An Integrated Approach to Environmental Education: James Madison University's Integrated Science and Technology Program

Environmental problems can be best addressed not just by an elite cadre of technicians and engineers, but by people grounded in an integrated knowledge of technology, science, business, economics, ethics, and politics. The ISAT program at JMU aims to produce such well-rounded graduates. by James J. Winebrake and Steven P. Frysinger

Historically, our educational system has not been designed to meet the demand for an environmental problem-solver who can integrate knowledge of science and technology within a social context. Yet today's environmental problems require integrated problem-solvers who are also communicators and savvy information technologists.

The existing disciplinary (i.e., major) approach of higher education tends to guide students into subject matter that is deep, yet isolated and disjointed, taught by faculty who are detached from one another, working in various departments across campus. Students rarely gain an appreciation for the true interconnection of disciplines when there is no explicit link between what is learned in a given science course and what is being learned in another class.

The Integrated Science and Technology (ISAT) program at James Madison University (JMU) offers an alternative designed to develop problem-solvers who will meet the needs of an employer posting the *Help Wanted* announcement shown here.

Help Wanted

Environmental professional with science/technology background. Must be familiar with air, water, and waste problems and control technologies. Must be knowledgeable about business, regulatory, and political issues that affect the environment. Should have extensive computer training and work well in teams. Candidate must also be an exceptional communicator.

THE ISAT VISION

The ISAT program at JMU was established by a governor-appointed blue ribbon panel to develop what Russell Peterson, former director of research at DuPont, governor of Delaware, and director of the Office of Technology Assessment, referred to as "professional generalists,"[1] those who have the ability to integrate aspects of science, technology, economics, business, politics, and ethics into a consolidated method of problem-solving and thinking.

ISAT's panel of representatives from academe, government, and the private sector recognized that solving the technological problems of the future required an education grounded in basic science, but decidedly more broad and integrated. The student demand for such an integrated science education has been phenomenal; since 1993, ISAT has grown from an initial group of 40 students to over 700 students.

A major objective of the ISAT curriculum is to develop graduates who are science generalists in the sense that they play a central role in solving scientific and technological problems in a context relevant to society. Students develop an understanding of the economic, social, political, and legal considerations that may drive solutions to technologically based problems. Using a computer is a central feature of the curriculum, as is an emphasis on collaborative (team) problem-solving.

The ISAT approach is guided by the principles of inquiry-based learning. It is specifically designed to engage students in studying science, business, and technology by combining scientific theory with hands-on experience.

ISAT Methodology

There are seven characteristics that, considered collectively, distinguish the ISAT program in its educational methodology.

1. **Integrated Instruction.** Subjects such as calculus, physics, biology, and chemistry are not treated in isolation. Real-life problems come to us through a mixture of disciplines, and ISAT students are confronted with this challenging truth early in their studies.
2. **Team Teaching.** Integrated instruction is difficult for professors educated in a scientific or technical specialty, so most courses are developed and taught by interdisciplinary faculty teams. This approach has an additional advantage in that it models problem-solving in the professional world.
3. **Consideration of Non-Technological Issues.** Complex, technological problems often have solutions constrained and motivated by politics, economics, ethics, or some other

issue. This social dimension of science and technology is a common theme throughout the four years of study.

4. **Collaborative Learning.** Developing teamwork skills further prepares students for the contemporary workplace.
5. **Intrinsic Use of the Computer.** The computer is used as a problem-solving tool throughout the curriculum. Students use a variety of software and take specific courses covering how information systems affect business, science, and technology.
6. **Use of Modern Teaching Methods.** Student-centered teaching and inquiry-based learning methods improve learning and increase student motivation and interest. In the ISAT program, these approaches are coupled with instructional technology to communicate concepts that are often foreign or arcane to the undergraduate.
7. **Development of Motivational Content.** By actively engaging students in the practice of science, faculty members can share their excitement for the topic with their students.

THE ISAT ENVIRONMENT CURRICULUM

Curriculum Overview

ISAT aims to produce a scientific generalist broadly acquainted with basic science, information systems, and business. During their freshman and sophomore years, all students study the role of science and technology in society, discrete and continuous mathematics, information systems, knowledge-based systems, statistics, management, organizational behavior, chemistry, physics, biology, environmental science, engineering, and manufacturing.

Students pursue deeper study during the junior year, taking three courses each in three "sectors"chosen from the following: energy, environment, manufacturing, biotechnology, knowledge management, health systems, or telecommunications. In the senior year, students select concentrations requiring at least four additional classes in one of the sectors, as well as their senior thesis projects. Teamwork and lab work in the requisite sciences is heavily emphasized.

The environment sector provides students with an appreciation of environmental concerns in today's society by teaching fundamental concepts in environmental science, pollution control technologies, environmental management techniques, and regulatory approaches. Students apply the latest computer technology and software to their investigations, and address problems within the framework of environmental management and stewardship.

About 75% of those students who concentrate in the environment sector also opt to concentrate in at least one other area. This approach is unique in environmental education because few, if any, graduating environmental engineers have taken advanced coursework in manufacturing systems and, perhaps more important, few graduating manufacturing engineers have taken advanced courses in environmental science. A sustainable society requires environmentally aware graduates in many professions.

Environmental Management in the Curriculum

Given JMU's location in the headwaters of the Shenandoah River (a major contributor in the Chesapeake Bay watershed), it is not surprising that there is considerable emphasis on surface water quality and non–point source pollution in our program. However, our students are also interested in public land management, sustainable agriculture, air quality, and growth management and planning. Many students are seeking careers in industrial environmental management, including environmental compliance, occupational safety and health, and such areas as industrial ecology, pollution prevention, and design for environment. Other students pursue natural resources management. Some of our courses clearly fall into one area or another, and some cross the boundaries, while the overall curriculum maintains a broad systems perspective.

RESEARCH AND OUTREACH

Faculty Research

ISAT's faculty of 35 specialize in manufacturing, biology, chemistry, environmental science, ecology, economics, political science, computer science, philosophy, business management, and physics. The six faculty members who manage the environment sector have considerable expertise in information systems, air quality, agroforestry, hydrology, chemistry, occupational safety and health, ecology, and energy. Faculty members also have extensive experience outside of academe, and they often use these experiences in their teaching and student advising. Environment faculty research activities, which usually feature some level of student involvement, include water quality assessments, ecological fieldwork, air pollution modeling, transportation analysis, watershed analysis, environmental information systems, and risk analysis. Centralized offices encourage the development of interdisciplinary teams of faculty and students.

Our faculty are involved in a potpourri of student-engaged research projects, including

- developing a greenhouse gas inventory for the Commonwealth of Virginia;
- creating a novel computer simulation role-playing game for air quality management at national parks;
- leading efforts to partner universities and national parks across the country to address energy and environmental issues at the parks;
- conducting water quality assessments on local rivers and streams;
- measuring emissions from in-home products and discerning how these products affect indoor air quality;
- working to promote alternative fuel vehicles on campus and off, including studying the emissions characteristics of these vehicles;

- developing environmental education material and workshops for K-12 teachers; and
- implementing an ISO 14001 environmental management system for the university.

In addition, a well-equipped analytical environmental lab that includes gas chromatography, atomic absorption, ion chromatography, and FTIR equipment allows faculty to conduct environmental analyses in compliance with U.S. Environmental Protection Agency (EPA) test methods and protocols. The environment sector also operates a mobile lab so students and faculty can study environmental problems in the field, throughout the Shenandoah Valley.

Environmental Education and Outreach

ISAT is very active in promoting and fostering environmental education in the K-12 area, as well as throughout the community at large. Our interest is manifested in several ways, ranging from participation in the development of a new governor's school with an environmental science theme to an environmental education center at the head of the Shenandoah River. ISAT faculty members regularly assist local educators with student research projects, demonstrations, and science and career fairs. Among other goals, we hope this outreach will encourage nontraditional students to enter the science and technology fields, as well as produce more environmentally aware citizens.

ISAT attracts nontraditional students who are interested in science and technology but do not want to become "scientists."

Outreach to External Sponsors

Another important and unique aspect of the ISAT program is its effort to develop mutually beneficial partnerships with business, government, and nonprofit organizations. ISAT encourages students and faculty to work with "external sponsors" in their courses and senior thesis projects. We hold regular meetings with local sponsors, and even have administrative personnel whose responsibilities include nurturing these external relationships. By working with external sponsors, students gain a useful perspective on problem-solving in a real-world context, while our external sponsors receive valuable student and faculty input on the important problems these sponsors face.

Some of our partners include the U.S. Department of Energy, EPA, the Virginia Department of Environmental Quality, the National Park Service, the U.S. Forest Service, Merck Pharmaceuticals, Coors Brewing Co., and AT&T.

ASSESSING SUCCESS

ISAT attracts nontraditional students who are interested in science and technology but do not want to become "scientists" or "engineers." They enjoyed high school science and math classes, but do not necessarily see themselves working in a chemistry lab or behind a drafting bench.

Our environment students want a different career experience—one that maintains a connection with environmental science and technology but also allows them the opportunity to work on multi-faceted problems that combine environmental issues with other science and non-science issues. Such a student is in high demand by those industry, government, and consulting companies that need environmental and project managers who understand the many dimensions of environment-related problems.

ISAT environment students have found positions with American Management Systems, Andersen Consulting, Bechtel, Booz Allen & Hamilton, CMG Information Systems, the U.S. Department of Energy, Electronic Data Systems, ICF Kaiser, Merck, the National Park Service, and Science Applications International Co. A small percentage of environment students have chosen traditional, science-related graduate programs or law or business school.

Although the true success of the ISAT program does not rest solely on its ability to produce attractive students for future employers, the continued demand for our students from the companies mentioned here suggests that they are well-prepared for the environmental challenges facing industry and government.

CONCLUSION

Contemporary environmental problems cannot be solved exclusively by an elite group of environmental scientists or engineers, but must be addressed by people who appreciate the multidisciplinary nature of these problems and know how to work within a systems framework to solve them. ISAT students must learn to synthesize information from many topical areas, analyze this information, and develop solutions appropriate for the social and economic settings in which they will be deployed. ISAT is one approach to developing such an environmentally educated professional generalist, adept at managing the array of environmental problems that we will have to address in the coming decades.

REFERENCE

1. Peterson, R.W. In *Rethinking the Curriculum*; Clark, M.E.; Wawrytko, S.A., Eds.; Greenwood Press: Westport, CT, 1990: pp 215-226.

About the Authors

Dr. James J. Winebrake and Dr. Steven P. Frysinger teach in the environment concentration in the ISAT program at JMU. More information about ISAT can be found at *www.isat.jmu.edu*, and about the environment concentration in particular at *www.isat.jmu.edu/environment*. Dr. Winebrake can be reached at winebrjj@jmu.edu, and Dr. Frysinger can be reached at frysinsp@jmu.edu. In 1999, the JMU Student Chapter of A&WMA won first-place honors for student chapters in the middle-division category.