Development of a B.S. Degree Program in Environmental Science

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ABSTRACT

Increasing national and international concern over environmental quality and an awareness of the large social and economic costs of environmental problems have led to burgeoning job opportunities for technically trained individuals who can cope with complex problems involving environmental quality assessment and control. Individuals with a broad understanding of environmental problems combined with specific technical skills are in high demand for employment with governmental agencies, industry, and private consulting firms. It is the purpose of this curriculum to train professionals who can meet the challenges posed by environmental management in the next century. The first 2 yr of the program concentrate on the development of essential skills in basic and applied sciences and mathematics. For this reason it is possible for students to declare entry into the program as late as their junior year and still complete the program in 4 yr. The curriculum contains considerably more mathematics and physical sciences than many previous environmental science programs that have had a reputation as nontechnical curricula. A recommended internship between junior and senior years is coordinated with private sector and government employers. All seniors participate in a senior seminar, which provides orientation to opportunities in environmental sciences and training in communication skills. Students in this program major in *environmental science* with one of three options: waste management, aquatic resources, or land resources. Courses for the freshman and sophomore years are common across all options. In the junior and senior years, some courses are common to all options, but the majority are option-specific.

HEIGHTENED AWARENESS of environmental pollution caused by improper waste disposal, accidental discharges of hazardous materials into the environment, and general ecosystem disturbance has led to a great increase in employment opportunities for technically trained individuals who can cope with complex problems of environmental quality assessment and control. Due to growing worldwide industrial production, urbanization, and increasing needs for agricultural production, the need for trained professionals will increase in the foreseeable future. A myriad of federal and state environmental regulatory programs has evolved over the past several decades, generating a tremendous demand for adequately trained environmental scientists in both the public and private sectors.

In developing this program, potential employers in state and federal agencies and in the private sector were solicited for input. Detailed replies were used in developing the curriculum and employment estimates. Most responded with estimates of their own needs, but nearly all stated that graduates from this program would be employable.

In the early 1970s, as a result of increased public interest in the environment, many universities initiated courses dealing with environmental protection and studies, and some began to offer majors in the field. There are an increasing number of universities that now offer an interdisciplinary program in environmental sciences. Many of these programs have obtained the reputation of being nontechnical curricula, which produce individuals who have a broad knowledge of many subjects but are masters of none (Weis, 1990). They are often particularly lacking in quantitative, problem-solving skills and in technological methodology for the solution of environmental problems. Many also focus on the theoretical bases of environmental problems without adequately preparing the student for the physical and biological difficulties faced in the field.

Environmental science is an important issue in undergraduate education, but one in which curricular issues generally have not been examined. "Environmental education" efforts are focused on in the curriculum for elementary and secondary schools. For example, the "Alliance for Environmental Education," a broad coalition of diverse scientific, educational, industrial, and environmental groups, focuses on programs for teacher training, dissemination of information, and outreach (Paulk, 1988).

At the college level, faculty in the traditional scientific and engineering fields have professional societies that provide mechanisms for discussion of curriculum issues, but there is no single professional society to which directors of environmental science programs are likely to belong (Weis, 1990). A number of studies in the 1970s discussed the content and structure of environmental programs (Aldrich and Kormondy, 1973; McCormick and Barrett, 1979).

Natural resource management as a subject matter discipline has long been associated with agricultural education in a limited way. Agronomy departments at land-grant universities have conducted environmentally related research for many years, but have not adjusted curricula to produce the broadly trained scientists needed to do environmental work. The study of soil is a prevalent example (Kirts, 1990). Over time, however, natural resource topics in agriculture have expanded to include water quality, energy, forests, wildlife, reclamation, and in general, a more global view of "land resources stewardship" (Committee on Agricultural Education, 1988). On

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the other hand, many of these natural resource programs are not adequately addressing modern environmental issues and technologies (Roy and Pearson, 1989).

The curriculum described in this article was designed to develop a broad understanding of environmental problems and the various scientific and engineering fields essential to their study.

STUDENT RECRUITMENT

Over the past several years, the recruiting program in the Department of Crop and Soil Environmental Sciences (CSES) at Virginia Polytechnic Institute and State University (VPI & SU) has more than quadrupled potential student contacts and increased enrollment from 38 to 122, with 65% of those students entering study in the area of environmental science. The mechanics of this recruiting effort was reported by McKenna (1990) and involved:

1. Preparation and distribution of a descriptive brochure
2. Development of a direct-mailing system to track interested high school juniors and seniors. This approach has been particularly effective for the CSES department over the past several years.
3. Integration of the environmental science recruitment effort with the overall recruitment program for the College of Agriculture and Life Sciences
4. Interaction with recruitment activities in the College of Engineering particularly with regard to the possibility of feeding graduates into the existing interdisciplinary M.S. program in environmental sciences and engineering
5. Some direct high school promotion by relevant faculty, especially in the initial years of the program. This includes direct presentations, attendance at job-fairs, and interaction with science and technology teachers

PROGRAM ADVISORY GROUP AND MANAGEMENT

Responsibility for continuing review of the curriculum, implementation of changes in the program of study, and procedures for student assessment rests with the Environmental Science Program Advisory Committee. This advisory committee includes representatives from the Departments of Agricultural Engineering, Agricultural Economics, Biology, Civil Engineering, Crop and Soil Environmental Sciences, and Geology, along with those departments within the College of Agriculture directly involved in natural resource management. This group was responsible for the development of this truly interdisciplinary curriculum, and ensures that it remains interdisciplinary. The program is managed by the CSES department with oversight by the Program Advisory Committee.

The chairperson of the Program Advisory Committee is responsible for implementing student outcome assessments and for communicating these results to advisory committee members as appropriate. The chairperson will also serve as liaison with student advisors to ensure consistency of advising quality.

INTERNSHIP PROGRAM

Internships are a real strength of this program. Internships offer a unique learning experience for the undergraduate student (Herring et al., 1990). Providing such internships to undergraduate students can be a challenge for faculty, but provides many benefits for the students (Muser and Flowerday, 1983). These benefits include the development of problem-solving skills (Barnes, 1987; Nelson, 1983), and vocabulary development (Anderson, 1985). Students learn the relevance of their on-campus education (Cessna, 1977; Hedin, 1983; Pedro, 1985), and they learn about the structure and responsibilities of a career with the company or agency following graduation (Herring et al., 1990).

A structured internship in which students work for a period of at least three months, typically between the junior and senior years, with a private firm or government agency in a position that provides relevant work experience is strongly recommended (university policy does not allow required internships). Internship positions are subject to approval by the student's faculty advisor. Internship programs have been established with a number of firms and agencies with whom regular contact has been maintained. We anticipate that an excess of job demand over student supply will arise for student placement into such a program. Potential employers view this program as an efficient way to screen potential employees, to compete more effectively for qualified employees, and to facilitate the transition of new employees into an organization.

Environmental problems are international in scope, and many other industrialized countries, especially in Europe, have highly developed environmental protection regulations and technological protocols for dealing with environmental problems. Contacts already exist between faculty affiliated with the proposed program and universities, government agencies, and private companies in England, Germany, Switzerland, Netherlands, and China. These contacts are being pursued further with the aim of expanding the program to include overseas internships. This is expected to have many benefits for the students as well as the program as a whole.

SAMPLE PROGRAM

All students in this program major in environmental science (ENSC). However, there are three options: waste management, aquatic resources, and land resources. Courses in the freshman and sophomore years are common across all options. In the junior year, about half the courses are common to all options; but in the senior year, the majority are option-specific (Table 1).

The first 2 yr of the program concentrate on the development of essential skills in basic and applied sciences and mathematics. For this reason, it is feasible for students to declare entry into the program as late as their junior year and still complete the program in 4 yr. All seniors participate in a senior seminar, which provides orientation to opportunities in environmental sciences and training in communication skills. A minimum of 130 semester hours are required for graduation.

Table 1. Course of study for environmental science curriculum.

Course	No.	Title	Fall semester	Spring semester
			h	
		Freshman year		
BIOL	1105	Principles of biology + laboratory	4	
BIOL	1106	Principles of biology + laboratory		4
CHEM	1035	General chemistry	3	
CHEM	1036	General chemistry		3
CHEM	1045	General chemistry laboratory	1	
CHEM	1046	General chemistry laboratory		1
ENGL	1105	Freshman English	3	
ENGL	1106	Freshman English		3
MATH	1016	Elementary calculus with trig. I	3	
MATH	2015	Elementary calculus with trig. II		3
		Humanities electives	3	3
		Total hours, freshman year	17	17
		Sophomore year		
CHEM	2114	Analytical chemistry		4
CHEM	2535	Organic chemistry	3	
CHEM	2545	Organic chemistry laboratory	1	
CS	1014	Numerical computational techniques		3
ECON	2115	Principles of economics *or*		
AGEC	1005	Economics of food & fiber system	3	
ECON	2116	Principles of economics *or*		
AGEC	1006	Economics of food & fiber system		3
GEOL	1004	Physical geology	3	
GEOL	1104	Physical geology laboratory	1	
MATH	2016	Elementary calculus with trig. II	3	
MATH	2514	Elementary differential equations		3
PHYS	2405	Elements of physics	3	
PHYS	2406	Elements of physics		3
		Total hours, sophomore year	17	16
		Junior year		
CSES	3114	Soils	3	
CSES	3124	Soils laboratory	1	
CSES	3604	Man & environment		3
ENGL	3764	Technical writing		3
GEOL	4114	Groundwater hydrology	3	
		Option requirements	6	6
		Free electives	3	3
		Total hours, junior year	16	15
		Senior year		
STAT	4604	Statistical methods for engineers	3	
CSES	4594	Soil and groundwater pollution	3	
ENSC	4004	Senior seminar	1	
		Option requirements	6	15
		Free electives	3	3
		Total hours, senior year	16	18
		Total hours (4 yr)	130	

(Continued)

Table 1. Continued.

Course	No.	Title	Fall semester	Spring semester
			h	
		Option Requirements (33 h)		
I. Waste management option				
A. Additional required courses				
	AGE	3304	Soil & water conservation engineering	3
	AGE	4324	Nonpoint-source pollution	3
	BIOL	3604	General microbiology	3
	BIOL	3614	General microbiology laboratory	1
	BIOL	4254	Microbiology of aquatic systems	3
	CE	4164	Hazardous waste management	3
	CSES	4644	Soils for waste disposal	3
			Total hours	19
B. Technical electives (minimum of 14 credits required)				
	AGEC	3341	Environmental law	3
	AGEC	4304	Natural resource economics	3
	BIOL	4684	Soil microbiology	2
	BIOL	4694	Soil microbiology laboratory	1
	CE	3104	Introduction to environmental engineering	1
	CE	4104	Water & wastewater treatment plant design	3
	CE	4114	Fundamentals of public health engineering	3
	CE	4124	Water quality management	3
	CE	4344	Water resources planning	3
	ECON	4014	Environmental economics	3
	ENT	4264	Pesticide usage	3
	LAR	4044	Land analysis and evaluation	3
	MATH	3524	Matrices, modeling & linear programming	3
	MATH	4544	Ordinary & partial differential equations	3
	MATH	4554	Numerical methods for engineers	3
	MGT	3304	Administrative theory & practice	3
	UAP	4374	Land use, environmental policy & planning	3
	UAP	4384	Pollution control planning & policy	3
II. Aquatic Resources Option				
A. Additional Required Courses				
	AGE	4324	Nonpoint-source pollution	3
	BIOL	3604	General microbiology	3
	BIOL	3614	General microbiology laboratory	1
	BIOL	3104	Principles of ecology	3
	BIOL	4004	Freshwater ecology	4
	FIW	4614	Fish ecology	3
	CE	4124	Water quality management	3
	ENT	4354	Aquatic entomology	3
			Total hours	23

(Continued)

Table 1. Continued.

Course	No.	Title	Fall semester	Spring semester
			h	
B. Technical electives (minimum of 10 credits required)				
AGEC	3341	Environmental law	3	
AGEC	4304	Natural resource economics	3	
BIOL	3114	Field and laboratory ecology	1	
BIOL	4154	Microbiology of aquatic systems	3	
BIOL	4234	Algae	4	
BIOL	4464	Zooplankton ecology	4	
CE	4114	Principles of public health engineering	3	
CE	4164	Hazardous waste management	3	
CE	4344	Water resources planning	3	
ECON	4014	Environmental economics	3	
ENT	4264	Pesticide usage	3	
GEOG	4354	Introduction to remote sensing	3	
MGT	3304	Administrative theory & practice	3	
UAP	4384	Pollution control planning & policy	3	
III. Land resources option				
A. Additional required courses				
AGE	3304	Soil & water conservation engineering	3	
CSES	4124	Soil morphology & cartography	3	
CSES	4644	Soils for waste disposal	3	
GEOG	4354	Introduction to remote sensing	3	
GEOL	3204	Geomorphology	3	
GEOL	3404	Structural geology	3	
UAP	4374	Land use & environment: planning & policy	3	
		Total	20	
B. Technical electives (minimum of 13 credits required)				
AGE	3304	Soil & water conservation engineering	3	
AGEC	4304	Natural resource economics	3	
AGEC	3314	Environmental law	3	
CSES	4134	Soil genesis & taxonomy	3	
CE	4344	Water resources planning	3	
CE	4164	Hazardous waste management	3	
GEOG	4104	Advanced physical geography	3	
GEOL	3114	Introduction to meteorology	3	
GEOL	4414	Engineering geology	2	
LAR	2024	Basic landscape architecture technology	3	
MGT	3304	Administrative theory & practice	3	
PSCI	1016	Introduction to government & politics II	3	
PSCI	3424	State & local government	3	
UAP	3054	Urbanization & environment	3	
UAP	4384	Pollution control planning & policy	3	

When compared to conventional agriculture or resource management curricula at this university and elsewhere, this program is rigorous, particularly with regard to mathematics, physical sciences, chemistry, and applied environmental sciences. It is our intention to recruit and train students with a mix of strong quantitative skills and an interest in applied environmental problems. In the past these students have had to choose among more conventional agriculture, engineering, or biology degree programs that did not fully meet their personal needs nor those of employers. This curriculum will, hopefully, meet those needs.

SUMMARY

The B.S. in the environmental science curriculum described here takes advantage of existing faculty expertise and courses related to the management of environmental problems in several departments and colleges at VPI & SU to synthesize a broad but well-integrated program. Because the program is largely predicated on utilization of existing courses and currently available faculty, initial costs of the program are low. Within Virginia, approximately 25 to 50 job openings in this field are available per year in various regulatory agencies, along with similar demand by private consultants. For example, faculty within the CSES Department handled over 40 requests for qualified students in 1990, but had only a handful of graduates to recommend. Due to the strong demand for technically trained individuals in the field, prospects for student placement are expected to be very good. As a result, risks of a program failure are very low, but the potential benefits are great. The internship program is a unique aspect of this degree program. The opportunity to serve an internship is of great benefit to the student and to potential employers. Students trained in this program will be in a position to contribute significantly to the social welfare by assisting in the development and implementation of technically sound solutions to environmental problems. This program is presented here in the hope that others might adopt similar curricula at their institutions. This is not presented as a finished program, but a starting point which may change with future employment demands and social needs.

REFERENCES

Aldrich, J.L., and E.J. Kormondy. 1973. Content and structure of environmental programs. J. Environ. Educ. 3:1-4.

Anderson, W.A. 1985. Agronomic terminology. Do our students comprehend? J. Agron. Educ. 14:73-76.

Barnes, R.F. 1987. Human resource needs, educational challenges and professionalism in the agronomic sciences. J. Agron. Educ. 16:49-51.

Cessna, D. 1977. Experimental learning: A detail case study. NACTA J. 21:8-11.

Committee on Agricultural Education in Secondary Schools. 1988. Understanding agriculture: New directions for education. Board on Agriculture, Natural Research Council, National Academy Press, Washington, DC.

Hedin, D. 1983. The impact of experience on academic learning: A summary of theories and review of recent research. Rep. 9. Inst. for Responsive Education, Boston, MA.

Herring, M.D., C.J. Gantzer, and G.A. Nolting. 1990. Academic value

of interships in agronomy: A Survey. J. Agron. Educ. 17:13–17.
Kirts, C.A. 1990. Linking agricultural and environmental education by interacting environmental concepts and vocational skills. NACTA J. 34:31–35.
McCormick, F.J., and G.W. Barrett. 1979. Structure of environmental science curriculum. BioScience 29:419–424.
McKenna, J.R. 1990. Development and Implementation of a recruiting strategy for an undergraduate agronomy program. J. Agron. Educ. 19:150–155.
Muser, L.E., and A.D. Flowerday. 1983. Providing experimental education for crop science students. J. Agron. Educ. 12:73–76.
Nelson, C.J. 1983. Curriculum trends in crop production and management. J. Agron. Educ. 12:92–99.
Paulk, J. 1988. Environmental education. Environ. Sci. Technol. 22:25–27.
Pedro, J.D. 1985. Cooperative experimental education programs: The effect of their structure. J. Coop. Educ. 21:9–19.
Roy, S., and C. Pearson. 1989. Natural resources and forestry: More than fishing and cutting trees. The Agricultural Education Magazine 61:17–19.
Weis, J.S. 1990. The status of undergraduate programs in environmental science. Environ. Sci. Technol. 24:8.