

# Issues in Science and Technology

Student-Driven Inquiry Directed  
by the Scientific Process

*Nora Egan Demers*

*In this course, students select a current issue in science and technology and then explore it in a scientific manner. They work in groups and individually to examine the history behind the science and technology that have led to the issue and consider how politics, culture, and society influence the concern.*

Issues in Science and Technology is one of a handful of required courses making up the Collegium of Integrated Learning at Florida Gulf Coast University (FGCU). The collegium, a series of courses designed to improve achievement of students at FGCU, is the core upper-division offering in the College of Arts and Sciences and is required of all students regardless of major. The collegium is designed around improvement in achieving the FGCU University student learning outcomes (a description of which is available online at [www.fgcu.edu/info/outcomes.asp](http://www.fgcu.edu/info/outcomes.asp)), rather than around specific course content.

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My approach to teaching this course was drawn from the American Association for the Advancement of Science and National Academy of Science, Science for All Americans goals (Rutherford 1990; Mulvihill 1995). Issues in Science and Technology is a model for courses or modules that help students actively practice, acquire, and hone the skills of skepticism, critical thinking, technological literacy, and problem solving; these skills are necessary to successfully perform the scientific method. As is the case with many other successful courses described in this and other journals, the constructivist style of inquiry requires creativity (Schaible and Rhodes 1992; Cherif 1994; Kosticka 1995; Tichenor 1997), examines ethics (Bisbee 1994), and demands oral and written presentations (R. Moore 1993) to improve literacy. This course is much like the course described by Markham and McKone (1993), in which participants apply these scientific habits of mind to societal issues.

### Course Design

Students in this course come from across the college, and many have not had a science class since their general education course work, which may have been two or more years in the past. Many are initially uninterested in science, and some are actually afraid of it. To allay their fears and to help them gain valuable experiences from the diversity of knowledge they each have, I designed the course around group and individual research projects (modified case studies that require students to present and then discuss their issue with the class).

The use of case studies has a long and productive history (Conant 1947) and was recently the single topic for an entire issue of the *Journal of College Science Teaching* (Herreid 2000). My approach is slightly different from traditional methods because I allow students to select the case to be studied. The course exposes students to the history and process of science and then teaches about current issues using problem-solving and critical-thinking skills. Each student states a hypothesis about an issue in science and technology. The hypothesis is drawn from what they know about the issue from the media and through life experiences. They are expected to draw on their interdisciplinary knowledge to communicate the complex nature of the issue as they develop their information and technological literacy by researching the topic beyond the headlines and sound bites that helped them form their opinion.

The in-class format is discussion-based, with a faculty member acting as facilitator. Written assignments, oral reports, and class discussion regarding science and technology make up the bulk of the assessment (the format of which is available online at [ruby.fgcu.edu/courses/ndemers/80775/](http://ruby.fgcu.edu/courses/ndemers/80775/)). Groups work together to explore selected issues and present non-scientific aspects (political, moral, economic, and so forth) of the issues. Individual students research their issues, give brief oral reports, and then submit final written reports (after intermediate drafts have been evaluated by peers, the instructors, and the writing center staff). Class time is used to discuss the process of science, the issues of technology, and how the issues affect our society. The final week

is used to bring together the issues explored and find common threads. We also consider the future implications of the issues and how students might contribute to what occurs. The specific university student outcomes identified for the course include effective communication, information literacy, problem solving, and technological literacy.

### What Is Science?

A primer of the scientific method (Lee 2000) is the only required text, with additional readings available on course reserve and numerous links available from the course Web site (available online at [ruby.fgcu.edu/courses/ndemers/80462/](http://ruby.fgcu.edu/courses/ndemers/80462/)). The text begins by explaining the differences between science, nonscience, and pseudo-science. It discusses ethics, misconduct, and critical thinking and then reiterates the basic model of the scientific process: observation, hypothesis, testing, concluding, and perhaps most important, communicating those findings to a larger audience.

Small groups of students highlight the most important aspects and memorable quotes from each chapter. Then, as a larger group, we discuss the chapters, reiterate the author's intent, say whether we agree, and explain how it fits into our discussion of the issues. Using the text as a guide, we discuss the practice of science and the skills of critical thinking and how to practice them while undertaking inquiry. The first written assignment is an essay defining and distinguishing science from technology. Students write about what science is, what technology



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**Figure 1. Sampling of topics explored by students in *Issues in Science and Technology*.**

Creatine is a safe way to build muscle bulk and strength.

People should be allowed to select the gender of their child.

Golden rice will not provide nutritional food to third world countries and end world hunger.

St. John's Wort is as effective as pharmaceutical drugs for treating mild depression, at a lower cost and with fewer side effects.

Medical uses of marijuana are valuable and therefore the laws that make marijuana illegal should be lifted.

The one-child policy of China and its family planning methods are the best way to curb population growth.

Gene therapy for the treatment of Parkinson's Disease is worth the cost in lives and money.

Saving the Giant Panda: Cloning can be beneficial to the conservation efforts of this endangered species.

Adult stem cells are adequate to treat many diseases and are not morally wrong like embryonic stem cell technology.

Mental state can affect our ability to cure, fight, or beat cancer and funding should be redirected to this research.

Genetically modified rice can help stop world hunger in South Asia.

The United States is not technologically ready for a national missile defense system.

Scientists should not use germ line gene therapy to improve IQ levels.

Bovine growth hormone safely increased milk productivity in the United States.

Cloning animal organs is beneficial for society.

Earth-based solar is more beneficial and realistic than solar-powered satellites.



is, and how society influences each. This essay, in an improved, revised form, serves as the introduction to their final report.

### Selecting and Exploring an Issue

By immediate immersion, students are exposed to issues. On the first day of class, I supply students with recent issues of *Natural History*, *Smithsonian*, *Popular Science*, *Scientific American*, *Science News*, as well as links to *New Scientist*, the Centers for Disease Control, the World Health Organization, and other informational Web sites to help them become aware of various issues. In the class session, each student provides a list of five issues in science and technology; these must be stated in the form of a

population, the effect of technology on children, genetically modified food, space technology, cloning, food additives, and recombinant bovine growth hormone (Figure 1). Ideally, students are then assigned to groups with a member from each of the represented majors (English, history, science, art, and so forth). They are required to state a hypothesis drawn from their observations and research the information available through a series of guided assignments.

The second assignment is to make a timeline of the events surrounding the issue. By design, it starts generally, as an "intellectual history" of the issue, and as it approaches the present, becomes as narrow as the topic. For example,

hypothesis. Each student offers one hypothesis at a time, which I write on the board. As a class, we discuss what the issue is, which aspects are scientific, which are technological, which are societal, and whether the issue faces us today or if it will face us sometime in the near future. Then we group the topics into similar subjects. Types of issues about which students have made hypotheses in past semesters include over-

while learning about genetically modified foods, students are encouraged to learn the history of the field of genetics and agriculture. They learn that modifications to food have been occurring since agriculture and civilization began. They learn about the science behind the technological advances and realize how scientists have increased our ability to select desirable traits and modifications. Usually, after beginning to explore the issues and discovering the abundance of information available, students realize they need to narrow their topics. This is probably the most difficult aspect of the course.

The wealth of books and electronic resources available from the library and Internet are resources for exploring the issues, and students acquire increasingly improved skills in gathering information. Many students are at first overwhelmed by the wealth and breadth of information available and need guidance on how to filter the information. Excellent reference librarians are an indispensable help in their independent inquiry of the issue.

Each semester, I incorporate the course work closely with the Information Literacy Program (available online at [library.fgcu.edu/Policies/infolit.htm](http://library.fgcu.edu/Policies/infolit.htm)) and the reference librarians at FGCU. Early in the term, we have one class scheduled in a computer classroom, and the librarians tutor students in advanced library training. The session focuses on finding timeline information, finding annotated bibliographies, and evaluating Internet resources.



***Ideally, students will continue to explore more carefully the details of how we are using the applications of technology made possible by science to influence our society.***

After an initial exploration of the topic, students state their issue in the form of a hypothesis that they can attempt to falsify using the information they acquire. This approach demands that they find conflicting information on the issues. They realize that their resources usually are biased and that an understanding of the bias is necessary to find their interpretation of “truth.” Class discussions center on the bias evident in most information and emphasize the need to better develop skeptical inquiry skills.

As the term progresses, class time is split among discussion of the text, discussion of how to proceed in answering questions, and time for the groups to organize their work. I reiterate that all claims need to be supported with data and information, have proper citations telling who acquired the information, and consider the credibility of the source. For instance, I ask them to explain to me the difference between what I would see on *Dateline* and on *Inside Edition*.

The next assignment is to create an annotated bibliography; students

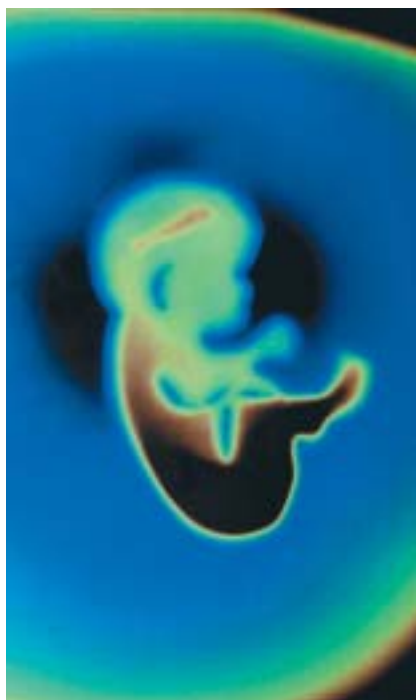
make a compilation of their resources, stating what the resources have added to their understanding of the issue. The assignment also requires that they tell about the background of the author and publisher and how it might bias information they present. Completing this assignment allows them to evaluate resources and consider how the information they are acquiring contributes to answering their question. It helps them stay on task while wading through the wealth of information available. Students must link a reference to each piece of factual information they provide that cannot be found in encyclopedias or textbooks. This requirement helps them understand the importance of providing and evaluating their resources.

Because so many of the issues selected are based on biological principles, I sometimes give a brief basic biology lecture. I explain the simplicity of biological organization, emphasizing the major macromolecules and compartmentalization of functions; describe the central dogma on how information is trans-

mitted across generations and expressed as functional proteins; describe how the structure of DNA allows its function; and explain how, with recent technological advances, genes can be transferred among organisms. These minilectures are useful when students need them to understand the issue they have chosen. Students comment that they remember hearing something like the minilecture in previous science classes, but had not understood the concepts as fully previously.

Because it is impossible to understand topics like bovine growth hormone or how cloning works without knowing basic biology, learning about the inner working of a cell has more meaning and holds more value for students. The general science education of years past is stirred to the surface, and an educational experience is connected with a real-life experience (Dewey 1938). I get the reward of seeing faces light up with understanding complex processes, and students get the reward of realizing that science is not only important but also approachable and understandable. Ideally, they will continue to explore more carefully the details of how we are using the applications of technology made possible by science to influence our society.

In my minilecture, I attempt to model a presentation that engages, enlightens, and educates. The class then takes the time to talk about the presentation, what worked and what didn't, what was distracting and what was successful, and how they can incorporate components into their own presentations. They find it useful to have class time to discuss what makes a good presentation. Most students use various audiovisual support materials, which improves their technological literacy proficiency. I expect them to leave several minutes at the end of the presentation for questions and comments, providing time for immediate discussion. Students interact with the speakers and each other, asking questions that challenge the speaker to provide additional information.



## ***Students learn about the science behind technological advances and realize how we have increased our ability to select desirable traits and modifications.***

One student began the term by stating that Olestra, the fat substitute developed by Proctor and Gamble, was good. She was initially committed to her opinion, derived mostly from the commercial Internet sites set up to sell the product. Because she was required to explore contradicting claims, she discovered the potential for nutritional deficiencies in fat-soluble vitamins if too much of the product was consumed (and the entire diet was snack foods).

Another student was adamantly opposed to genetic modification of food until she began to explore how “golden rice,” developed by the biotechnology food company Monsanto, might help alleviate malnutrition in many parts of the world. In a subsequent class, another student exploring this issue discussed whether or not golden rice is really the cure-all for a malnutrition problem with numerous contributing factors.

Monsanto’s recombinant bovine growth hormone for increasing milk production, its potentially detrimental side effects, and the governmental subsidy paid for overproduction of milk have held the interest of several classes. The big-business aspects of technology are clear and undeniable, and learning how industry interacts with the Food and Drug Administration provides sobering lessons.

Some students are frustrated at the apparent manipulation of information and resources that they discover in the political process. The inextricable links among science and technology, politics, economics, culture, society, media, and arts and literature become obvious. These other topics (politics, economics, and so forth) are the focus of the other courses in the collegium.

The final week of the term is set aside for summarizing the presentations, re-examining the issues, and finding common themes. We explore the current aspects of the issues, including the political and social components. Class discussions revolve around the diversity of opinions, how they were acquired, and how they influence us as individuals and a society. We realize that consensus is seldom possible among our small group, and we now better understand the difficulties of the democratic process. Finally, we consider what future actions might be taken to resolve these issues.

### **Course Evaluation**

This course is not constrained by specific content, so we can focus on the complexity of the issues that face society. The course assists students in gaining expertise in the university student learning outcomes. In written evaluations of the course, students state that they have become more cognizant of the distinction between science and technology by realizing that the application of science to technology is the primary area of contention around these issues, rather than the scientific knowledge itself.

Through their own inquiry and reading beyond popular press and news briefs, which sometimes simplify things to the point of error, students learn the importance of being aware of the scientific background surrounding the issues of technology application that face our society. Many students mention to me that, for the first time, they have begun to read newspapers and magazines and watch public television, the Learning Channel, or Discovery.

Students evaluate the presentations of their classmates and provide a brief written summary of each issue. This requires each to pay attention to the presentations and draw inferences of similarities among the issues selected. The comment I most often hear from students is that allowing them to select current issues makes the course more relevant, and they can more easily make the connection to their everyday life. The ability to choose issues to explore helps students become more mindful learners (Langer 1997).

Students recognize that their written and oral communication skills are improved as a result of this course. By observing and evaluating their peers, they learn which behaviors and techniques are successful and which are not. Students better understand the importance of being able to express themselves clearly and eloquently in both formats.

Many students initially express frustration with the requirement for group work and comment on difficulties in scheduling time to meet outside of class and the variable contributions of group members. Careful

grade distribution regarding the contributions of individuals to the whole are necessary and help allay concerns, as does devoting some class time to coordinating group planning. Students realize that this frustrating group work helps them learn how to delegate responsibilities, and they learn the importance of having a backup plan for when a group member drops the class or otherwise fails to uphold his or her part of the work. This real-life problem-solving skill is a valuable one. Perhaps most importantly, students come to understand how decisions are made. They realize the importance of scientific skepticism in evaluating contemporary issues, including applications of technology, to make informed decisions.

Assessment was based on improvements in writing quality, demonstration of skepticism, and the use of credible resources; by their own assessment, and mine as evaluator, they were less adept at these skills at the beginning of the term. I have brought each of them further along the path, as they have helped me to more clearly articulate my expectations and help students achieve them. Ultimately, the final assessment of the course will take place in future years as we track the progress of these students and determine whether the course, and the collegium, has met its goals.

Because Issues in Science and Technology is required of all students in the College of Arts and Sciences, regardless of the major, convincing students to appreciate and rise to the demands I place on them often is an uphill battle. The reward comes when students clearly articulate concepts of which they were completely unaware only a term earlier. Their expression of a clearer understanding of the distinction between science and technology and their realization of the importance of applying the skepticism of science to everyday situations is my reward as an educator. As has been expressed by others in this journal (Bernstein 1993; Ganem 1993), it is important to offer students ap-

proachable methods of acquiring scientific habits of mind. This course provides another model to help liberal arts educators enlighten and engage science and nonscience students in the process, excitement, and importance of learning about science and technology.

We in the College of Arts and Sciences at FGCU are fortunate in having a required core of upper division courses designed to address the university student learning outcomes, divorced from the strictly defined content-laden material of most college classes. Student-driven inquiry is a useful model for other classes that give science and nonscience students the opportunity to perfect the necessary skills of information and technological literacy, problem solving, and effective communication. That is, those who desire to help others use science as a way of knowing (J. Moore 1993).

When asked what they will recall in five years, students say they will continue to be aware and skeptical of what they are told. They understand that technology is changing the face of our world, and they say they appreciate the fact that being unaware of these issues gives others an unimpeded opportunity to decide our fate for us.

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