A MULTIDISCIPLINARY MASTERS PROGRAM IN GLOBAL TECHNOLOGY AND DEVELOPMENT

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Abstract

The College of Technology and Applied Sciences at Arizona State University initiated a new graduate concentration – Global Technology & Development (GTD) - for the M.S. in Technology degree in 2001. This paper presents the details of this truly multidisciplinary, innovative curriculum development in technology, which offers students the opportunity to study applications of technology for global development, how systems of technology interface, and technology's role in global economic, political, and social development and change. While the traditional M.S. in Technology disciplines produce specialized technologists, the GTD concentration integrates social scientific approaches to the study of human development with coursework in systems of technology to train students to become "technology interpreters" for careers in technology-related public policy, administration, government service, and international development and management. Some of the central issues addressed in this concentration include technological change and its effects on societies and their economies, and how, in turn, social change influences technological advance. Thus, engineering students are exposed to graduate level theoretical foundations in the social sciences, and liberal arts students are exposed to courses in information technology software, transportation systems, technology forecasting, and sustainable energy studies. The experience of implementing this multidisciplinary graduate program, bridging technology and the social sciences, provides a model for further multidisciplinary curriculum development.

Key words: global technology and development, social sciences and engineering, international development and engineering

Introduction

The impact of technology on societies, economies and political systems, especially in developing countries, can be multifaceted. While it can enhance the economy of a country or region, it can also cause unintended consequences, perhaps at the cost of local culture, life style, and regional development. A current example is the water and

development project in the Southeast Anatolian Region of Turkey [1, 2], a region that has experienced large scale development projects, including the Ataturk Dam, one of the largest in the world. Technological change is being introduced to modernize and increase irrigation and farming, and a new international airport is being designed to serve the region, which is also seeking foreign direct investment. The Turkish government is also implementing programs to deal with the economic impact of displaced communities from the dam construction, and to address the overall low levels of development in the region. Some interesting and difficult questions could be raised about these activities. What impact would the Dam and other large scale development projects have on the region's social and cultural institutions, or on Turkey's political system? How would technological advance and globalization of trade and investment impact the country's economic, social and political institutions? Are changes necessary in these institutions for the country to fully participate in the global economy, and more pressingly, to join with the European Union? Does technological development advantage some groups while disadvantaging others, in other words, exacerbating income inequities?

This and similar scenarios around the world laid the foundation for a multidisciplinary collaboration that would follow in the development of a program designed to provide graduates with knowledge of the broad trends of technological development and how these systems of technology influence human development around the globe. While the College has excelled in producing technologists and applied scientists, the concept of the new master's programs was to produce graduates prepared to act as analysts of the effects of those technologies on society. In order to organize these basic concepts into a curriculum, a multidisciplinary faculty committee was formed. The various departments include Information Technology Management (which also includes Environmental Management Technology), Social and Behavioral Sciences, Aeronautical Management Technology, Electronics & Computer Engineering Technology, Geography, Transportation and Planning, and International Programs. The committee designed the curriculum with areas of human activity potentially revolutionized by technology, while utilizing the disciplinary strengths present within the College and other units of the University. The initial categories are under continuous revision since the programs' inception to allow students more options in selecting an area of concentration.

Curriculum Design

The M.S. in Technology/Global Technology and Development Concentration curriculum combines social science courses in development with technology courses, while giving students substantial flexibility in designing programs of study which fit their particular interests. To provide an overview of the curriculum, the following requirements have been chosen:

Technology Core	9
GTD Core	6
Research/Statistics	6
Electives/Specialization	6
Thesis/Applied Project	6
Total Credits	33

Technology Core

The technology core was designed by conceptualizing areas perceived to have been 'revolutionized' by technology, resulting in the categories of telecommunications, transportation and commercial activity, with sustainable development covering energy and environmental issues, critical to any study of development. These subject areas also reflect the disciplinary strengths at the university. At the same time, as students began entering the program, feedback received from students indicated that these were areas that fit, for many of them, topics that they were interested in professionally. Students are therefore able to take their elective courses in a selected technology core area as well, particularly if their capstone work fits into one of these themes.

Each student is required to take one course from three different areas. There are a range of courses available each semester, to suite the wide spectrum of student interests and backgrounds in the program. For example, in Information Technology/Telecommunications, students can take courses in Geographic Information Systems or Project Management with software applications, or, if they have a background in electronics, they can take an advanced course in telecommunications. Thus those with less technical backgrounds learn a software application, and those with technical backgrounds can either take more advanced technical courses, or other courses in the management and forecasting of technology. The areas of Transportation and Commerce further touch upon the technological forces enabling globalization. Sustainable development includes courses in alternative, sustainable energies, such as courses in fuel cell technology and solar technology, as well as courses related to the policy implications of sustainable issues, such as international environmental law. Following are sample Technology Core Courses available. There are currently plans to add the areas of Biotechnology and Education to the choices.

Information technology/Telecommunications

ITM 570	Project Management	3
EET 579	Digital Data Communications	3
GIS 598	Geographic Information Systems	3

Transportation

AMT 523	Aviations Systems Management	3
AMT 528	International Aviation	3
AMT 522	Strategic Multi-Model Transportation Planning	3
PUP 598	Transportation and Planning	3

Commerce

ITM 540	International Management	3
AGB 552	International agricultural Policy	3
AGB 494	E-Commerce and Trade	3
GTD 598	Area Studies Courses	3

Sustainable Development

ETM 526	Current Environmental Technology Issues	3
ETM 428	International Environmental Management	3
EET 598	Introduction to Green Technology	3
GPH 405	Energy and Environment	3

GTD Core Seminars

The following two core seminars form the foundation of the GTD curriculum, and they are presented reflecting the current credit hour designation. Together with the research sequence they are the common courses that all students take. Designed to integrate the program and provide a solid basis for approaching issues in development, these seminars are taken during the first two semesters, in either order, to allow flexibility on when students may enter the program.

GTD 501	Introduction to Global Technology and Development	3
GTD 503	Technology and the International Political System	3

The first seminar, GTD 501 Introduction to Global Technology and Development, introduces the major approaches to economic, social and political development, seeking to expose students to the theoretical heritage that integrates these aspects, from Adam Smith and Karl Marx, to Amartya Sen and Paul Streeten. It is assumed that students entering the program are not familiar with this literature, and the text chosen (Martinussen [3]) offers one of the best overviews of multidisciplinary development literature available. In addition, they are assigned books on globalization, the information revolution, and information technology and development (Lechner and Boli [4], Castells [5], Mansell and When [6]). As they become familiar with the development paradigms, students are challenged to formulate their own approach to development. Does development, for example, essentially mean economic growth? Technological advance? Alleviation of poverty and disease? Freedom from political repression? The goal is for each student to crystallize their own perspective on these questions and be able to defend it, verbally and in writing.

The other seminar, GTD 503 Technology and the International Political System, focuses more specifically on political development and change, both at the national-state level and the global level of the international political system. The texts mentioned above also provide readings for this seminar, as well as journal articles from many academic journals, including *World Development, Human Development, World Politics, Technology and Society, Third World Quarterly, Information Technology and Society, and Information Technology and International Development.* Students in this seminar must consider questions that center on nation-building, war and conflict, technology and

the possible changing role of the nation-state. Does democratization equal political development? Is the secular western model of state-building relevant or applicable to other social, cultural and religious contexts? Does technology serve to promote political participation, or enhance the power of repressive states?

Student assessment in both seminars is designed to help each student develop and improve his/her ability to read critically, analyze varying perspectives, and articulate their views both orally and in written form. Assignments therefore consist of 3-4 critical essays, where students discuss various themes, such as 'What is development?' and a critique of a country's science and technology policy, utilizing and critiquing the assigned literature to formulate their views. Students are also required to begin a 'research portfolio' which they will maintain throughout their program, in which they keep track of their progress and utilize their course work to develop their ideas for their capstone requirement.

Research Sequence and Capstone Experience

The research sequence includes a course in research design that focuses on the construction of research questions and problem statements, literature reviews and methodology selection, with an introduction to quantitative (statistical) and qualitative methods. Students can choose between a research-focused thesis or an applied project, which they need to prepare for by developing a proposal, which they are encouraged to develop throughout the research sequence. Part of the capstone experience includes a defense of the proposal, and a defense of the final thesis or project. We have found that a proposal defense is extremely valuable to the student, not only as a practice run for the final defense, but to gain faculty input and reaction and minimize later problems with research, methodology, etc. Table I illustrates the course distribution for thesis and applied project students related to research sequence and capstone experience.

Table I: Course Distribution for Thesis and Applied Project Students related to research sequence and capstone experience

Course	Thesis	Applied Project
GTD 505 Research Design	3	3
GTD 506 Quantitative Analysis	3	3
GTD 599 Thesis	6	0
GTD 593 Applied Project*	0	3
Approved Elective	0	3

As mentioned above, students are encouraged, via their elective courses and capstone requirement, to specialize in a particular area. Often these areas correspond to the technical content areas, but students can specialize in some other area in which there are courses they can take at the university. This can lead to contact with a wide range of faculty, who can serve on the thesis or applied project committees. So far there have been committees made up of faculty from Electronics & Computer Engineering

Technology, Technology Management, Geography, Urban Planning, Justice Studies, Tourism and Development, and Global Technology and Development. Multidisciplinary faculty collaboration on student projects is thus a reality, with faculty research collaboration an opportunity that will be pursued in the future.

The multidisciplinary makeup of the curriculum combined with the wide variety of student backgrounds and interests has resulted in a range of topics that students have pursued so far. Following are examples of completed theses and applied projects between 2003 and 2007:

- *The Re-Enforcement of Traditional Gender Roles in the Technology Sector: A Case Study of Female Engineers in India* (thesis)
- *Multilateral Aid Allocation and Patterns of Informational Marginalization in South America* (thesis)
- *Framework for Development of Contextual Information Storage and Search Mechanism* (applied project)
- *Ecotourism and Development: Survey of Leader Attitudes in Chobe National Park, Bostwana (thesis)*
- *Technology Solutions for Consulting Companies in Ecuador* (applied project)
- *U.S. Science Parks and Regional Inventiveness* (thesis)
- *ICT National Policy and Political Freedoms in Jordan* (thesis)
- *Seeking Sustainability: Economic Empowerment of Indigenous Women in Atla, Mexico* (applied project)
- *Analyzing Development Theories using a Computer-based Modeling Tool* (applied project)
- *Purifying Water using the Sand Filter and Moringa Seed* (applied project)

Electives

As mentioned above, students may select their electives from the technology core areas. These courses would follow the theme of a chosen core class, and, depending upon the student's background, provide an area of specialization in a technological or social scientific field, designed with the counseling and the approval of the faculty advisor. Students may also select electives from another department at the university. For example, we had a student, with interest in women, technology and development, take electives from the women studies' curriculum. Another, interested in non-governmental organizations and aid for technology development, took classes in non-profit organizational management. Either way, students are strongly urged to specialize in a specific area of their choice and choose electives accordingly, with their capstone thesis or applied project fitting into this theme as well.

Admissions and Student Body

The challenge of setting admissions standards, apart from the basic graduate school requirements of the university of a 3.0 cumulative GPA from an accredited institution of higher education, has centered on what standards to require, given the assumption that students with degrees ranging from engineering to English might apply. The faculty committee agreed upon the following:

- Minimum of 12 credits of social sciences
- Coursework and/or professional experience in computer science/technology
- International or intercultural experience

Occasionally a student might be admitted with a 'deficiency' in one of these areas, with extra courses, as co-requisites, required as a condition for admissions.

The current student body, as of the fall of 2008, of 31 students represents the following undergraduate degrees upon entry into the program:

Undergraduate Degree	Number of Students in GTD program
Engineering	6
Science/Computer Science	7
Social Sciences	10
Business/Management	8

The student body has also continued to be very diverse culturally, with 1/3 of the students on international student visas from India, Uzbekistan, Kazakhstan, Turkey, and another 1/3 U.S. citizens with significant experience living abroad in the Peace Corps, missionary programs, or the military. The remaining 1/3 of the student population do not have significant international experience, but their academic experience is enhanced by their classmates from around the globe, and many of them pursue trips for study and/or research abroad during the course of the program. Regarding gender, the current (fall of 2008) student body is almost evenly split, with 17 (55%) males and 14 (45%) females. The unifying feature of this group of students with highly diversified academic and life experiences is the interest in technology, globalization and world development.

GTD Trips Abroad

In order to allow students and faculty the opportunity to explore GTD topics in real world contexts, and to stay current on global development issues, the students and the faculty have undertaken three short term study trips abroad so far. While short term study abroad cannot take the place of longer, more integrated experiences living and working abroad, it provides important international educational opportunities for students that fit well logistically with a graduate student's relatively short length of study (and the fact that most of our students work fulltime). In May of 2002 faculty and students visited Turkey, the location that inspired the initial conceptualization of the program. The group visited the GAP (Southeast Anatolian Project) region, observing large scale dam and irrigation projects as well as small farm and women's cooperatives, gaining insight into the benefits

and trade offs of large scale technological advances in rural areas (Figs. 1 and 2). Meetings with business and government leaders included one with Suleyman Demiral, former Prime Minister and President of Turkey, where the discussion included the country's long time quest to enter the European Union.

Fig. 1: Ataturk Dam-Turkey

Fig. 2: GTD group at a farm house in southern Turkey

During January 2005 a GTD group of faculty, staff and students traveled to Ecuador, where they met with Sixto Duran Ballen, former President of Ecuador, under whose presidency the current tenets of globalization, privatization and de-regulation of industries, were pursued. The students had already read a book (Gerlach [7]) on the oil industry and the transformation of Indian societies in the Amazon, and thus were well prepared to discuss economic, social and political issues with President Duran Ballen and other Ecuadorian officials and intellectuals. The trip spanned from the Andean capital of Quito, to the edge of the Amazon basin, where the students witnessed vast diversity in human development and technology. They also visited the northern coastal region of Esmeraldas, where shrimp farming (Fig. 3) is being enhanced with technology, but at environmental costs. Each student kept a journal, raising his/her questions of interest, and reflecting upon them throughout the trip. The students received one credit, turning in

an essay discussing, from their area of interest, what they learned about the country and its most pressing issues during the trip. One student commented in the final paper that the "trip to Ecuador this January was a wonderful experience and an opportunity to see first hand development issues we wrestled with in the classroom."

Fig. 3: Visiting a Shrimp Farm, Esmeraldas Province, Ecuador, January 2005

More recently, in January of 2007 we took students to Brussels, Belgium to visit the institutions of the European Union (EU), and then on to Cyprus, where we traveled to both parts of this divided island which had just been admitted into the EU (Fig. 4). While the emphasis was on the political conflict that divides the Turkish and Greek communities, and how EU membership influences a developing or divided society, students were able to pursue their particular interests as well. One result of the trip was a Fulbright application where the student proposed to study the role of electronic communication in inter-communal dialogue and reconciliation on the island. Students were also able to see firsthand the technological divide between the heart of the EU and the periphery, with stark contrasts in technological and socioeconomic development within Cyprus as well.

Fig 4: GTD students and staff in Cyprus, January 2007

Results and Future Directions

The ongoing challenges of administering the curriculum continues to center on how to integrate students with technical/science/engineering backgrounds, and social science/humanities/business backgrounds, and give them a common core, with common goals and outcomes. Some students with heavily technical backgrounds have been challenged by the level of written work required, and some of those with liberal arts and sciences backgrounds have had to take some extra courses in science and technology. The university has an excellent writing center that has helped many of the students in the program improve their written skills, a key goal of the program. The benefits of multidisciplinary study appear to outweigh the inherent challenges.

What we are continuing to see with the ongoing applicants and current students in the GTD program are students from engineering and technological backgrounds who want to understand their work within the social, political, cultural and economic context, and they are motivated to pursue difficult questions about technology and development in societies around the globe. One student participated in the program on leave from the Japanese Transportation Agency, where he was a civil engineer, in order to pursue the GTD degree. After completion, he returned to work for the Japanese government on transportation infrastructure in developing nations. We are also seeing students from the liberal arts and sciences, some of whom have had work experience in developing countries, such as in the Peace Corps, who seek solutions to development issues and want to increase their knowledge of technology for that application. Again, the diverse student body intersects at this point where science and technology is perceived as a factor in global forces that are transforming social, political and economic institutions, and indeed cannot be fully understood outside of these institutions.

Student research is leading participants in very interesting and fruitful directions, including one graduate who did field research in Botswana on the effects of ecotourism development on local populations, and in particular on the attitudes of leaders towards this development. Another GTD student, with an electrical engineering background, received a Fulbright to study business, trade issues and development in Mexico during 2005-2006. The program has also received on incoming foreign Fulbright scholar from Ecuador, as well had one faculty member complete a research Fulbright in Turkey.

Of the students who have graduated (14 as of fall 2008), we have been surprised at the number seeking to pursue doctoral degrees (3 out of the 14). While the focus of this terminal master's is on application and policy implications, the theoretical exposure seems to have motivated several students to continue their graduate studies. One of our graduates has just completed a doctorate in human geography, and two more (one with an undergraduate degree in engineering and urban planning) are pursuing doctoral degrees in geography as well. Other graduates are working, many in technology in the private sector, and two in South America in private businesses. At least three are working in the field of international development for non-governmental organizations (NGOs), with one recently (2007) in Iraq for an NGO implementing an information technology system for the central government. Comments from graduates of the program have been extremely positive. Feedback has indicated that they feel they have learned to comprehend and analyze global economic and political forces, and effectively conduct research, with one recent graduate commenting that the research and writing skills gained 'directly contributed to. . . admission to Ph.D. programs.' Another, living outside of the U.S., has noted that the GTD program has enhanced and broadened his perspective as an architect, and this wider view is brought into the local context for the benefit of others.

After seven years, the GTD faculty has begun to look into future directions and areas for growth. By sharing resources and faculty strength, it is felt that the multidisciplinary nature of the program can be further enhanced, as well as allowing for the creation of some options for students. The GTD faculty has been involved with the creation of a doctoral program on the Human and Social Dimensions of Science and Technology, and a GTD graduate is among the first cohort this fall. There is also a new B.S. in Science, Technology and Society degree established in the fall of 2008, which has a GTD track, modeled after the graduate program. This program offers minors as well, and these will be available to the engineering and technology students on ASU's Polytechnic Campus. The articulation between these three degree programs will be attractive to some students, but offering the curriculum at these varying levels also allows students in other disciplines to integrate their studies in a myriad of ways. What is clear is that the GTD master's program continues to receive interest from a broad range of potential students, with the program's common objective of examining global challenges and trends in a multidisciplinary fashion that brings the social sciences and technological fields together in a joint effort to explore the issues facing the planet as we complete the first decade of the 21st century.

Acknowledgments

Grateful acknowledgement is given to former Dean Albert McHenry of the College of Technology and Applied Sciences, and Associate Professor Gary Grossman of Social and Behavioral Sciences, Arizona State University, for their origination of the concept for the Global Technology and Development curriculum.

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