The Evolution of an Electronic-only Course Delivery Method in Engineering Economy for On-campus Students

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Abstract

This paper describes a three-year effort of delivering an undergraduate course in engineering economy to on-campus students using streaming video and the Internet. The initial effort relied primarily on internet-based video streams and the use of a traditional textbook. Technical difficulties with the internet-based delivery of the lectures together with pedagogical observations of student performance and feedback have led to significant changes. Beginning in the fall of 2002, the course will become completely electronic and will be pedagogically repackaged into integrated video stream lecture vignettes and related text material contained on a CD-ROM while the day-to-day course administration and student-to-faculty communications will continue to be conducted via the internet. Student evaluations and performance are presented, as well as some lessons learned.

Index Terms – Electronic technologies, engineering economy, Internet, remote learning, video streaming

Introduction

Electronic technology, such as video tapes, satellite transmissions, and the internet, has been used to address the needs of off-campus students where either their location or schedules preclude their attendance at on-campus classes.[1,2,3] Increasingly, however, such technology is being used for the delivery of course materials for on-campus courses where neither location nor schedules-are issues. Generally, the use of such technologies in these situations has been only to either facilitate or supplement face-to-face classroom instruction and laboratory exercises[4,5]. However, several factors are now making electronic technologies a principal mode of instruction, even for on-campus courses: most students now either own or have easy access to computing technology, and thus access to the internet; electronic technologies offer some pedagogical advantages over live lectures, such as repeatability and graphical presentation; electronic technologies and courseware are becoming increasingly easier to use by the faculty and, therefore, more readily adopted; and engineering enrollments continue to climb in face of diminishing resources in support of faculty instruction, thus encouraging engineering programs to pursue alternative cost-effective means to deliver their curriculum.[6,7,8,9]

This paper describes the development and evolution of a junior-level course, ISyE 3025 Engineering Economy, that has been taught solely through the Internet to on-campus students during the past three years.[10,11,12] The course organization, administration, lectures, and communications between the faculty and students occurred through the Internet. The only non-electronic elements were the use of a traditional textbook and in-class quizzes. Based on student feedback and the experience of the instructors, the course organization, administration, and faculty-student interaction will continue through the Internet, however, the lectures and traditional textbook will soon be replaced with an electronic audiovisual textbook provided on a CD-ROM.

The paper first describes the rationale for offering the on-campus course via the Internet; it then presents the principal issues in creating the new course and in its evolution leading to the creation of an electronic audiovisual textbook. The paper then provides a description of the course as it will be delivered in its new all-electronic format beginning in the fall of 2002 as well as some observations from the experiences of the instructors during the last three years. The instructors offer six suggestions for those contemplating substantial internet-based instruction for their courses.

Rationale for an Internet-Only Course for On-Campus Students

ISyE 3025, Engineering Economy, is a required, 1-credit hour internet-only sophomore/junior-level course in the industrial engineering baccalaureate curriculum at the Georgia Institute of Technology. It is also required by the mechanical engineering baccalaureate curriculum, and it is taken as an elective by many other baccalaureate engineering majors. Enrollment in the course is about 250 students per semester. The subject matter covered in the course was previously presented in a traditional live lecture 3-credit hour courses of identical numbering and title. Two events led to the replacement of this course by a single 1-credit hour internet-only course. First, in 1995, the Board of Regents of the University System of Georgia mandated that every unit within the system would convert from a quarter-based system to a semester-based system and that all baccalaureate programs would be limited to no more than 120 credit hours, with some exceptions (engineering was allowed up to 130 hours). Because of this conversion as well as the credit hour reduction, some quarter-based courses were eliminated but most courses were combined and redesigned. ISyE 3025 was redesigned by reducing the credit hours and mode of delivery. This redesigned course was also to be complemented by a new course in Financial Modeling. Second, the evolution of computing technology by the late 1990s, and particularly the Internet, had advanced to the point where courseware had become more versatile and accessible for both faculty and students. All Georgia Tech students were required to purchase computers beginning in 1997, consequently, more courses began to use computer technology to supplement live on-campus lectures and laboratory work.

The redesigned ISyE 3025 was unique among all the new semester-based curricula at Georgia Tech in that this on-campus course would be offered without live lectures. Specifically, all

course materials (except the textbook), administrative policies, procedures, and announcements, would be posted to the course website; bulletin boards discussion groups and e-mail access to the instructors would be provided; and streaming video lectures would be available together with accompanying PowerPoint™ presentations that could be downloaded. The only face-to-face interaction would be either during the optional help sessions provided by the teaching assistants (and occasionally attended by faculty), or through appointments with the faculty, and the in-class quizzes. The reduction in course hours coupled with the versatility of electronic technology made an internet-only course appear to be an attractive mode to provide the essentials of the subject in a cost-effective manner to a large population.

Issues in the Creation of Steaming-Video Lectures

The faculty faced several interdependent pedagogical and technological challenges in creating an internet-only course, but most of them related to the development of the streaming-video lectures. Three principal ones were reducing the course content, repackaging the material into logical segments of content, and developing and taping the lectures.

Reducing the course content was driven by the credit hour reduction, and the principal challenge was identifying either material to be eliminated or ways to present the same concepts in less time. This challenge was not too difficult since both instructors were very familiar with the subject and came to quick agreement on what they considered the essentials of engineering economy for a 1-credit hour course. Repackaging the reduced material into segments of logical content, something we called "knowledge bites," was more challenging since it required the instructors to think differently about how to present the material through taped lectures, delivered over the internet, and on small computer screens rather than in live, 50-minute increments, delivered in a large auditorium, and on a huge screen. Without the benefit of the normal face-to-face ("wake up") interactions that occur during a live class, it was felt that the material needed to be presented in shorter segments than a typical live lecture to keep the students' attention. Further, since it was desired that the lectures taped have a useful life beyond one semester, the material presented in each video segment needed to cover relatively few key concepts (so that if re-taping was needed, only short segments would be required), focus only on the course subject and avoid discussion of time-dependent course administrative matters (e.g., announcements of homework due dates), and employ terminology and notation commonly found in most any classic textbook on the subject (so that the textbook could be changed without re-taping all the lectures). Ultimately, all of these factors were considered and a detailed outline of the key concepts to be presented, examples to be used, and the ordering of the coverage of material was developed. This outline was then organized into "knowledge bites" and lecture minutes assigned so that the total lecture time was consistent with a 1-credit hour course. The lectures that resulted varied initially in length from about 15 to 45 minutes. However, the longest lectures were subsequently split so that all lectures were on the order of 15 to 25 minutes.

Developing and taping the lectures was mostly a technological challenge. PowerPoint™ was chosen as the presentation software for the lectures and it worked quite well provided one used a

bold typeface, large font (no smaller than 24 points), and dark colors (light colors, such as yellow, were difficult to see on the predominantly white background of a computer screen, and some colors, like red, had a tendency to "bleed" on the screen). It was also decided to have the instructor's upper torso appear on the screen as it was believed that an audio-only lecture would be too monotonous, and a "talking head" inset only would be too small to be seen well on most computer screens (especially laptops). Thus, the presentation format forced the instructors to either split material into more than one slide that they could otherwise show in one slide in a live lecture class or present it progressively in layered slides because of the large font size needed and the need to leave about 1/4th to 1/3rd of the screen image blank so that the instructor would not stand in front of the material while he was presenting it. The lectures were taped in a well-equipped room in the Institute's continuing education facilities. They were taped without a live audience in front of a green monochrome screen in a fashion similar to weather reporting on television. Off camera and to each side were television monitors, which the instructors used to position themselves on the screen and to point to material on the monochrome screen as necessary. While the instructors did not read from written scripts, it became apparent from experimental taping sessions that the typical "free-wheeling" style used in live lectures was not a mode well suited for this medium. More formal, well-rehearsed lectures were required. As a result, nearly all lectures required more than one taping to produce a quality presentation. It is estimated that it took about 20 hours of preparation for each hour of finished video material. The resulting video streams contained a total of ten hours of material.

Creation of a CD-ROM Electronic Audiovisual Textbook

During nearly three years of course offerings, several issues have arisen, however, two have resulted in modifying considerably the mode of delivery of the material. First, the quality of the lectures from the Internet could be affected significantly by the quality of their transmission. While the instructors made every effort to prepare quality presentations in terms of visual image and subject content, their delivery to the students could be easily compromised by either the network load or the connection technologies used by the students. Second, the textbook had become a problem because the original textbook selected was increasingly difficult to procure and no others seemed suitable as replacements. Textbooks designed for live lecture, 3-credit hour courses are ill suited for a 1-credit hour, streaming-video course. An interim solution was adopted for the fall of 2001 when text material created by the authors tailored to the course was made available to students via the Internet. It was felt that this change made it easier for students to follow the course. Fundamentally, there needed to be a tighter integration between the reading material and the lectures. Since the lectures do not require real-time interaction with the students, they could be provided on a CD-ROM and distributed to the students, thus assuring higher quality presentations on a consistent basis and integrate them into an electronic audiovisual textbook.

The notion behind an electronic audiovisual textbook is to: 1) integrate the video material with the written material so that a student can view a concise presentation on short sections of written material; and 2) permit the student to "click" on links to review quickly a particular topic or

concept. Thus, depending on student's preferred learning style, he/she could either read material first and then view a lecture or view a lecture first and then read material. In either case, students can progress through the electronic audiovisual textbook in a fashion that requires neither extensive a priori reading nor a priori listening/viewing, but rather the two forms of learning can progress more or less equally. In effect, there are neither "chapters" nor "lectures" but instead a logical progression of topics in written, audio, and visual forms.

Description of the Course Offering

The first lecture is live in a large auditorium where the mode of delivery of the course is explained and demonstrated with an Internet connection. The course material was initially organized into two-week learning cycles in which students: read the assigned material from the textbook and viewed the lectures; did the homework assignments; attended the help sessions, if needed, offered six hours per week; reviewed sample quiz questions available on the internet site; took a 50-minute quiz administered to all students in a large lecture hall; viewed individual grades on the website as well as the class distribution; and obtained individual quiz papers either in a subsequent help session or at the next class quiz. A typical semester included seven learning cycles. More recently, the course has been re-organized into four learning cycles: financial mathematics, economic decision criteria, depreciation and taxes, and inflation and uncertainty.

Initially, there were a large number of absences from quizzes, and many students performed poorly on the quizzes. Thus, a general make-up quiz was scheduled and made available to all students during final exam week. Absences from quizzes have declined during the subsequent offerings of the course. Another recent change has been the addition of structured lectures by the teaching assistants on days when there is no scheduled quiz. Attendance at these lectures ranges from 15 to 25%. The reason for this addition was the perception that some students have difficulty learning by themselves using the video streams.

The website was organized into two main categories: 1) the publicly-available video streams and PowerPoint™ slides, and 2) the part accessible only to students registered in the course, which includes homework assignments, a bulletin board, and student grades.

The new format will have the course organized into six sections with each further subdivided into three to nine modules. Each module will contain text material (3 to 4 pages), a video presentation of approximately 5 to 8 minutes, additional solved problems in text format, and homework problems. All of this material will be provided on the CD in a browser format with links to a glossary, selected links to websites, and navigation links. A website will continue to be maintained with a bulletin board, homework and quiz solutions, and grades. The bulletin board will have topic forums by section, and additional forums for topics of current interest related to the course.

The course outline is as follows:

- *Introduction*
  - Organization and Navigation of the Materials
  - Learning Objectives
- *Financial Mathematics*
  - Compound Interest
  - Equivalence
  - Equivalence Formulas
    - Single Cash Flow
    - Uniform Cash Flow
    - Arithmetic Cash Flow
    - Geometric Cash Flow
  - Interest Rate Conversions
- *Economic Decision Criteria*
  - Fundamental Choice of an Economic Decision
  - Benefits and Costs
  - Net Future Value
  - Net Present Value
  - Net Uniform Value
  - Internal Rate of Return
  - Benefit/Cost Ratio
  - Logical Relationships among Alternatives
  - Multiple Alternatives
  - Unequal Lifetimes
  - Case Study: Mortgage Refinancing
- *Taxes*
  - Types of Taxes
  - Profit and Cash Flow
  - Graduated Corporate Tax Structure
  - Classical Depreciation Methods
  - MACRS Methods
  - Profit on the sale of an Asset
  - Financing With a Loan
  - Comprehensive Example
- *Inflation*
  - Price Indices
  - General Inflation Example
  - Relationship between MARR and Inflation
  - Actual and Constant Dollar Analysis
  - Retirement Planning Example
- *Uncertainty*
  - Scenarios and Expected Net Present Value
  - Breakeven Analysis

Observations and Experiences

During the first offering the most notable student reaction was surprise and frustration. There was little if any advance notice of the internet-only method of lecture delivery. Incompatible software, poor quality video streams for the 56K download for off-campus students, interrupted downloads, and improper switch settings contributed to the frustrations. During the subsequent offerings there was relatively little outspoken frustration. Apparently, the word had spread among most of the students and they were aware of the new format. In addition, feedback gradually became more positive and the overall course rating actually became higher than the last live lecture offering. Data for Fall ′01 are not directly comparable because the form of the question was changed.

The comparisons presented in Tables I and II and Figures I and II are based on feedback responses by students near the end of the academic term. The Fall ′98 offering was a 3-credit hour, traditional live lecture class. The others thereafter were the 1-credit hour, internet-only class. Because of the reduction in material covered, the data for Fall ′98 are not strictly comparable. Further, the response rates have been affected by an Institute-wide policy started in the Fall of ′99 that changed the collection of student feedback from paper forms distributed in class to one in which students submit their evaluations electronically outside of class on their own time. Nonetheless, student ratings remain somewhat below average for other, for the most part, live lecture classes at the Institute.

TABLE I
Responses to the Question, "The course has been valuable to me."

Offering	*N*[*]	*SA*[*]	*A*[*]	*PA/PD*[*]	*D*[*]	*SD*[*]	*Rating*[*]
Fall ′98[**]	32	20%	30%	20%	20%	10%	3.5
Fall ′99	120	10%	38%	23%	16%	13%	3.4
Spr ′00	61	8%	45%	23%	10%	13%	3.6
Sum ′00	20	14%	52%	24%	5%	5%	3.8
Fall ′00	74	11%	37%	33%	14%	5%	3.4
Spr ′01	78	16%	43%	26%	12%	3%	3.7
Sum ′01	16	31%	25%	19%	6%	19%	3.8

[*] N = Number responding; SA = Strongly Agree; A = Agree;
PA/PD = Partly Agree and Partly Disagree; D = Disagree; SD = Strongly Disagree;
Rating = Overall rating of the course, 1 = Low, High = 5.
[**]3-credit hour, live lecture class. All others internet-based.

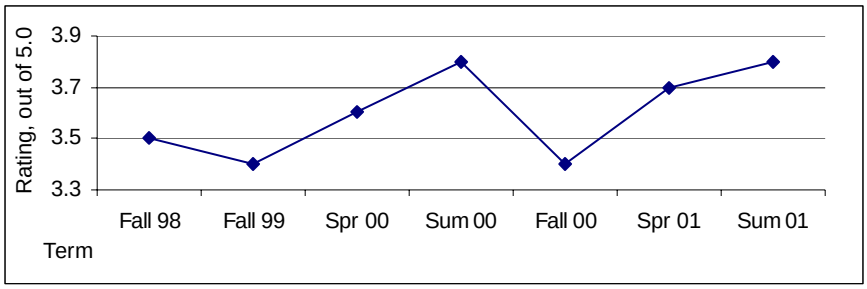


Figure I. Rating on question, "The course has been valuable to me."

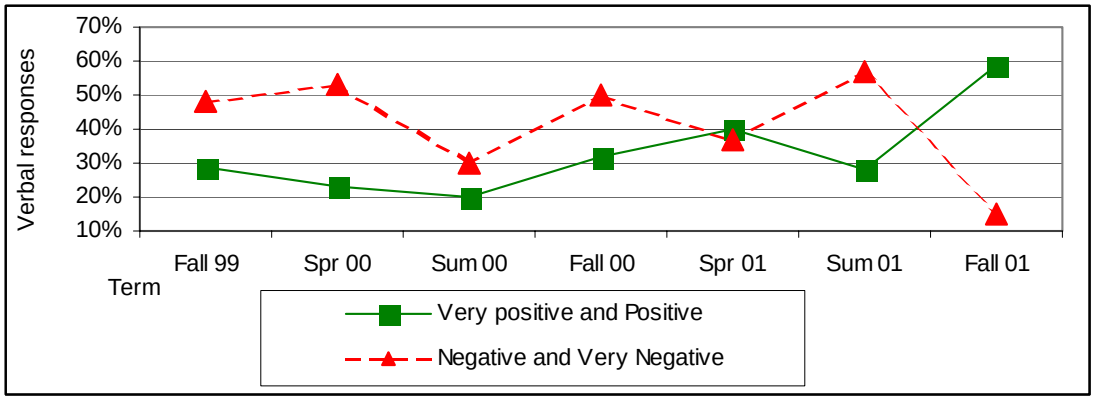
A summary of an analysis of the voluntary verbal comments is shown in Table II. There has been a gradual improvement from the initial negative reaction, with some outlier statistics during the Summer ′01 when very few students responded.

TABLE II
Classification of Verbal Responses on All Aspects of Course

Offering	*N**	*VP**	*P**	*M**	*N**	*VN**
Fall ′99	98	13%	16%	23%	38%	10%
Spr ′00	36	13%	10%	23%	45%	8%
Sum ′00	14	10%	10%	50%	30%	0%
Fall ′00	44	11%	21%	18%	50%	0%
Spr ′01	45	16%	24%	24%	37%	0%
Sum ′01	7	14%	14%	14%	57%	0%
Fall ′01	36	12%	47%	26%	15%	0%

* N = Number responding; VP = Very Positive; P = Positive; M = Mixed; N= Negative; VN = Very Negative.

FIGURE II
Grouped Classification of Verbal Responses on All Aspects of Course



The major complaints have focused on: 1) the method of delivery, 2) inconvenient times for help sessions, 3) physical limitations of the classroom used for administering quizzes; 4) technical problems with downloading material, including the inability to save some material; 5) disappointment with an 8:00 AM class time (for quizzes); 6) the feeling there was too much material for a 1-hour course.

Help session attendance has dropped from the first offering, when it ranged from 4% to 12% the week leading up to a quiz, to a range from 0.2% to 8%. Obviously, the students changed their learning habits. Interestingly, the overall grades achieved by the students have been generally higher after the conversion, as shown in Table III. This must be tempered by the fact that the coverage of material was reduced considerably. An attempt to relate student grades to website visits and bulletin board articles read did not yield statistically significant results.

One of the disadvantages of internet-only lectures is the lack of personal interaction between the faculty and the students. The element of real-time discovery is reduced. Further, video taped lectures do not lend themselves well to discussing ill-structured, real world examples to motivate the students about the material. There is an increased administrative burden in maintaining the website and bulletin board on daily basis, and in assuring that all documents are available and consistent.

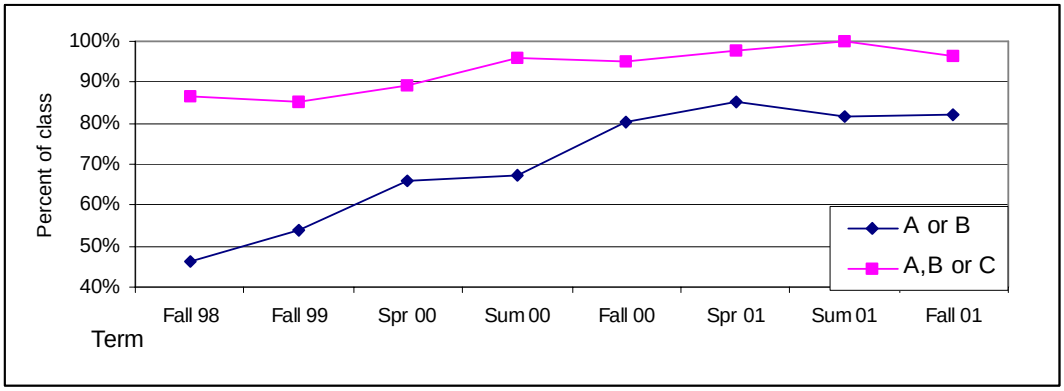
On the other hand, the flexibility of viewing the lectures at any time is convenient for those students with job interview trips or who incur an illness. Students who must schedule other classes during the same time period can do so.

TABLE III
Grades Achieved by Students Before and After Conversion

Offering	*N*[*]	*A*	*A or B*	*A,B or C*	*D or F*	*I or W*[*]
Fall ′98[**]	53	23.1%	46.2%	86.5%	9.6%	3.8%
Fall ′99	250	48.1%	53.7%	85.2%	9.3%	5.4%
Spr ′00	259	26.2%	65.8%	89.2%	3.9%	6.9%
Sum ′00	98	35.7%	67.3%	95.9%	2.0%	2.0%
Fall ′00	252	40.2%	80.4%	95.1%	0.8%	4.0%
Spr ′01	270	45.2%	85.2%	97.8%	1.4%	0.7%
Sum ′01	93	46.2%	81.7%	100%	0%	0%
Fall ′01	263	48.7%	82.1%	96.2%	1.9%	1.9%

[*] N = Number responding; I or W = Incomplete or Withdrew.
[**]3-credit hour, live lecture class. All others internet-based.

FIGURE III
Grades Achieved by Students Before and After Conversion



The remote learning method forces the instructor to clearly define the contents of the course more so than the live lecture method since typically all of the videotaping must be done before the class begins. An unintended consequence is that some students perceive a greater workload than they would with live lectures. This may be because they are learning to manage their time in a new a learning environment. A hoped-for consequence is that students might adjust better to this medium for lifelong learning.

Conclusions

We have six observations to offer for those contemplating substantial internet-based instruction.

- The process for creating and administering the course is very time consuming, especially at the beginning. The learning curve has a high, initial step function.
- Every step of the process should be tried in an experimental form first. Anticipate and allow time to deal with technical surprises.
- More formality and rigor are required in the presentations than in a live lecture, and more attention to the details is required in managing the course.
- Electronic audiovisual textbooks and substantially internet-based courses must be reorganized into short segments of content and the presentation style of the instructor must be modified to suit the medium
- Since most on-campus students still take live lecture courses, the surprise reaction of students should be expected and advance publicity of the manner of delivery of the course should be made to mitigate it.
- Students appear to adopt a much more relaxed approach to the course. In our case, this may be because it is a 1-credit hour course.

Finally, as the cost of technologies lowers and their use becomes easier for more faculty, more and more internet-based or CD-based materials are likely to be used in place of live lecture classes. There are a number of pros and cons to doing so. At the moment, most students have been exposed mostly to live lecture classes throughout their academic lives. As such, it is to be expected that their reactions will vary to this new form of educational delivery. As resources tighten and interest in engineering education and continuing education grows, the use of electronic technologies will become a much more prevalent part of our means of educational delivery.

Bibliography

1. Benjamin, N.N., A. Johnson, M. Zidon, D. Moen, and D.K. Ludlow, "The Development of an Undergraduate Distance Learning Degree for Industry – A University/Industry Collaboration," *Journal of Engineering Education*, vol. 87, no. 3, (July 1998), pp. 277-282.
2. Shute, N., "Open University," *PRISM*, vol. 11, no. 3, (November 2001), pp. 18-25.
3. Boulet, M-M., and S. Boudreault, "Using Technology to Deliver Distance Education in Computer Science," *Journal of Engineering Education*, vol. 87, no. 4, (October 1998), pp. 433-436.
4. Gramoll, K., "An Internet Portal for Statics and Dynamics Engineering Courses," ," *(Web) Proceedings of the 2001 International Conference on Engineering Education (Session 7B1*), http://fie.engrng.pitt.edu/icee/papers/183.pdf, Oslo, Norway, August, 2001, pp. 7B1.1-7B1.6.
5. Salzmann, C., H. Latchman, D. Gillet, and O. Crisalle, "Virtual Laboratories and Real-Time Experiments in Engineering Education," *(Web) Proceedings of the 1999 International Conference on Engineering Education*, <http://www.fs.vsb.cz/akce/1999/ICEE99/Proceedings/papers/427/427.htm>, Ostrava, Czech Republic, August, 1999.
6. Kadiyala, M., and B.L. Crynes, "A Review of Literature of Effectiveness of Use of Information Technology in Education," *Journal of Engineering Education*, vol. 89, no. 3, (July 2000), pp. 279-283.
7. Chen, J.C., M. Ellis, J. Lockhart, S. Hamoush, C.E. Brawner, and J.G. Tront, "Technology in Engineering Education: What Do the Faculty Know and Want?," *Journal of Engineering Education*, vol. 89, no. 2, (April 2000), pp. 177-189.
8. Jackson, J.R., D.V. Anderson, T.P. Barnwell, and M.H. Hayes, III, "Effective and Efficient Distance Learning Over the Internet: Implementation of an Online DSP Course," *(CD) Proceedings of the 2000 International Conference on Engineering Education*, Taipei, Taiwan, August, 2000, 4 pg.
9. Dutton, J., M. Dutton, and J. Perry, "Do Online Students Perform as Well as Lecture Students?," Journal of Engineering Education, vol. 90, no. 1, (January 2001), pp. 131-136.
10. <http://www.isye.gatech.edu/~engecon/>
11. Lohmann, J.R. and G.P. Sharp, "Video-stream Lecture Series for Remote Learning by On-Campus Students: Results After Two Years," *(Web) Proceedings of the 2001 International Conference on Engineering Education (Session 6E4*), <http://fie.engrng.pitt.edu/icee/papers/361.pdf>, Oslo, Norway, August, 2001, pp. 6E4.1-6E4.7.
12. Lohmann, J.R. and G.P. Sharp, "Development of a Video-stream Lecture Series for Remote Learning," *(CD) Proceedings of the 2000 International Conference on Engineering Education (Session WD7-5)*, Taipei, Taiwan, August, 2000, 5 pg.

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