production from oxidation of fossil fuels, the chemical and physical processes involved in refining petroleum, and the concepts of quality control in production processes are examined. Students independently investigate the technological advances (such as fractional distillation, catalytic cracking and drilling technology), social and historical changes (such as the transition from coal to oil use, and the interrelationship between development of the oil and automobile industries) and environmental impacts of petroleum refining and usage. As a class activity students develop a time-line of the events they have investigated individually so that they can appreciate how the interplay of technological and social developments have led to a typical modern day refinery,

The final module is based upon Nanotechnology. The fact that the chemistry of substances is often altered at the nano scale and that the behavior of matter at the nano scale often differs from what our experience at the macro scale would predict is demonstrated with a variety of examples. Scientific notation, units of measurement, significant digits, order of magnitude, and the ratio of surface area to volume are all explained and then practiced. Students are exposed to some of the methods of creating and measuring structures at the nano scale, as well as some of their current applications. Use of nanostructured devices for tracking versus privacy issues and a hypothetical case study of a solar panel company (which uses nanotechnology in its manufacturing process) moving into a town provide opportunities to explore the societal impacts of nanotechnology.[6]

Pedagogy

The pedagogy employed for all the modules is active and cooperative and includes some if not all of these techniques in each module: group work, project based learning, role plays, panel discussions and guest speakers. The use of interactive, team-based activities in the course are drawn from many of the "best-practices" identified in educational literature that have been shown to increase student understanding and retention of materials as well as improve student persistence. The Biotechnology module will be used to demonstrate how these techniques are utilized.

Specifically we focus on genetically modified foods. At the end of the unit, students are asked to write an evidence-based personal position paper on genetically modified foods. Many students are unlikely to know that many of the foods they eat may have been genetically modified or what the implications of that are. Students are also unlikely to have any understanding of genetic engineering. Thus the challenge is to provide students with enough background to develop an informed position about genetically modified foods. The general strategy utilized is to introduce the topic in a non-threatening way that will enable students to relate directly to the topic, provide scientific background, and help students understand different viewpoints on the topic.

We begin the module with a case study—"The Case of the Tainted Taco Shells."[7] Students are given a short reading/role play which presents the controversy surrounding genetically modified foods in a quasi-story format. The case study provides a take-off point for discussion, and students are asked to think about pros and cons of genetically modified food crops, and to list questions they have about the topic. Helping students identify the questions they need to answer in order to complete the personal position paper builds on the discussion of the scientific method that preceded the unit on biotechnology. In addition, the activity provides students with a context for learning about the scientific foundation of biotechnology.

Students are then given a list of terms related to biotechnology to look up, which are reviewed in the next class session. Since students sometimes have a tendency to write down a definition for a word without really understanding it, the emphasis on review of the terms in the next class is intended to help students have a basic understanding of the terms. Students may have limited or no prior knowledge about biotechnology or related concepts from chemistry and biology. Familiarity with some of the terminology is intended to help them understand subsequent lectures on the topic by providing students with a basic foundation to build upon.

At the following class session a lecture is presented which defines biotechnology, gives a basic overview of the chemical and biological principles involved, explains common techniques currently used in biotechnology, and gives examples of some common genetic modifications applied to food crops.

As a follow-up assignment to the lecture, students are given a list of questions to research related to the scientific and technological aspects of biotechnology. Working in groups of three or four, students are asked to address five of the questions on the list. Members of each group then report back to the class on their answers. Since there is overlap in the five questions that each group researches, there is opportunity for other students to enlarge on or correct answers given by other students. In any case, the instructor ensures that all students have heard the correct information related to each question. Understanding of the scientific and technological aspects of biotechnology is assessed by giving students a quiz on these topics.

Up to this point, the work of this module has addressed the question of "What is possible?" in regard to genetic modifications. Next, the question "Is it a good idea?" is addressed. Of course, whether one thinks genetic modification of food crops is a good idea or not depends a great deal on the point of view one takes. Continuing to work in groups, students are asked to address the "Is it a good idea?" question from the perspective of a particular stakeholder (for example, consumers, farmers, environmentalists, foreign aid workers, and so on.) Students are provided with necessary support by purposefully incorporating library instruction to teach them about using the College's data bases to research their topics, as well as to discuss plagiarism. The results of the group's research are submitted as a report, and must draw a conclusion based upon factual information about genetically modified foods.

Subsequently, based on the group research, each group selects a representative to "testify" on the question "Should genetically modified foods be banned?" The members of the class who are not on the panel serve as the hearing board. After giving a statement, each panel member may be asked questions by other members of the class or the instructor. Students are instructed to address the question based on evidence they have found, and to tie their conclusion to the facts they presented. Thus, for example, an environmentalist may look at concerns about unforeseen effects on the genome or harm to other species on the one hand, and reduced use of pesticides on the other, in coming to their conclusions. Engaging students in a class discussion after they have explored some of the issues in their groups helps students gain a greater appreciation for the complexities of the issues.

Once the panel discussion is completed, students are assigned an individual "Personal Position Paper" to write. Since at least some students in the class may be at a pre-college writing level, the assignment is highly structured. Students are given a choice of templates to follow, drawn from an introductory book on academic writing. For example, one template asked students to start their personal position paper with "While _____________ believes ________________, I believe that _________________."[8] Students must then state at least three reasons, based on their understanding of the science and technology involved, to support their position.

It is not an expectation of the course that students will come out of it with a full understanding of the scientific foundations of biotechnology, or a full understanding of biotechnology methods and techniques. It is an expectation that students will have a rudimentary understanding of the science and the techniques, will understand that it isn't magic and will recognize that a deeper understanding is within their grasp. What we hope students get from this course, which they might not get from a more standard science class, is a clearer understanding of how the material is relevant to their lives, and the importance of understanding the science and technology.

Institutional Context

The ability to reach a wide audience and to sustain the effort over time are important considerations in the success of any mechanism to incorporate technological literacy into the institution. How these issued are addressed depends upon the context of the institution.

We will examine four factors at Community College of Philadelphia that were important in the development of this course:

1. Establishment of a new curriculum in Applied Science and Engineering Technology (ASET)
2. General Education Requirements
3. Transferability
4. Developmental Education

The emphasis of the Applied Science and Engineering Technology (ASET) Program is to enable students to enter the workforce on the technician level in high technology, high demand employment areas. The program has a very flexible design to enable rapid response to changing technological, workforce, and student needs. Courses leading to an Associate in Applied Science in the ASET program fall into three categories: There are four program courses that are required of all ASET students; there are courses that meet the College's general education requirements; and, there are a number of technology-specific courses that are organized into what the College refers to as proficiency certificates. Currently we are offering, or will shortly be offering, proficiency certificates in Biotechnology, Nanotechnology and Process Technology.

As student demand and workforce needs evolve, we can add or remove proficiency certificates without the need to develop a whole new curriculum. All courses that support the certificates are credit courses and count towards a student's graduation in the ASET curriculum. Students also have the option of pursuing the certificates independently of the degree and going directly into the workforce, in which case they could return later to complete the remaining degree requirements.

The four program courses required of all students are:

- ASET 101: Science, Technology and Public Policy
- ASET 110: Health, Safety and the Environment
- ASET 130: Quality Assurance and Quality Control
- ASET 185: Interpersonal and Organizational Skills for the Workplace

The first of these courses, Science, Technology and Public Policy (ASET 101), is the subject of this paper. As described above, the course is intended to provide students in the ASET program with an introduction to basic concepts of the scientific method, basic background in biology, chemistry and physics, technological applications that are based on these scientific principles, and an understanding of societal issues related to the implementation of these technologies.

For students in the ASET curriculum, the course provides an overview of the technology areas that correspond with the certificate offerings available at the College. It is hoped that the course will help students clarify areas of interest for themselves as they make decisions regarding their future studies.

Nevertheless, the course was not designed exclusively for ASET students. The course also satisfies the College's general education science requirement. This provides us with the opportunity to do broad outreach across the College community as we seek to generate interest in the course and the curriculum. Because ASET 101 is a course that helps students understand the science and technology behind the headlines, we believe the course will have very broad appeal, including students who haven't necessarily thought about science as an area of interest for them. Many students at the College are not decided on their career directions upon matriculation, and are put into a Liberal Studies curriculum. While this curriculum requires two science courses, the College's general education requirement is for a single lab or non-lab science course. By designing ASET 101 to have broad appeal and by positioning it so that students may take it early in their College education, it is our hope that some of these students will find that they are interested in an area of science and/or technology, and will decide to pursue further study in these areas.

Although fulfilling a general education requirement is beneficial, it is not a sufficient condition to attracting large numbers of students. The course must also be transferable. A high percentage of CCP students transfer and will not be interested in taking a course that won't transfer. (For 2008 the institution's transfer rate was 76% for graduates of transfer programs, and 49% for graduates of career programs.)[9] In addition, Academic Advisors are reluctant to recommend a course that is not transferable.

Prior to the course being offered we confirmed with Temple University, the most popular transfer destination of our students, that they would accept the course for transfer as a non-lab science elective. In addition, we are working on an articulation agreement with Drexel University for their Applied Engineering Technology program, which will provide transfer credit for ASET 101. We also learned that a student who transferred to Cornell University in Spring 2010 has been given transfer credit for this course as a core course in his curriculum (Biology and Society). We anticipate increasing the number of 4-year institutions willing to grant transfer credit for this course.

Another area where we focused attention was Developmental Education. Approximately 60% of students who enter the College are found to need developmental work in math and/or English (which includes both reading and writing components). For many students it is not simply a matter of needing to brush up on basic skills—it is also a matter of learning to be college students—to take initiative and responsibility for their learning. (Indeed, we believe many students who test college-ready have this need as well but in smaller numbers.) Generally, students in developmental courses are barred from taking college-level courses, unless those courses are on the College's waiver list.

While ASET 101 was in the development stage, we decided to make it open to students at the high end of the developmental spectrum because this would enable us to connect with students early in their college career. (We also included higher level ESL students, though their issues are often different from those of developmental students.) Making early connections was viewed as important to our program recruitment as well as critical to College retention efforts.

In order to actually improve student retention, however, the course had to be designed to address the needs of developmental students, while still providing sufficient "meat" for non-developmental students. For example, the Personal Position Paper on genetically modified foods (described above) is highly structured, providing guidance for students who may not be strong writers.

Anticipated Outcomes and Program Assessment

- Increased technological literacy
- Increased awareness of, and interest in, pursuing science/technology curricula/careers
- Increased retention rates of students

Increased Technological Literacy

In the realm of technological literacy, our goal is to have all students who take the course realize the relevance of science and technology in their day-to-day lives and to have them understand that scientific principles are not inaccessible to them. Using the National Academy of Engineering's three-fold definition of technological literacy ("an understanding of the nature and history of technology, a basic-hands-on capability related to technology, and an ability to think critically about technological development."[10]), the course's final project is used to re-emphasize and measure achievement of this outcome. For the report (and class presentation based upon it) students work in groups of three. Topics of current technological applications across a broad spectrum of areas are given to the students from which they can choose. (Students are also permitted to propose topics of their own pending approval.) For each topic, the research is presented in a specified format. A description of the technology followed by its scientific underpinnings (the *what* and *how* of the technology) constitute the introductory section. The technology is then examined for both advantages and disadvantages from the perspective of at least three stakeholders. Lastly, each member of the group is asked to take a position on whether they favor using or rejecting the technology and supporting their decision using arguments raised in the previous sections.

As the course has only been offered one time, the results of assessing this goal are very preliminary and the assignment will no doubt be tweaked in the future to make the expectations clearer to students.

Overall, with notable exceptions on both ends of the spectrum, students did demonstrate acceptable technological literacy as evidenced by their grades on this final project. In general, defining the technology was not problematic but the scientific underpinnings were often weak reflecting their superficial understanding of the science itself. The advantages and disadvantages from the required number of perspectives were usually there and accurate but frequently the stakeholder was not clearly identified or all the points were based on the same stakeholder. Lastly, in the personal opinion portion, the students' choices were sometimes ambiguous demonstrating how conflict-ridden these new technologies are and how difficult it is to make a risk vs. benefit choice.

In addition to student achievement of technological literacy, as evidenced by their final projects, an indirect measure of this goal would be an increase in the number of colleges and universities accepting this course for transfer credit as fulfilling a science requirement. As noted previously, Temple University is already accepting this course for transfer and other agreements are being and will be pursued with multiple surrounding institutions in the Philadelphia area.

Increased Awareness of, and Interest in, Pursuing Science/Technology Curricula/Careers

Since this course fulfills our College's general education science requirement and is open to high-end Developmental Education program students, while also serving as a beginning course in the ASET curriculum, arousing student interest in pursuing a scientifically-based technological career is another major goal. Although not all students taking the course will be attracted to such career paths, exposing them to the variety of such paths and shining a light on the abilities and background needed to pursue them will demonstrate to them that they are indeed capable of succeeding in these careers if they so choose.

The measure of our success in this area will be to examine the curriculum codes of students before and after they have taken ASET 101, and see if there is any shift towards the ASET program or one of our other science related programs.

Increased Retention Rates of Students

The effectiveness of the built-in support systems and active–learning pedagogies to increase student retention at the College will be measurable by examining the semester-to-semester retention/return rates of students who have taken ASET 101, including developmental, ESL, and college-level students, as compared to the College-wide retention rate.

Overall, as the Fall 2009 semester was the inaugural offering of ASET 101, there is as yet insufficient accumulated data from which to extract any meaningful measures of success in achieving our goals.

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