Interdisciplinary Approach to Environmental Education

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Abstract: This paper examines the need for an interdisciplinary educational approach in environmental engineering and science, discusses the constituents of interdisciplinary environmental education, and addresses its advantages. A case of interdisciplinary environmental education within the Interfaculty Graduate Environmental Sciences Program at the American University of Beiurt is then presented. Specifically, this newly created program is introduced with a description of its structure, content, and performance in terms of mission accomplishment, student enrollment, and marketability of its graduates. Future curriculum development and constraints are also examined.

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Introduction

In many respects, environmental degradation has become one of the most prominent adverse phenomena in today's world. The scope of environmental problems has grown substantially in the past decade and will continue to expand and diversify more in the future; no generation has ever faced a more daunting agenda. The world today confronts a multitude of environmental problems, more than ever before, over a wider range of spatial and temporal scales, and requiring various skills for proper control (Luthy et al. 1992). Consequently, the profession of environmental engineers and scientists is becoming increasingly multidisciplinary, and necessitates the integration of expertise from a wide range of fields (Luthy and Small 1990; Mino 2000).

The total environment consists of and is impacted by various interconnected frameworks, namely, physical, biological, social, legal, political, economic, and cultural. The interrelationship between such elements is a major consideration needed to develop integrated environmental solutions that are acceptable from the standpoint of economics, political reality, and public attitudes. Today's environmental engineers and scientists are challenged to recognize the ramifications of the interdependence of such factors since environmental dilemmas cut across various disciplinary bounds, and thus cannot be resolved from a single perspective. It is well recognized that protecting and preserving environmental qualities require input from multidisciplinary experts, and that environmental engineering and sciences programs should be interdisciplinary in nature and include aspects of various engineering and science disciplines (Safferman et al. 1996; Bishop 2000; Mino 2000). A quality interdisciplinary environmental education offers vast opportunities and cultivates the ability of future environmental scientists and engineers to recognize the components contributing to environmental problems. Moreover, environmental education should emphasize critical and integrative thinking, develop communication and problem-solving skills, as well as highlight the role of attitudes, values, and commitments in resolving environmental issues (Anderson 1991; Theis 1996a; Simmons 2000).

This paper assesses the need for an interdisciplinary approach in environmental education. A case of interdisciplinary environmental education within the Interfaculty Graduate Environmental Sciences Program (IGESP) at the American University of Beirut is then presented. This newly created program is introduced with a description of its structure, content, and performance in terms of mission accomplishment, student enrollment, and marketability of its graduates. Finally, future curriculum development and constraints are examined in the context of exit surveys targeting graduating students.

Interdisciplinary and Multidisciplinary Approach in Environmental Education

Today's environmental problems have necessitated the continuous scrutiny and modification in the structure and content of environmental curricula, particularly that the magnitude, diversity, and changing nature of the environmental market and regulations have made it difficult for educational institutions to address the obligations in the environmental practice (Weisner and Theis 1996). This environmental revolution has gradually forced environmental education to enter a new era, especially in higher education institutions. Universities have been and still are regularly revising their engineering and science curricula in order to meet the requirements of the profession, and keep up with requirements of industry, municipalities, and other government agencies (Tansel 1994; Mino 2000).

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In the past decade, university-level environmental education was subject to great controversy as whether it should be delivered as disciplinary education, or instructed within interdisciplinary and multidisciplinary frameworks. Moreover, a debate as to whether environmental sciences and engineering should be taught as an application area or a discipline resulted in diverse models of teaching. A single formula for environmental education seems unlikely, and perhaps even undesirable. Various schools may adopt different educational missions, and various student constituencies will require different educational approaches (Weisner and Theis 1996).

Historically, the environmental education system did not allow adequate interplay between disciplines, and did not view engineering and scientific phenomena from different perspectives (Tansel 1994). Early feedback of such an educational system indicated that students, in spite of their exposure to a number of different disciplinary approaches in environmental issues, often found it difficult to synthesize those approaches into a more holistic vision of the environment. Moreover, surveys and performance evaluation of graduates in environmental engineering revealed poor education in life sciences, public policy, ethics, and risk assessment, and indicated the need for better communication (oral presentation and writing skills), management, and leadership skills (Rowe 1978; Paustenbach 1987; Safferman 1996; Suidan and Biswas 1997; McCuen 1999). This led to several curricular reforms designed to provide the student with a greater sense of conceptual coherence, and to the development of an increasing number of program-dedicated interdisciplinary course offerings. Conceptual strength was further intensified by identifying solid threads that could be woven through environmental programs and link individual courses together (Hargreave 2000). Therefore, basic training programs started changing gradually from specific disciplinary fields to areas requiring multidisciplinary involvement. Consequently, educational institutions started developing comprehensive multidisciplinary programs that teach future scientists and engineers to be fully aware of various dimensions of environmental dilemmas, as well as to better understand the significance of their work in relation to environmental dynamics (Tansel 1994; Bishop 2000). It became obvious that understanding the behavior of environmental systems and solving environmental problems require the cooperation and employment of multidisciplinary efforts and concepts which meet at the ''environmental'' interface between disciplines, and mold together for the improvement of the total physical, biological, as well as social environment (Padival 1998; Wiesner and Theis 1996). Within the same context, the United States Committee on Science, Engineering, and Public Policy of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, emphasizes the need for ''broadening'' graduate education integration to respond to a working environment that will be ''more interdisciplinary, collaborative, and global'' while maintaining technical proficiency. Also, the American Society for Engineering Education stresses the need for engineering education to meet the challenges of ''international economic competitiveness, communications, and sustainable development'' by designing environmental engineering curricula that develop ''team skills'', ''a systems perspective'', ''an understanding of the societal, economic, and environmental impacts of engineering decisions'', and ''a multidisciplinary perspective''. However, broadening must not be adopted at the expense of technical proficiency. Therefore, the appreciation of management concepts, history, economics, and communication skills must be parallel with the need for good engineering and science fundamentals in environmental education (Wiesner and Theis 1996).

Recently, the study of environmental engineering and science has matured along the lines of individual subspecialties and evolved to unite traditional technological and engineering methods with the chemical, physical, mathematical, and institutional components of environmental problems, to achieve overall improvement in environmental quality (Weisner and Theis 1996). The goal of this curricular reform has been the establishment of tightly interwoven interdisciplinary programs that encourage students to engage in integrated learning, and to utilize systemic or rigorously holistic approaches to understanding and solving complex multifaceted environmental problems (Bishop 2000; Hargreave 2000). It is recognized that in the environmental arena, broad, holistic, or systemic thinkers are best suited to fulfill a role in a collaborative setting involving disciplinary experts. They can bridge gaps, coordinate the collaboration, and provide the overarching vision. In recognition of this essential epistemological characteristic, environmental studies programs always focus on interdisciplinary education (Hargreave 2000). This interdisciplinary approach in education, which gives students opportunities to explore interconnections among the subject areas they are studying, has many advantages. Interdisciplinary instruction adds significance and relevancy to knowledge as students discover compelling relationships between the disciplines. New perspectives are developed which help students construct a more integrated web of knowledge. Not only does this powerful knowledge structure facilitate the assimilation of new information, it also increases students' understanding of and appreciation for the wealth of information and ideas they already possess. Interdisciplinary environmental education equips future environmental engineers and scientists with adequate communication and socioeconomic skills, ethical character, and respect toward the environment, leadership and managerial capabilities, problem-solving abilities, in addition to technical insights and scientific fundamentals which are at the core of environmental engineering and science curricula. Such capabilities are prized in environmental engineers and scientists, and are practiced depending on an individual's career stage. Typically, technical competency may be paramount at the entry level, but communication, organizational, managerial, and social skills dominate by midcareer (Theis 1996b). Delivering interdisciplinary environmental education invites the contribution of diverse faculty members with backgrounds in the traditional legal sciences, economic and social sciences, natural and earth sciences, in addition to environmental and water resources engineers (Logan 1996; Theis 1996a).

Several universities have restructured their traditional academic disciplines of environmental engineering or sciences to meet the multidisciplinary nature of the profession. For example, the University of Karlsruhe in Germany has developed an alternative program whereby students may choose to major in environmental engineering within the context or on the basis of an economic and business administration curriculum. This program was established approximately ten years ago, and has proved viable and successful in terms of the number of enrolled students as well as employment of graduates (Hahn 2000). Also in Germany, the University of Paderborn redesigned its undergraduate environmental engineering program of study as an interdisciplinary curriculum whereby courses in basic natural sciences, process engineering/instrumentation, environmental law, and economy were introduced (Fettig et al. 2000). The Commission on Scientific Research and Teaching carried out a recent evaluation of the environmental research and teaching sector in Germany. Out-

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comes revealed higher grades for all of those institutions where good interdisciplinary programs of training and research existed in a combination of engineering disciplines with natural sciences or life sciences (Hahn 2000). Another example of the application of an interdisciplinary approach is the integration of environmental education and environmental management in the ''European Master's Program on Environmental Management'' which aims at providing holistic training of personnel concerned with environmental management. This initiative has been followed by various other European universities thus many institutions offering postgraduate diplomas or Master's degrees in environmental management now include environmental education components (Filho 1997). In North America, the traditional affiliation of environmental engineering to the departments of civil or chemical engineering is retreating, thus environmental engineering programs are standing as independent interdisciplinary degree programs, or merging with other diverse nonengineering groupings, such as geography and environmental sciences (Logan 1996; Bishop 2000). For instance, Texas Tech University has formulated a five-year master of environmental engineering curriculum to focus more on the environmental sciences of biology, chemistry, and geology rather than a broad civil engineering background (Rainwater et al. 1999). Also, the Faculty of Environmental Studies at Syracuse University-New York has developed an interdisciplinary program integrating the fields of environmental policy and science (Nordenstam and Smardon 2000). In Japan, the Department of Environmental Studies was established at the University of Tokyo to fuse different traditional disciplines, and develop novel approaches in solving environmental problems. Both faculty members and students have realized the importance of cooperation with different disciplines to cope with environmental problems, and organized various interdisciplinary activities within the department (Mino 2000).

Need for University-Level Environmental Education in Lebanon

As mentioned previously, the scope of environmental degradation has grown substantially worldwide. However, consequences may be more profound in countries that lack comprehensive environmental management strategies, environmental quality standards and codes, proficient human resources, adequate financial resources, and public environmental awareness.

Within this context, the Middle East, in general, and Lebanon in particular, is no exception in suffering from major environmental problems and natural resource degradation. Fifteen years of civil unrest (1975–1990) resulted in the devastating deterioration of natural resources. Environmental pollution is evident throughout the country and exhibited various types of degradation whether water (coastal and inland surface, and ground), soil, and air (indoor and outdoor). In recent years, the Government started dealing with environmental issues with a more systematic approach, but due to the limited availability of resources, environmental management has lagged far behind the socioeconomic development and other infrastructural requirements.

More recently, an increase in public awareness toward environmental issues has been noted at the nongovernmental level. Nongovernmental organizations, private and public associations, youth organizations, and mass media are making considerable efforts to promote awareness and launch environmental campaigns. Undoubtedly, such efforts can help in developing environmentally literate citizenry through the provision of basic knowledge, skills, and life habits that translate into a community that is more able to lead its life in an environmentally healthy framework. However, such efforts are not adequate to remedy the present adverse environmental situation and prevent further deterioration.

Table 1. Educational Indicator in Selected Countries for the Academic Year 1998–1999

Country	University students/1000 population
Australia	36.2
Canada	27.3
China	27.3
Cyprus	35.0
Germany	22.0
Israel	18.6
Jordan	24.4
Lebanon	***29.2***
Tunisia	21.7
United States	54.0

Note: Sources: Lebanon 1998; Jordan 1999; China 1999; Australia 2000; Cyprus 2000; Tunisia 2000; United States 2000; Canada 2001; Germany 2001; Israel 2001.

Practical environmental management cannot be implemented in the absence of comprehensive environmental policies and legislation, well-defined responsibilities and action plans, cooperative environmental auditing and monitoring authorities, and, most importantly, proficient local expertise, such as environmental scientists, engineers, economists, and administrators. In fact, the availability of human resources is a major limiting factor for the existence, performance, and implementation of the other mentioned criteria.

The current adverse environmental situation in Lebanon necessitates a considerable number of multidisciplinary environmental professionals, capable of identifying and solving environmental problems within proper natural, technical, economic, social, ethical, and political frameworks. However, the country suffers from a shortage in such professionals, and thus either relies on foreign human resources or employs local professionals in closely related fields. This shortage may be highly attributed to the lack of environmental education at various universities. Quality environmental education can serve as a measure to quench the demand for local environmental professionals. In fact, effective university-level environmental education is a vital and urgent need for capacity building in Lebanon and the Middle East in general to meet future environmental challenges.

University-Level Environmental Education in Lebanon: Current Situation

Currently, 44 higher education institutions exist in Lebanon, of which 17 are classified as universities (Ministry of Education and Higher Learning 2001). The country's nine major universities [American University of Beirut (AUB), Balamand University (BU), Beirut Arab University (BAU), Haigazian University (HU), Holy Spirit University of Kaslik (USEK), Lebanese American University (LAU), Lebanese University (LU), Notre-Dame University (NDU), and Saint Joseph University (USJ)] had a total number of about 101,440 students in the academic year 1998–1999, resulting in a relatively high student-to-population ratio (Table 1), thus indicating that effective university-level environmental education can reach a considerable portion of the population.

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Table 2. Environmental Programs Offered in Major Universities in Lebanon

University	Degree
American University of Beirut (AUB 2001)	• Bachelor of Engineering Civil and Environmental Engineering • Master of Engineering Environmental and Water Resources Engineering • Bachelor of Science Environmental Health • Master of Science Environmental Science Environmental Technology Ecosystem Management Environmental Health • Environmental Policy Planning
Balamand University (BU 2000)	• Bachelor of Science Public Health and Development Sciences
Lebanese American University (LAU 2000)	• Bachelor of Science Civil and Environmental Engineering
Notre-Dame University (NDU 2000)	• Bachelor of Science Environmental Sciences
Saint Joseph University (USJ 2000)	• Bachelor and Master of Science Life and Earth Sciences • Master of Science Option Water and Environment • Postgraduate diploma in Water Sciences • Doctorate Water Sciences

Generally, universities have complete autonomy in constructing their individual curricula. Thus, academic university programs vary according to the educational objectives set by each university. Within the same context, the mode and goals of university-level environmental education varies among the different universities. In general, environmental education is taught as an independent subject matter in some programs, or is integrated in some courses (mainly engineering and science courses) in other programs. In some universities, environmental education is limited to very few courses. In fact, five universities offer a degree in environmental sciences, or civil and environmental engineering at the undergraduate level, whereas only two universities offer a degree in environmental engineering or sciences at the graduate level (Table 2).

Interfaculty Environmental Sciences Program: Case Study

In view of the present diverse and complex environmental dilemmas, the AUB in Lebanon launched an IGESP in the year 1997. The program was supported greatly by the United States Agency for International Development by funding various research and laboratory facilities.

General Description

The Interfaculty Graduate Environmental Sciences Program is a multidisciplinary field of study which leads to the Master of Sciences (MS) degree in Environmental Sciences with four possible majors namely, Environmental Technology, Ecosystem Management, Environmental Health, and Environmental Policy Planning. The Environmental Policy Planning track has recently been approved and will start in the Spring 2003. IGESP draws on the resources of various faculties/departments and provides opportunities for study and research in the field of the environment in its totality. While the program caters mostly to physical and natural sciences students, it is offered to students holding a Bachelor's degree in any approved discipline of engineering or science. It provides graduates with the necessary tools to assess diversified and multidisciplinary environmental issues. The program focuses on enhancing students' research, analytical, problem-solving, and critical-thinking skills by emphasizing the case study approach to learning and solving environmental problems. After graduation, students may practice the acquired profession and/or pursue higher education. Administratively, the IGESP is administered by an Interfaculty Coordinating Committee representing all Faculties in the university. While the members of the committee are appointed by the Deans of the various faculties, the committee ultimately reports to the Provost of the university as well as the Deans. As admission requirements, an applicant to IGESP must (1) meet general University requirements for admission to graduate study, (2) be recommended by the appropriate Faculty Graduate Committee and accepted by the Interfaculty Coordinating Committee of the Program, and (3) meet the necessary background in the physical, natural, and mathematical sciences. Alternatively, the Academic Advisor may suggest remedial courses for those who lack this background. Graduation requirements for the MS degree in Environmental Sciences are:

- Completion of 12 credits (4 courses) of core courses,
- Completion of 12 credits (4 courses) of electives,
- Completion of 6 credits equivalent to an MS thesis,
- Attendance of the seminar in environmental sciences,
- Maintaining a minimum overall average of 80 over 100,
- Passing a comprehensive exam
- Passing a thesis defense, and
- Satisfying University residency requirements (typically one year).

It is noteworthy to mention that the program was initiated with 18 credits (6 core courses) which was recently decreased to 12 credits in response to a program evaluation at the end of five years. A nonthesis option is also available whereby the thesis is replaced by a three-credit project, and a three-credit additional elective.

Curriculum and Course Description

The IGESP curriculum is composed of various courses that span diverse disciplines and are structured to provide students with a diversified and multidisciplinary background in environmental sciences (Table 3). Mandatory core courses (Group A) serve as introductory courses that provide a road map to guide students through the array of disciplinary offerings to follow. The Seminar in Environmental Sciences exposes students to the latest technologies, legislation, current research, or applied projects through presentations by faculty members; guest speakers from the indus-

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Table 3. List of Most Relevant Courses (1998–2002)

Group	Type	Title	Faculty
A	Core	Environmental technology	FEA
		Natural resources management	FAFS
		Toxicology and environmental health hazards	FHS
		Environmental policy	FAS
		Seminar in environmental sciences	FAFS/FEA/FAS/FHS
B	Elective	Air pollution and control	FEA
		Solid waste management	FEA
		Water and wastewater treatment	FEA
		Methods of environmental sampling and analysis	FEA
		Environmental impact assessment	FEA
		Industrial/hazardous waste management	FEA
		Water and sewage design	FEA
		Environmental chemistry and microbiology (with lab)	FEA
		Groundwater hydrology	FEA
		Resources and environmental economics	FAFS
		Agricultural pollution and control	FAFS
		Physical and biological resources in terrestrial ecosystems	FAFS
		Research design and statistical methods	FHS
		Occupational health	FHS
		Epidemiology and biostatistics	FHS
		Environmental regulations and legislation	FAS
		Environmental ethics	FAS
		Environmental economics	FAS
		Environmental conflict resolution	FAS
		Population and community ecology	FAS
		Special projects	FAFS/FEA/FAS/FHS
		Internship	FAFS/FEA/FAS/FHS
C	Special	Master of science or project thesis	FAFS/FEA/FAS/FHS

Note: FEA: Faculty of Engineering & Architecture, FAFS: Faculty of Agriculture & Food Sciences, FHS: Faculty of Health Sciences, and FAS: Faculty of Arts and Sciences.

try, government, and other academic institutions; or recent graduates of the program. Elective courses (Group B) further nurture the students' knowledge and capabilities through the exposure to complex multidimensional environmental issues. Such courses reveal the natural, physical, mathematical, and institutional facets of the environment, and allow future environmental scientists to build a more holistic vision toward environmental dilemmas. The majority of the courses include projects about realistic environmental problems that allow students to demonstrate and enhance their independent ability in field work, literature search, interviews and surveys, basic environmental sampling and laboratory analysis, communication, teamwork, leadership, organization and management, as well as statistics and computer work. While it is not required to specialize in any one field, students are encouraged to do so, when feasible, as it helps them in selecting a thesis or project topic, as well as a future career. The MS thesis or project serves as a capstone course that ties and integrates the students' educational experiences together, and enhances their research, analytical, communication, and critical-thinking skills.

The criteria for selecting and developing the courses outlined under groups A and B included:

- The provision of students with a core and broad background in Environmental Sciences,
- The provision of students with the opportunity to specialize in specific Environmental fields,
- Ensuring that students will learn the skills and will possess an adequate knowledge in Environmental Sciences that will allow them to fill the market demand, and
- Eliminating or minimizing duplication in courses between Faculties and ensuring that faculty resources can meet the program's demands.

Note that the Faculty of Engineering and Architecture still offers the majority of courses. This can be attributed to the presence of a graduate program in Environmental and Water Resources Engineering in the faculty prior to the establishment of the Interfaculty program. Certainly, this trend is decreasing or will decrease as more courses are introduced from other faculties across the university, and as these courses are becoming more known to students. Note also that since the initiation of the program, no additional faculty members were hired. The program has relied primarily on existing members in various faculties.

Student Enrollment

Students holding a Bachelor's degree in any approved discipline of science or engineering are eligible to be enrolled in IGESP. The program has attracted students with various backgrounds, a phenomenon that affirms and strengthens its interdisciplinary nature. The majority of students hold an undergraduate degree in health sciences, agriculture, or natural sciences, followed by geological or medical sciences. Engineering students continue to register in the traditional MS program in Environmental and Water Resources engineering. Efforts to combine the latter with IGESP are ongoing. Fig. 1 presents the distribution of undergraduate backgrounds of students that have been enrolled in IGESP from 1997 to 2001. Student enrollment has been satisfactory for a newly

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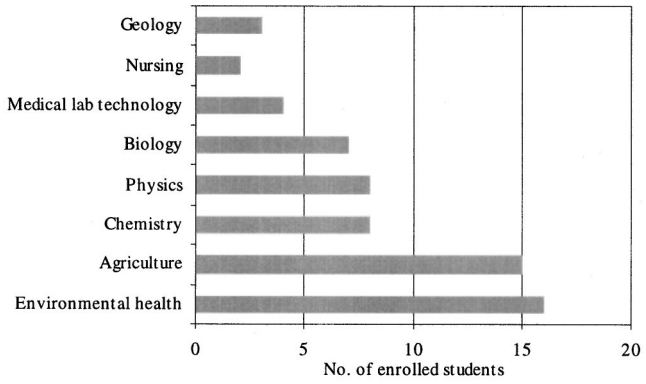

Fig. 1. Undergraduate backgrounds of students enrolled in the program from 1997 to 2001

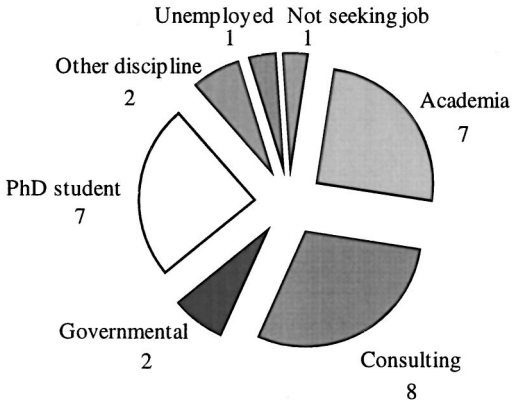

Fig. 3. Current occupational status of graduates from the Interfaculty Graduate Environmental Sciences Program

established graduate program (Fig. 2). As for previous career experiences of registering students, most are fresh graduates of undergraduate science programs while few have been serving as AUB staff or research assistants and have registered to IGESP as part-time students. Also, few students obtained jobs in the environmental industry before completing their graduate study.

Theses, Research Projects, and Publications

Research is a vital and integral component of graduate studies; thus students and faculty members in IGESP have been involved in numerous environmental research projects. Because of the interdisciplinary nature of the program, submitted theses and research projects target various environmental disciplines, namely, management of domestic and industrial wastewaters, solid wastes, environmental and occupational health, biodiversity and ecosystem management, environmental and water resources management, and air pollution assessment and control. Environmental research and services have resulted in the publication of over 200 articles, reports, and training manuals during the past 5 years. Nearly one-half of these are in internationally refereed journals. What is interesting to note is that none of the faculty members who are contributing to IGESP is dedicated on a full-time basis to the program. Indeed, all have been hired to fill unrelated positions in their respective faculties before the program even started.

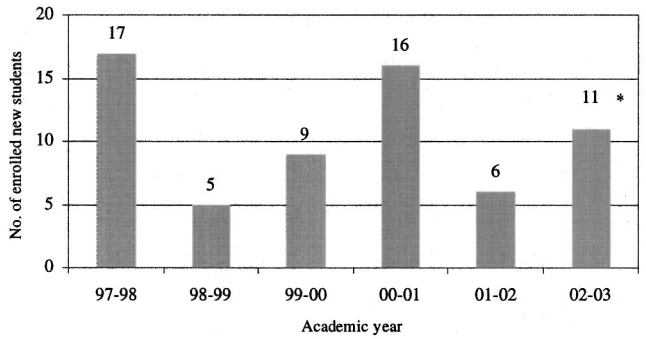

Fig. 2. Student enrollment in the program from 1997 to 2001 *excluding potential enrollment in the spring and summer semesters

Graduate Employment

Apart from student enrollment, the successfulness of any academic or institutional program can also be measured by the marketability of its graduates (Fig. 3). To date, twenty-eight students have graduated from IGESP. Graduates in environmental sciences have mostly found jobs with consulting firms, local government and regulatory agencies, or in academia. On the other hand, several graduate students have opted for the pursuit of higher education abroad.

Learning Experiences and Future Needs

Over the past three years, exit questionnaires were distributed to graduating students of IGESP (Table 4). The purpose of this survey was to identify educational deficiencies experienced by the graduating students, as well as highlight the positive aspects of the program. Such feedback is important for the continuous improvement of the program, and ultimately a better mission accomplishment. Results of the exit survey revealed that being exposed to a multidisciplinary environmental educational approach, learning new environmental concepts, integrating acquired knowledge in theses or professional and technical reports, as well as enhancing communication skills (writing and oral presentation) are among the best learning experiences of graduating students. On the other hand, students recommended additional concepts and skills to be included in the program for the better development of a comprehensive and sustainable vision of the surrounding environment, such as courses focusing on ecology; environmental laws, policy, and management; environmental economics; and environmental education. Moreover, field activities, internship, sampling and analytical applications, as well as environmental community work were proposed to be integral components of the program. These suggestions further corroborate the need for an interdisciplinary and multidisciplinary educational approach in environmental studies. Feedback from future graduating classes has been considered for further modifications and improvements of the program since the longevity of any academic program will ultimately be based on its quality as perceived by its students as well as its sponsors and coordinators. In response to students' feedback, the integration of a fourth specialization track in Environmental Policy and Planning was approved and will be initiated in Spring 2003. This proposed track may further narrow the educational gaps experienced by several graduating students by introducing into the program courses such as environmental policy,

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Table 4. Most Relevant Questions/Comments from Exit Interviews

Questions/Comments	SA	A	D	SD
Teaching in the program encouraged student involvement (group learning, cooperative learning).		■		
Teachers usually invited students to relate outside events/activities to subjects covered in the courses.		■		
Term papers and other take-home work were designed to encourage students to do independent research.		■		
The overall quality of instruction in my Program was not good.			■	
The content of required courses in my major were adequate.		■		
I have attended special talks, lectures, or panel discussions held on campus related to my field.		■		
The overall quality of academic advising provided to me was not adequate.			■	
I have worked with a faculty member on research projects.		■		
I have taken a course that required accessing information through the internet.		■		
The program I am enrolled in prepared me to apply my knowledge in my field to solve relevant problems.		■		
I am able to reinforce and support ideas from team members.		■		
The program helped me learn how to plan work and set goals.		■		
The program helped me learn how to communicate effectively with persons from other disciplines.		■		
The program enhanced my ability to convince others with my ideas and solutions by effective presentations.		■		
The program enhanced my ability to prepare professional technical reports.		■		
The program prepared me to make ethical decisions in my field.		■		
I was satisfied with the topic and writing of my thesis.	■			
I would recommend thesis track to new students.		■		
Suggest important changes to teaching practices in the program.	Better integration, shorter duration, practical and lab skills, more specialization, less technical, more discussions with thesis committee.			
Recommend topics, skills, or concepts that were not covered during your study in the program that you feel strongly should have been covered.	Environmental management and economics, environmental laws and policy, environmental education , ecology, environmental sampling and laboratory applications, community work, training.			
Describe your best and worst learning experiences	Best: multidisciplinary groups, thesis, professional/technical reports, new concepts. Worst: administrative difficulties, funding problems, too many courses, unfair group projects.			

SA: Strongly agree; A: Agree; D: Disagree; SD: Strongly disagree

environmental regulation and legislation, environmental conflict resolution, environmental ethics, environmental economics, and population and community ecology. Moreover, this option will attract students with backgrounds in the arts (economics, public administration, sociology, political science, etc.) to enroll in the program. The program has also initiated a three-credit internship course whereby students can work on a well-defined project at a consulting firm or government institution during the summer while being periodically supervised by a faculty member. Initially, the three elective courses (air pollution control, solid waste management, and water/wastewater treatment) were given as core courses. During the five-year program evaluation, these courses were set as electives and a single core environmental technology course was introduced in an effort to balance core course offering between faculties while granting the choice to students to still take them as electives.

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Concluding Remarks

The scope of environmental problems has grown substantially in the past decade and will continue to expand in the future. Thus, environmental engineering and science education and practice should be flexible, and evolve to address present and future challenges. The profession can no longer be focused on a single environmental discipline. A lesson from the past is that graduates must be prepared for change by acquiring an interdisciplinary education that includes a mix of engineering, natural sciences, humanities, economics, and legal/social sciences. Such an interdisciplinary environmental program should strive for a multidisciplinary synthesis whereby knowledge from several disciplines must be brought together to understand the complex environment we live in. The mere juxtaposition of courses in a student's academic career does not serve to elucidate and visualize those relationships. Hence, while it is the case that the majority of environmental programs are multidisciplinary, few may be truly interdisciplinary in spite of their titles. To promote and ensure integrated learning across disciplinary boundaries, individual courses within the program should be seen themselves as part of a systemic whole rather than disciplinary monads. Moreover, a preference should be developed in students for holistic or systemic approaches to environmental issues. Such an epistemological mindset will greatly facilitate interdisciplinary environmental education, and consequently attain comprehensive and sustainable environmental development.

In environmental studies, it is highly recommended that environmental practitioners, whether in industrial, consulting, regulatory, or other private and public sectors, assist the graduate education process by serving as external review groups, providing seminars, and serving as adjunct faculty. Practitioners provide important perspectives on the value of research, and can point to new advances in design methodologies, emerging technologies, and novel approaches for solutions of modern environmental problems. Thus, they contribute in incorporating the most highly developed concepts of the profession into the educational enterprise. Merging research, consulting, and hands-on work experience in the educational process allows students to gain an understanding of how the fundamentals taught in courses relate to applied practice. As such, stronger links with the environmental market will benefit both parties. Also, the employment market may sometimes act as a mediator of the educational approach to be adopted. Finally, environmental engineers and scientists need to become more involved in emerging social and political issues relating to their field as to help structure and articulate rational environmental policy, and properly practice their profession at the interface between policy and technology.

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References

American University of Beirut. (2002). *Academic catalogue 2001–2002*, ⟨http://www.aub.edu.lb⟩ (Aug. 3, 2002).

Anderson, W. (1991). ''Environmental engineers: A shortage?'' *Civ. Eng. (N.Y.)*, 61(8), 6.

Australia. (2000). ''Australia Now.'' *Australian bureau of statistics*, ⟨http://www.abs.gov.au⟩ (July 25, 2002).

Balamand University. (2001). *Academic catalogue 2000–2001*, ⟨http://www.balamand.edu.lb⟩ (Aug. 3, 2002).

Bishop, P. (2000). ''Environmental engineering education in North America.'' *Water Sci. Technol.*, 41(2), 9–16.

Canada. (2001). *Statistics Canada*, ⟨http://www.statcan.ca/english/Pgdb/People/Education/educ03a.htm⟩ (July 23, 2002).

China. (1999). *China statistical yearbook*, ⟨http://www.stats.gov.cn/english/yearbookml.html⟩ (July 23, 2002).

Cyprus. (2000). *Statistical services*, ⟨http://www.pio.gov.cy/dsr/key_figures⟩ (July 25, 2002).

Fettig, J., Miethe, M., and Rathke, K. (2000). ''Four-year undergraduate course in environmental engineering in Germany.'' *Water Sci. Technol.*, 41(2), 55–59.

Filho, W. L. (1997). ''Integrating environmental education and environmental management.'' *Environ. Manage. Health*, 8(2), 80–82.

Germany. (2001). ''Institutions of higher education.'' ⟨http://www.statistikbund.de/basis/e/biwiku/hochtxte.htm⟩ (July 25, 2002).

Hahn, H. (2000). ''Environmental engineering education in conjunction with or as part of social sciences curricula.'' *Water Sci. Technol.*, 41(2), 47–54.

Hargreave, D. (2000). ''What constitutes an interdisciplinary environmental education?'' *Environmental writings at Western Michigan University*, ⟨http://www.wmic.edu/environmental-studies/Writings/hargreave2.html⟩ (July 2, 2002).

Israel. (2001). ''Statistical abstracts of israel 2000.'' *Central bureau of statistics*, ⟨http://www.cbs.gov.il/shnaton51/shnaton51.htm⟩ (July 24, 2002).

Jordan. (1999). *Department of statistics*, ⟨http://www.dos.gov.jo/sdb_jd⟩ (July 23, 2002).

Lebanese American University. (2001). *Academic catalogue 2000–2001*, ⟨http://www.lau.edu.lb⟩ (Aug. 4, 2002).

Lebanon. (1998). *Census for academic year 1998–1999*. Ministry of Education and Higher Learning, Center of Pedagogical Research and Development, Beirut, Lebanon.

Logan, B. (1996). ''1996 conference on environmental engineering education.'' *J. Environ. Eng.*, 122(3), 167.

Luthy, R., and Small, M. (1990). ''Environmental research: A clearer focus over a broader horizon.'' *Environ. Sci. Technol.*, 24(11), 1620–1623.

Luthy, R. et al. (1992). ''Future concerns in environmental engineering graduate education.'' *J. Prof. Issues Eng. Educ. Pract.*, 118(4), 361–380.

McCuen, B. (1999). ''A course on engineering leadership.'' *J. Prof. Issues Eng. Educ. Pract.*, 125(3), 79–82.

Ministry of Education and Higher Learning. (2001). Center of Pedagogical Research and Development, Beirut, Republic of Lebanon.

Mino, T. (2000). ''Environmental engineering education in Japan.'' *Water Sci. Technol.*, 41(2), 17–22.

Nordenstam, B. J., and Smardon, R. C. (2000). ''A perspective of educational needs in environmental science and policy for the next century.'' *Environ. Sci. Policy*, 3, 57–58.

Notre-Dame University of Loueize. (2001). *Academic catalogue 2000–2001*, ⟨http://www.ndu.lb⟩ (Aug. 4, 2002).

Padival, N. (1998). ''Discussion of undergraduate environmental engineering education.'' *J. Environ. Eng.*, 124(3), 199–201.

Paustenbach, D. (1987). ''Should engineering schools address environmental and occupational health issues?'' *J. Prof. Issues Eng. Educ. Pract.*, 113(2), 93–111.

Rainwater, K., Heyward-Ramsey, R., and Thompson, D. (1999). ''A five-year master of environmental engineering curriculum.'' *J. Prof. Issues Eng. Educ. Pract.*, 125(2), 40–46.

Rowe, D. (1978). ''Follow-up of environmental technology graduates.'' *J. Prof. Issues Eng. Educ. Pract.*, 104(1), 19–27.

Safferman, S., Utgikar, V., and Sandhu, S. (1996). ''Closure to 'Undergraduate environmental engineering education.'" *J. Environ. Eng.*,

122(9), 779–784.
Saint Joseph University. (2001). *Academic catalogue 2000–2001*, ⟨http://www.usj.edu.lb⟩ (Aug. 4, 2002).
Simmons, B. (2000). ''Towards excellence in environmental education: A view from the United States.'' *Water, Air, Soil Pollut.*, 123, 517–524.
Suidan, M., and Biswas, P. (1997). ''Specialist or generalist at the undergraduate level?'' *J. Environ. Eng.*, 123(3), 203.
Tansel, B. (1994). ''Outlook for environmental education in 21st century.'' *J. Prof. Issues Eng. Educ. Pract.*, 120(2), 129–134.
Theis, T. (1996a). ''Too many equations?'' *J. Environ. Eng.*, 122(6), 451.
Theis, T. (1996b). ''Trends in engineering: Education and practice.'' *Civ. Eng. (N.Y.)*, 66(11), 6.
Tunisia. (2000). *National institute of statistics*, ⟨http://www.ins.nat.tn/private/idc⟩ (July 25, 2002).
United States. (2000). *Statistical abstracts of the United States*, ⟨http://www.census.gov/prod/www/statistical-abstracts-us.html⟩ (July 24, 2002).
Wiesner, M., and Theis, T. (1996). ''Environmental engineering education: Application area and discipline.'' *J. Environ. Eng.*, 122(2), 89–90.