Online Delivery of the MSME Program from Georgia Tech*

WARD O. WINER, WILLIAM J. WEPFER, JOSEPH S. DIGREGORIO, GEORGE W. WRIGHT and
JOSEPH S. BOLAND
*The Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA 30332,
USA. E-mail: george.wright@conted.gatec.edu*

*Georgia Tech is currently developing twenty-two three-semester credit hour courses, to be delivered
in an asynchronous mode via the Internet, which will allow remote students to earn a Master of
Science in Mechanical Engineering (MSME) degree completely online. We are using several
innovations in online course delivery to produce a better product than currently offered by other US
institutions delivering courses and degrees via the Internet. We expect to spend $670,000 to develop
the twenty-two online courses. The MSME degree is the first in a series of graduate degrees
Georgia Tech will develop and offer completely online.*

INTRODUCTION

IN ITS groundbreaking 1988 report entitled *Focus on the Future: A National Action Plan for Career-Long Education for Engineers*, [1] a report of the National Academy of Engineering (NAE) summarized what US business and industry had long recognized, i.e. that the nation's supply and quality of engineering intellectual capital might be insufficient to meet future goals. NAE outlined several reasons for this, including fierce worldwide economic competition, rapid technological advancement, and the changing nature of the pool from which future engineers would be drawn. Furthermore, the NAE offered strong arguments for the nation to invest in post-baccalaureate, career-long education of practicing engineers to help overcome the shortfall of engineering intellectual capital, and for individual engineers to participate in continuous career development.

National and international events during the twelve years since the NAE report have not only strengthened its conclusions, but also have added a new dimension to it, i.e. the ability to deliver lifelong education to engineers and other working adults at a distance via media-based technologies, and recently to deliver courses and degrees via the Internet in both synchronous and asynchronous modes. No longer are working professionals constrained by limitations on time and location in their desire to continue their education. And no longer are universities limited in their ability to reach beyond their traditional campuses to serve new student audiences. Indeed the Internet delivery of courses and degrees is rapidly becoming the accepted mode of delivery to working adults throughout the nation and the world.

Recognizing the implications that Internet delivery of courses and degrees would have on traditional higher education in Georgia and throughout the nation, and with the far-sighted leadership of then-Governor Zell Miller, the state of Georgia in 1996 began the development of a virtual university known as the 'Georgia Statewide Desktop Distance Learning Network.' This network has brought together the thirty-four Georgia public colleges and universities that comprise the University System of Georgia into a unique online partnership. The System used Fiscal Year 1999 funding of $2.0 million to establish the hardware and software infrastructure for this program and to develop pilot courses and degrees at several of the thirty-four Georgia higher education institutions, including Georgia Tech.

One of the first official acts of current governor Roy Barnes was to propose to the state legislature the continuation of this initiative through a fiscal year 2000 appropriation of $1.5 million. As in the current fiscal year, the state will again provide funding in fiscal year 2001 for the online MSME degree described in this paper.

The University System of Georgia will expand the Statewide Desktop Distance Learning Network over the next several years to include all thirty-four Georgia institutions. When fully operational, the Network will allow Georgia citizens and other students throughout the nation and the world access to courses and degrees completely online, in both synchronous and asynchronous modes, from all thirty-four University Systems of Georgia.

APPROACH

During the fall 1999 and spring 2000 semesters Georgia Tech used some of these state funds to

produce four graduate-level credit courses in Mechanical Engineering:

ME 6222, Manufacturing Processes and Systems (Dr. Jonathan Colton);

ME 6401, Linear Control Systems (Dr. Nader Sadegh);

ME 6305, Applications of Thermodynamics (Dr. Sam Shelton);

ME 6442, Vibration of Mechanical Systems (Dr. Jerry Ginsberg).

Using additional funding from the state of Georgia, the Georgia Tech Foundation, and the Alfred P. Sloan Foundation, Georgia Tech's Woodruff School of Mechanical Engineering, the School of Mathematics, and the Center for Distance Learning (CDL) will place another 18 courses online over the next three academic years (see 'roll-out' plan below).

The goal of the Georgia Tech program is to allow distant students to obtain a Master's degree in Mechanical Engineering (10 three credit hour semester courses required) completely online in an asynchronous mode with a number of course options. To our knowledge, this would make Georgia Tech the first institution in the world to offer the complete MSME degree online.

Participating units

The following units at Georgia Tech are involved in the various tasks of developing and offering the MSME online degree program:

- The George W. Woodruff School of Mechanical Engineering
- The School of Mathematics
- The Center for Distance Learning
- The Office of Information Technology
- The Center for Effective Teaching and Learning
- The Assessment Office

Faculty from the Woodruff School and the School of Mathematics are developing the content for the 22 courses. Using project funding, the Schools have agreed to provide support in the form of faculty release time and staff services. Tech expects faculty to develop instructional content for the courses that capitalizes on the power and flexibility of the Internet, challenging faculty to seek innovative techniques to achieve the instructional objectives of the courses, and not just revising standard lecturing methodology.

The Center for Distance Learning manages the program. In collaboration with Tech instructional designers and faculty, the Center uses its studio facilities to record the audio and video portions of the courses, digitize and encode the materials used in the online courses, and synchronize the encoded audio/video with other supporting instructional material and reference items. The Center's staff then places the audio/video files and the supporting files on servers in the Office of Information Technology. In addition, the Center continuously apprises faculty of the newest multi-media tools

and techniques available to enhance the online student experience. Finally, the Center also handles logistics, support, and record keeping for the project.

The Georgia Tech Center for Effective Teaching and Learning supports the project with educational, instructional, and graphic design services. Instructional designers meet with individual faculty to design courses that are educationally effective for delivery via the Internet. Faculty are responsible for the content of the courses and student evaluation.

The Assessment Office is developing and implementing an effective evaluation and improvement plan for the online program in cooperation with the other program participants.

Faculty approval

In early 1998 the CDL first contacted the administration in the Woodruff School to determine preliminary interest in developing an online program in Mechanical Engineering. CDL choose Mechanical Engineering because it is the most aggressive school at Georgia Tech in marketing our existing videotape-based distance learning program and because its faculty is very cooperative in developing new distance learning courses. At that time CDL also contacted the School of Mathematics regarding providing three courses to satisfy the MSME minor requirement.

In late 1998, after obtaining tentative approval of the administration in the Woodruff School and the School of Mathematics, the CDL then began seeking funding for the project (see 'Financial plan'). In early 1999, with $670,000 of funding in place, CDL obtained approval from the Graduate Committee of the Woodruff School and the entire Woodruff School faculty.

Faculty participation

Faculty in the Woodruff School are as key to the success of our online program as they are for the videotape-based program. Tech uses only faculty volunteers who offer courses online. We provide one-quarter (25%) release time for a semester to a faculty member to develop each course, as well as a financial incentive when the course is offered, and technical and administrative support to place each course online. This approach is similar to the one that Georgia Tech has used in its highly successful, videotape-based program. We use faculty to do what they do best (i.e. provide high-quality course content), then provide them with the support they need for all the other tasks required to place courses online. In all cases, the approach used in placing courses online also greatly improves the campus presentations of the courses. We have consistently found this to be true in our videotape-based program. We anticipate that faculty who teach courses not offered at a distance will utilize the effective aspects of the online courses to improve their courses. Examples include the use of electronic slides, better preparation of

course objectives, additional usage of web resources, posting of homework assignments and other teaching materials on the web, such as the use of electronic bulletin boards, chat rooms and e-mail to increase student/student and student/faculty interaction.

In addition to release time mentioned above, Tech provides the offering academic department $105 per semester credit hour for each student enrolled online or in its videotape-based program for use by the faculty member teaching the course. This transfer of funds recognizes that students at a distance require additional work by the faculty. As an example, a distance learning course with six videotape-based students and with ten online students in a three-semester hour course would result in a transfer of $5040 to the Woodruff School or to the School of Mathematics. Thus, with the initial release time for developing the online courses and the return per credit hour for enrolled students, faculty delivering courses online have financial incentive to participate.

The chairs of the Woodruff School and the School of Mathematics have identified faculty interested in developing and teaching online courses in this program. We have experienced little problem in recruiting faculty to develop mechanical engineering online courses, since 35 of the approximately 70 faculty in the Woodruff School have voluntarily taught distance learning courses in the past. These faculty consistently receive excellent student reviews in course evaluations. Likewise, a number of faculty in the School of Mathematics have participated in the Tech videotape-based distance learning program.

PROGRAM INNOVATIONS IN ONLINE DELIVERY

A number of US institutions of higher education have recently introduced degree programs available for delivery via the Internet. Essentially, the innovators in the field have taken 'off-the-shelf' existing video footage, digitized and encoded it, and placed it on a streaming video server. Our experience with previous online courses indicates that this approach produces less than satisfactory results in the mind of the end-user (student). Video designed and produced for delivery on VHS tapes or via satellite does not result in high quality instructional material when digitized and compressed for delivery over a 28.8 kbs dial-up modem.

In contrast, the Georgia Tech MSME online program is producing courses designed with delivery via the Internet in mind. For example, whenever possible and appropriate, faculty use the full capabilities of the WebCT software for student/faculty and student/student interaction. Tech expects the capabilities of WebCT to increase both these interactions. Based on past experience, this will occur if faculty strongly encourage or require interaction. In some cases, large enrollment

online classes have a graduate assistant to help facilitate this interaction.

Where possible and appropriate, faculty use other techniques to take full advantage of the capability of the web:

- provide branching within the lecture to other web sites, either on a Georgia Tech server or elsewhere;
- provide graphs and pictures that further explain a concept they present in the lectures;
- require students to access the Georgia Tech computer network either over the Internet or by modem over a phone line to do simulations of their own (this capability is already in place for our video-based students);
- use animations, simulations, and electronic case studies in their presentations;
- use the bulletin board and threaded discussion capabilities of WebCT;
- encourage student/student and student/faculty interaction using the chat room capabilities of WebCT;
- use specialized studio equipment and capabilities, such as 'Chromakey' and 'SmartBoard' to add production value to the lectures.

In addition to these web-based innovations, Georgia Tech faculty segment course content into modules, which greatly increases the flexibility of course design. This module approach allows for more branching and redirection of content within the structure of the course and facilitates more economical revisions of the content. Georgia Tech also plans to use some of the modules of each course to offer non-credit certificate programs and continuing education programs online.

Administrative interactions between the online students and the Center for Distance Learning occur electronically. Faculty post homework and solutions on the web using the WebCT software. As in our video-based program, approved proctors assure that the person taking the exam is the enrolled student. Faculty post grades and other student information on the web with access restricted by student account number and password.

Working with an instructional designer in the Georgia Center for Effective Teaching and Learning, faculty develop course objectives and a course syllabus, and prepare electronic slides for each lecture. Some faculty find it more convenient to develop their own slides and some want to provide the Center for Distance Learning with hand-written material for creation of their electronic slides. The faculty member's department or school may use some of the $105 per semester credit hour it earns in online courses to pay for a teaching assistant to help with the above when the online class size is large.

After faculty organize each course and prepare electronic materials, the Center for Distance Learning tapes each lecture in one of its studios using its full capabilities to enhance video and

audio for presentation over the Internet. Since delivery over the Internet at 28.8 kbps greatly limits the quality of the streaming video and audio (especially the video), the Center digitally compresses each lecture at multiple rates to allow the server to stream data at rates higher than 28.8kbps for those students who have greater bandwidth access to the Internet.

The Center for Distance Learning edits each tape, then digitizes, encodes, and compresses each lecture. The Center creates an electronic table of contents for the lecture and synchronizes each lecture with web pages containing copies of all notes or materials the instructor uses in the lecture. The Center then converts and synchronizes PowerPoint slides and/or GIF images of overheads or whiteboard with the streaming video/audio. Finally, the Center places the digitized lecture and all electronic materials on servers in the Georgia Tech Office of Instructional Technology for delivery over the Internet. User account numbers and passwords restrict access to the files to students who register for the course.

The software selected for streaming the video and audio is RealServer G2 by RealNetworks and the course presentation and administrative software is WebCT. Georgia Tech has an institutional license for both software products. The state of Georgia uses the same in its Desktop Distance Learning Network. Thus, all courses Tech offers in the MSME program have the same 'look and feel' as other Internet courses that other schools in the University System of Georgia offer. Students registering for any of these courses online quickly become familiar with how to navigate through the course.

Georgia Tech is currently recording videotapes in a classroom studio where we can maintain accurate light and audio levels. In some classes, campus students are present in the studio during taping. However, our long-term goal is to record each lecture in a controlled environment in which campus students are not present. In such an environment faculty will be able to focus completely on the presentation of their materials to online students with little or no in-classroom distractions. Furthermore, based on our experience with other lectures Georgia Tech produced without students in the classroom, we know that instructors may actually deliver more concise and better-organized content in less time than is normally required when on-campus students are present.

The Center for Distance Learning provides support to students enrolled in the MSME program with the same quality provided to students in its traditional videotape-based program. Georgia Tech believes that successful online programs require both high-quality presentations and outstanding services for the distant student.

'Roll-out' plan

Georgia Tech offers 38 courses in its videotape-based MSME degree program, from which we will select courses for offering in our new online MSME degree program. We offered the first two courses in the MSME online program during the fall 1999 semester and two more courses during the spring 2000 semester. We will develop and offer an additional 18 courses over the next three academic years.

Georgia Tech plans to offer MSME courses during semesters in which the professor is delivering the course on campus and through the videotape-based program. Student admission, matriculation, course and graduation requirements are identical to those for campus students. Tech makes no distinction on a transcript or on the diploma that a student was enrolled in the Georgia Tech distance learning program. Distant students enjoy all of the rights and benefits of Georgia Tech campus students and must meet all the same standards.

We plan to place additional courses online for the MSME program using funds generated by the enrollments in the 22 courses developed in this program.

Program demand

Colleges and universities around the nation are finding significant demand for online courses and degrees at all degree levels, as evidenced by the large number of public and private educational institutions and for–profit organizations currently producing—or planning to produce—courses for delivery online. Enrollments in these courses and degree programs are also an indicator of growing demand. Georgia Tech receives numerous daily inquiries from our current videotape-based students asking us to place our courses online. In addition, for the past two years Georgia Tech has conducted 'listening forums' around the state of Georgia at which we consistently receive inquiries about our plans to deliver certain courses and degrees online. The Center for Distance Learning currently offers its videotape-based program internationally, but enrollments outside the United States are small because of the logistics involved in mailing videotapes overseas, as well as the high cost of such mailings. Thus, many students outside the US have expressed a desire for us to offer our distance learning programs online.

Like other highly-respected institutions of higher learning, Georgia Tech is firmly convinced that the higher education landscape will change dramatically over the next 25 years (it may not take that long) and that demand for high-quality online programming will continue to increase both in the U.S. and abroad. We believe those institutions that offer their campus academic programs via the Internet (or its successors) to students off campus will expand the visibility and reputation for teaching excellence they currently enjoy for their on-campus programs. We further believe higher education will become a 'market-driven' enterprise and only those institutions that provide a quality program at a time, place, and cost

convenient to the distant student will be able to compete successfully. We believe these changes will occur first in graduate level and lifelong learning programs for working professionals, and will eventually include undergraduate programs.

Program enrollments

Applicants to Georgia Tech's online MSME degree program must go through the same admission process as applicants to our on-campus or videotape-based degree programs. The application process is rigorous. Thus, the Woodruff School admits only a small number of students who apply to its program. In addition, time demands on the ME faculty are already heavy and the School chair indicated very early in the planning process that he did not want the workload added by the new online MSME degree to add greatly to the burden on faculty. Thus, from the beginning Georgia Tech has intended to keep admissions to this program at a reasonable level for at least the first three years. Georgia Tech's plan is to grow the current videotape based program of approximately 100 students enrolled with 15–20 graduates per year to 200 students enrolled producing 30–40 graduates per year. The goal is to register 10–15 students per course per semester.

Program marketing

To increase awareness of the new MSME degree program, we are heavily promoting and marketing it in the first year through targeted marketing to working technical professionals. We are promoting and marketing both our online and videotape-based program brochures to Georgia Tech BSME graduates of the last ten years and to members of selected divisions of the American Society of Mechanical Engineers through phone calls, letters, and direct mail-outs of flyers. We are also placing ads in selected ME professional journals and advertising in appropriate electronic and print media. In addition we are listing these programs on as many distance learning sites and in as many catalogs as possible (e.g., Peterson's Guide to Distance Learning, DANTES External Degree Catalog, Campus-Free College Degrees).

We are marketing the MSME online program in parallel with our traditional videotape-based program. Georgia Tech's reputation as an outstanding technical institution is always an influencing factor in generating interest in our distance learning courses and degrees in the U.S. and internationally.

PROGRAM ASSESSMENT

Georgia Tech's Director of the Assessment Office is assisting in the development and implementation of an effective evaluation and improvement plan for this program. We are fortunate in having three cohorts for each course offered online: the online students, the videotape-based students, and the campus students. We are using all three groups in the evaluation process. We anticipate encouraging some campus students to take the courses online, thus providing an additional perspective on the program.

Over the past eight years Georgia Tech's videotape-based program has used a 'during-term' feedback mechanism for its students and a more extensive 'end-of-term' evaluation. We consistently use this input to make improvements to the program and inform our students about these changes. Therefore, we enter the online distance education arena with a wealth of experiential knowledge of what works and what does not. In addition to the above, Georgia Tech is developing pre- and post-assessment tools for the online program.

Financial plan

Expenditures: The development of the first two courses was funded with FY 99 funds. Table 1 shows the itemized cost for each task in the program for FY 2000, 2001 and 2002. We anticipate the total cost of the project over these three fiscal years to be approximately $670,000. The Georgia Tech Foundation has committed $180,000 to the project, the University System of Georgia's Board of Regents has committed $340,000, and the Alfred P. Sloan Foundation has committed $150,000, each over a three-year period (through Academic Year 2001/2002). Such leveraged funding should allow Georgia Tech to complete the total project in three years.

Table 2 shows the yearly distribution of funding among the three participating agencies.

Table 3 gives the distribution of expenses by year. As shown in Table 1, the cost of professorial release time, instructional design, taping, digitizing, encoding and synchronizing the slides with the audio/video is $20,000/course. We expect program management costs to be constant each year. Marketing costs are higher in the first year to

Table 1. Expenses for 20-course program

Item	Cost		Total cost 20 courses 3 Years
Faculty support	$10,000	per course	$200,000
Instructional design	$3,000	per course	$60,000
Videotaping + editing	$4,000	per course	$80,000
Digitizing/encoding/ synchronizing	$3,000	per course	$60,000
Subtotal	**$20,000**	**per course**	**$400,000**
Marketing			$65,000
Program management	$60,000	per year	$180,000
Subtotal		**$645,000**	
Project evaluation		$25,000	
Grand Total		**$670,000**	

Table 2. Distribution of expenses among participants

Funding unit	1999–2000	2000–2001	2001–2002	Totals
Georgia Tech	$60,000	$60,000	$60,000	$180,000
State of Georgia	$140,000	$100,000	$100,000	$340,000
Sloan Foundation	$40,000	$70,000	$40,000	$150,000
TOTALS	**$240,000**	**$230,000**	**$200,000**	**$670,000**

Table 3. Expenses by year

	1999–2000	2000–2001	2001–2002	Totals
New courses developed	7	7	6	20
Cost	$140,000	$140,000	$120,000	$400,000
Program management	$60,000	$60,000	$60,000	$180,000
Marketing	$30,000	$20,000	$15,000	$65,000
Project evaluation	$10,000	$10,000	$5,000	$25,000
Totals	**$240,000**	**$230,000**	**$200,000**	**$670,000**

create awareness of the program. We are including the ME online program in all marketing of the Tech video-based distance learning program at no additional cost to this program. Project evaluation costs are higher in the first two years reflecting the costs of developing and implementing the evaluation tools.

Income: during AY 2003 and beyond, we expect to offer fifteen courses each year with a minimum online enrollment of eight in each course, yielding a minimum of 120 course enrollments per year.

Georgia Tech currently charges a tuition of $510/semester hour for its online courses, the same as for our videotape-based courses. The total fee for a three-semester-hour course is $1530. Of this amount the Center for Distance Learning uses approximately $1020 to cover direct costs including a transfer of funds to the offering academic unit and management and marketing costs. The Center will use the remaining $510/enrollment to develop additional online courses.

One hundred and twenty enrollments in three-semester-hour courses yields approximately $184,000 at the current tuition level. Of this amount the Center will use approximately $123,000 to pay the direct costs of the program and $61,000 for additional online course development. This will permit Georgia Tech to place approximately three additional courses online each year after the end of this project. A variety of factors, including course demand, competition, and increases in operating expenses, will determine future tuition charges/semester hour beyond the current AY for these online courses.

The MSME degree program is the first in a series of graduate degrees Georgia Tech plans to develop and offer the next several years. Current plans call for the development and online delivery of Master's degrees in Electrical Engineering and in Environmental Engineering. In partnership with one of our University System of Georgia sister schools, Georgia Tech also plans to develop and deliver a Systems Engineering/Software Engineering degree in the near future. Over the longer term Georgia Tech will explore additional online degrees, such as a Master's degree in Engineering Management.

REFERENCES

1. NAE, *Focus on the Future: A National Action Plan for Career-Long Education for Engineers,* a report of the National Academy of Engineering (NAE), Washington, DC, 1988.

Ward O. Winer, (BSE, MSE and Ph.D. The University of Michigan, and Ph.D. Cambridge University, England). Mechanical Engineering faculty The University of Michigan (1963–1969), joined Georgia Institute of Technology 1969, and is now Regents' Professor and Chair of the George W. Woodruff School of Mechanical Engineering and the Gene Gwaltney Chair in Advanced Manufacturing Systems. He is PI on a DoD Multi-University Research Initiative Center for Integrated Diagnostics of Mechanical Systems involving 21 Co-PI's in seven departments at three universities (Georgia Tech, Northwestern University, and the University of Minnesota). Dr. Winer received the ASME Melville Medal (1975), Mayo D. Hersey Award (1986), the ASME/Pi Tau Sigma Charles Russ Richards Award (1988) the Tribology Gold Medal from the British Tribology Trust of the Institution of Mechanical Engineers, Institution of Production Engineers, the Royal Aeronautical Society, and the Department of Industry and Trade, Great Britain, ASEE Benjamin Garver Lamme(1995) and Donald Marlowe (1996)Awards. He was elected to the National Academy of Engineering in 1988.

William J. Wepfer is Professor and Associate Chair of Graduate Studies in the George W. Woodruff School of Mechanical Engineering at Georgia Tech. He received his BSME from Marquette University, the MSME from Stanford and the Ph.D. from Wisconsin. His research focuses on thermal processing (heat and mass transfer) of textile composites, system analysis of advanced solid oxide fuel cell systems, and the design and optimization

of energy systems. Dr Wepfer is author of over 80 papers. Dr. Wepfer has administrative responsibility for the Woodruff School's graduate programs that include a significant distance learning component as well as an international component at Georgia Tech Lorraine in France.

Joseph DiGregorio is Vice Provost for Distance Learning, Continuing Education, and Outreach at Georgia Tech. He heads a central unit which delivers courses and degrees to technical professionals through traditional workshops, seminars, and conferences, as well as via distance learning. Dr DiGregorio has seventeen years experience in lifelong learning for engineers at Georgia Tech, Penn State, and Rice University. In addition he spent over ten years as a Senior Staff Engineer at Shell Oil Company in Houston, TX. Dr DiGregorio holds a BS in Chemistry from Notre Dame and a Ph.D. in Analytical Chemistry from Penn State.

George Wright is Associate Director of the Center for Distance Learning at Georgia Institute of Technology. His responsibilities include oversight of the daily operations of the Georgia Tech Online program. He has spent the past fifteen years advocating the application of emerging technologies to improve instruction and training. Most of his work has been in training and support of adult learners seeking new methods and techniques for the teaching process. Mr Wright holds masters degrees in Educational Psychology and Educational Administration and has been an instructor at both the secondary and higher education levels.

Joseph S. Boland is the Director of the Center for Distance Learning at Georgia Institute of Technology. This program provides graduate-level courses applicable toward five master's degrees via videotape, satellite, teleconferencing, microwave, and the Internet. From 1968 to July 1992, Dr Boland was an assistant, associate and full professor of Electrical Engineering at Auburn University. His research interests were in optimal control, digital control, microprocessors, and image processing. From 1984 to 1992, he was Associate Dean of Engineering at Auburn University and responsible for starting and building the engineering distance learning program.