

**Comparison of Classroom and Video-Based Instruction:  
A Case Study for a Graduate-Level Air Pollution Control Course**

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## **INTRODUCTION**

A graduate level air pollution control course was offered in the fall of 1995 at North Carolina State University (NCSU). A description of the course is given in Appendix A. This course was offered to 16 on-campus students in a live classroom environment and to 20 distance learners through videotape and satellite. The distance learners took the course through two different programs. One was the Video-Based Engineering Education (VBEE) program of the Industrial Extension Service (IES) at NCSU. A description of the VBEE program is given in Appendix B. The other program was the National Technology University (NTU). This paper focuses on a comparison and assessment of video-based teaching versus teaching in a traditional classroom. The paper includes identification of the challenges for video-based instruction, such as obstacles for interaction with distance learners, lack of distance learner access to on-campus resources such as a research library or computer facilities, problems with scheduling, and difficulty in implementing some preferred teaching styles. The paper will also discuss the strengths of such a course, including exploitation of the in-studio technology and the ability for students to take courses and pursue degrees while minimizing time away from work. The results of student surveys, as well as anecdotal information from students and the instructor, will be discussed.

This paper contains information that is intended to be helpful to an instructor who is considering whether to offer a video-based course. The paper highlights differences between traditional and video-based instruction, including a number of practical and logistical issues. The paper is based on the experiences of one instructor during one semester of one course. Thus, the results here may not be generalizable to other situations.

## **COMPARISON OF ON-CAMPUS AND DISTANCE LEARNER STUDENTS**

The distance learners tended to have more substantial work experiences in air pollution related activities compared to on-campus students. Many of the distance learners are mid-career professions. A number of on-campus students have come to NCSU for graduate study after several years in the workforce. However, many of the on-campus students are also on a straight-through path from a bachelors to a graduate degree and, therefore, have limited work experience. The differences in the student populations are perhaps sharpest with respect to work experiences relevant to the course and with respect to the specificity of students' statements of expectations. At least some of the distance learners could, in principle, translate the material in the course to their every day work environment.

### **Academic Backgrounds**

The air pollution control course attracts students with a broad range of backgrounds. Currently, the instructor is flexible regarding preparatory course work requirements. Both the on-campus and distance learner students had a broad range of academic backgrounds. While there appeared to be no typical undergraduate degree for either group, a typical distribution of degrees includes: chemistry, chemical engineering, civil engineering, electrical engineering, mechanical engineering, meteorology, oceanography, and physics.

### **Work Experience**

The distance learners typically had more substantial work experiences in fields related to air pollution control than did the on-campus students. A few of the on-campus students are currently working as research assistants on air pollution topics, one worked as an air inspector for a state agency, and another had some limited experience on hazardous pollutant releases while working for an oil company. In contrast, the distance learners described a variety of work experiences relevant to air pollution control or air quality engineering. Examples of these experiences include:

- "Conducted indoor air quality studies"

- "Responsible for air emissions inventory and permitting" and "environmental audits of suppliers"
- Performed air emissions testing, modeling, and permit applications
- "Industrial hygiene and hazardous waste emergency response"
- "Flame control instrumentation" and design of ventilation hoods
- "My company measures emissions" and does some dispersion modeling and emission inventory work
- "Environmental engineer at a textile dyeing and finishing plant in charge of all air permits and air quality issues"

### **Expectations**

The on-campus students expressed a variety of expectations for the course. Many can be summarized as general in nature as represented by one student's statement: "interested in developing a knowledge base in air quality and pollution control as part of a broadly structured environmental engineering master's degree program". Many of the students were interested in how air pollution relates to their primary area of study or research. For example, one student pursuing an civil engineering degree with a transportation focus was interested in understanding how to control and monitor mobile source air pollution emissions.

The distance learners also offered a number of general reasons for taking the course, including:

- Broaden education with an environmental science course
- Broaden work experience in wastewater with coursework in air pollution control
- Improve understanding of basic science of air pollution control
- General interest and preparation for Professional Engineer certification

Some of the distance learners offered more specific reasons for taking the course:

- To gain technical and theoretical depth to complement the regulatory side of air pollution control (which was part of the student's responsibility at work)
- Hope to learn the theories behind the formation of atmospheric pollutants and common control methods for each.
- Know how to obtain and test air samples and what technologies can be used to control these emissions
- Better understanding of VOC control options

In general, there did not seem to be any significant differences between the goals of on-campus versus distance learners. Because this course is primarily an engineering science course, some students who are interested in engineering design may feel that the course is not sufficiently "practical". However, it appeared that a substantial number of distance learners were as interested in theory and science as they were in design and practice.

### **ELECTRONIC COMMUNICATIONS**

Surprisingly, electronic communications were not readily available to many of the students who took the course by either video or satellite. Thus, although e-mail was highly encouraged as a means for communicating with the instructor, relatively few students were able to use this method for communication. Those students who did have e-mail tended to have access through their employer. A few had personal subscriptions to on-line services. In contrast, all of the on-campus students have a computer account through North Carolina State University.

During the semester, a limited amount of reserve material was made available to the on-campus students. The material consisted primarily of copies of all overheads presented during the lectures and of all handouts. It is not possible to provide a comprehensive set of reserve materials that would be available to both on-campus and distance learners. For example, it would be helpful to have a number of air pollution books on reserve, as well as copies of journals and trade magazines. While some may suggest use of the World Wide Web as a means to disseminate information, there are several limitations to this approach:

- Not all students have access to the World Wide Web. For example, only 7 of 13 distance learners who returned a beginning-of-the-semester questionnaire indicated that they had an internet e-mail address.
- Not all candidates for reserve materials are easily encoded for use on the World Wide Web. This is either because of logistical and resource issues (e.g., scanning in entire books, having the time to do this, having the knowledge to set up a web page, etc.), or legal issues (e.g., copyright).

## COMMUNICATION WITH STUDENTS

### Interaction with Students in the Classroom

The course was taught in a television studio. The facility had a relatively traditional classroom seating arrangement, with the exception that a microphone was located near each student. The presence of the microphones and cameras has an initial inhibiting effect on the on-campus students. It was quite clear that the students were, at first, intimidated by the studio. Some students expressed concerns, after class, about not only the typical fear of asking a "stupid" question in class, but also of having the "stupid" question videotaped and preserved for posterity, as well as being broadcast live by satellite.

The instructor stands behind a rather massive podium. The podium, which is approximately six feet across and four feet high, contains a TV monitor for the on-line signal, a second monitor for use with an illustrator pen, and an equipment console for operating the pen. The podium is located beneath an overhead camera which is used in the same manner as an overhead projector would be in a traditional classroom. To one side of the podium is a rack containing computer equipment. Thus, the students have a rather obstructed view of the instructor. (Other instructors who have taught in these studios have joked that you could wear shorts to class and no one would know.) The instructor can, in principle, meander around the room. However, this is only if the wireless microphone is: (a) available; and (b) working. Typically, the instructor must use a wired microphone, with a reach of perhaps a few feet from the podium. If the instructor is using the technology at the podium, movements are further restricted. The overall effect is that the instructor may tend to be separated from the live audience much more so than in a traditional classroom.

The studio environment tends to be relatively formal and inhibiting for the on-campus students. The students did relax over the course of the semester, and became more comfortable asking questions in class.

Students who viewed the course by videotape had no interaction with the live class. Students who took the course through NTU could, in principle, watch the class live. An 800 number was available for calling in questions. One student, who started the course by viewing the live broadcast, indicated that at times the quality of the broadcast was not very good. Some of the broadcast downlink sites had difficulties at times, and had to request videotapes of the lectures from NCSU. No one called in during the entire semester, even though students were repeatedly invited to do so and even though the 800 number was flashed on the screen during each lecture. A few of the distance learners commented that they depended heavily on the on-campus students to ask good questions.

Experts in teaching effectiveness often recommend the use of group exercises during class. Such activities break the monotony of a lecture and get students actively engaged in a topic. However, group activities in the studio are not particularly useful to a distance learner who may be working alone. Thus, although one or two group activities were attempted early in the semester, they were not pursued as aggressively by the instructor as they would have been in a traditional classroom setting.

### **Interaction with Students Outside of Class**

Typically, some significant fraction of on-campus students will interact with the instructor either in the classroom immediately after class or outside of class in the instructor's office. Because the videotaping was strictly timed, it was occasionally the case that the lecture would be cut off in mid sentence. In some cases, the on-campus students had pressing questions that would be addressed after the broadcast and taping were done. In such cases, the distance learners would not benefit from the interactions. However, it seemed unfair to cut off students in the studio merely because the video taping had to stop. The on-campus students have made a substantial commitment of time and money to attend the university and deserve the attention of the instructor even after the taping is done.

Of the 20 students who completed the course through VBEE or NTU, only one actually attended a class on-campus. Other than that one interaction, the instructor did not meet in person any of the other students. Less than half of the students made any significant effort to contact the instructor regarding questions about the lectures or homeworks. Contacts were typically made by telephone or e-mail. Telephone offered the advantage of being more personal and informal. E-mail offered the advantage of being quicker. Students were generally good about calling during office hours. However, at times students would call when the instructor was on the phone with other students or when the instructor was meeting with an on-campus student. E-mail offers the key advantage of allowing the instructor to reply to a question at the earliest convenient time, even if it is after work hours for the students. In some cases, students did not have voice mail, and calls returned after hours were met with many unanswered rings.

The lack of direct face-to-face interaction with students is a key shortcoming of distance learning. There were some cases in which it would have been easier and better to be able to sit down with students and work through some examples to answer their questions. However, talking on the phone does impose some discipline to verbalize answers in a clear way to communicate information that ideally would be relayed graphically or mathematically.

The VBEE program does include a provision that instructors must make visits to sites within North Carolina that have five or more students enrolled in the course. No more than two students were simultaneously enrolled in the course at any given site. Therefore, no site visits were required. However, such visits would have required a full day of travel and meetings with students.

### **INTERACTIONS WITH THE STUDIO DIRECTORS**

The studio directors can make a difference in the atmosphere of the classroom. There are times when a director may need to contact an instructor during a lecture regarding cues, updates on time remaining, communication of problems with equipment, and so on. Most importantly, the director controls the timing of what is seen by the distance learners. Some directors are better attuned to the timing of a particular instructor. For example, the instructor would often make use of a computer-generated slide to motivate a question for the class. The class would then have an opportunity to respond. To summarize what was learned, the instructor would return to the computer graphic. The timing of when the director switches from a view of the graphic to a view of the studio audience or instructor, and then back to the graphic can affect the flow of the lecture. Directors are knowledgeable about how much time to allow for students to read a graphic, and some instructors may tend to be impatient with the time spent dwelling on a graphic. As the semester

progresses, the instructor and director will typically find a rhythm that suits them both. However, if directors are rotated during the semester, the differences in rhythm can be quite obvious.

Some directors are less obtrusive than others about warning the instructor when class is about to end, for example. Others may be more humorous or friendly in tone. In one case, the director flashed on the studio monitor screens a rather serious looking warning message that no food or drink was allowed in the studio. Later, the director indicated that, because of all of the microphones located in the classroom, it was easy to hear the crinkling of candy wrappers. The students learned to respect the signs on the door regarding not bringing food or drink into the studio.

At times, the technology may fail. There were two or three lectures in which it was not possible to get a video signal from the computer used to display computer-based graphics, mainly due to rotation of directors to those who were less familiar with the procedure for hooking up the computer. In all cases, the instructor should have on hand backup materials that can be used. In this case, printouts of the PowerPoint slides were used under the camera. The printouts did not offer the color or some of the interactive features that could be utilized on the computer, but proved to be reasonably effective in an emergency.

The studio climate was a significant issue. At times it was either much too hot or much too cold. The tendency was to be too cold. Air conditioning is required not just for the comfort of the living occupants in the studio, but also for the durability of the heat-generating electronic components in the room.

The studio was used for the in-class exams and the final exam. The TV studio was not a particularly ideal environment for giving exams. The seats are relatively closely spaced compared to a traditional classroom.

## **INSTRUCTIONAL MATERIALS**

An advantage of teaching in a studio is that one can use technology to improve communication of materials to the students.

It is possible to use the overhead camera in the studio to display to students objects that would be more difficult to show in a traditional classroom. The camera can zoom in on even a relatively small object, and the instructor can point out its finer features without having to worry about whether students can see it. The on-campus students were able to view the camera images on two large-screen TV monitors located on either side of the front of the studio.

The overhead camera can be used to display a variety of text and graphic images. While there are some concerns regarding displaying line art that has closely spaced lines or dotted gray areas, most graphics from textbooks or previous presentations were easily adapted for display on the overhead camera. In a few cases, the instructor's lack of familiarity with the camera proved to be amusing. For example, one graphic illustrating acid rain yielded a dynamic moving pattern of rain under a cloud when viewed on the TV monitor. The overhead camera was good at displaying photographs of emission sources and control technologies taken by the instructor. At times, glare from the camera lights required that the photos be tilted to minimize reflections. This can pose a logistical problem, if the instructor is simultaneously operating a light pen. However, after a few lectures, familiarity with the studio equipment improves significantly.

The instructor made use of an Apple Macintosh PowerBook 180 portable computer to generate and display lecture materials. The studio directors were able to hook the computer into the video signal. It was therefore possible to transmit any graphic image that could be obtained on the computer. For the most part, the instructor made use of PowerPoint to develop clear graphics and

text for the lecture materials. The instructor also made use of digitized photos and some specialized environmental modeling software during the lectures.

The instructor decided to convert lecture notes from previous semesters, which had been used a basis for writing on a blackboard, to create graphics and computer-based presentation materials that otherwise would not have been used in a traditional classroom. However, it took typically two hours to prepare each lecture using the new format.

## **DEADLINES**

While distance learners who take a one day or a one week short course may be able to meet course deadlines, those who take a semester long course must integrate the coursework with their work schedules over a period of approximately four months. Because of travel schedules and work assignments, many students are not able to stay on a strict schedule for homeworks, exams, and projects. For example, several students taking the course were in the armed forces and were called to assignments during the course that prevented them from keeping up with the work. Two students worked in an emergency response unit for a federal agency, and had to deal with emergency situations during the semester. Others had regular travel on a monthly or even weekly basis.

In previous semesters, when the course was offered solely in a traditional classroom, students have been asked to follow a rigorous schedule of nearly weekly problem sets. Typically, the problem sets would be graded and returned by the next class period, and the solutions to the problem sets would be discussed in class. In some cases, the applications in the problems, such as emission sources and control technologies, are for technologies which have not been covered in class but for which the students should have sufficient engineering science background based upon previous lectures. Thus, the homeworks are often used to give some breadth to the course. For example, there is a detailed problem set on municipal solid waste incineration which builds upon material the students have already had related to emissions from coal-fired power plants. An important role for these types of thematic assignments is to provide the basis for an inductive classroom discussion regarding particular emission sources and control options.

However, it was typically the case that distance learners would turn in assignments approximately two to six weeks later than the on-campus students. This posed several problems:

- Originally, the instructor planned to put distance learners in touch with each other so that they could discuss or even collaborate on homework assignments. However, because students were on such varying schedules, the instructor was concerned that students who might have already received a graded assignment would inadvertently discuss solutions with students who had not yet attempted an assignment.
- The random arrival times of completed assignments poses an obstacle to consistent and time-efficient grading. In a traditional setting, an instructor might grade all assignments in one sitting, and do the grading in such a way (e.g., grade all of the responses to the first problem, then all of the responses to the second problem) to allow comparisons and consistency in grading answers. In contrast, it was rare when more than two or three submissions for a given assignment were available for grading. Thus, grading for any particular problem may occur over a four week period. It is not feasible to delay grading until all of the assignments are turned in, because then many of the students will not receive the timely feedback on their work that they need in order to do subsequent assignments.
- Delays in receiving assignment poses a dilemma for how frequently to discuss homework solutions in class. Ideally, homework solutions would have been discussed on a weekly basis. However, in order to discuss solutions in class, all distance learners

must either have turned in the assignment, or they must be prevented from viewing the lecture in which the solutions are given until they have turned in the assignment. The latter turned out to be a workable approach. However, this is only because students who took the course via NTU did not watch the live satellite broadcast. Instead, they used tapes made by their site coordinators. Clearly, there is a trade-off between promoting live interaction with distance learners and maintaining timely review of assignments.

The downside of imposing restrictions on when students may view a particular lecture is that additional delays may be incurred regarding exam dates. Students were allowed to take an exam after they had submitted all of the homework assignments scheduled prior to the exam. Upon submitting the homework, the students were entitled to receive a solution set. However, the students were not likely to receive back all of their graded assignments prior to having to take an exam. This is due to the two to three week turn around time for mailing the assignments in, having them graded, and mailing them back. Homework solutions were discussed in only about ten percent of the lectures. Distance learners therefore had considerable flexibility to view lectures, even if they were not on schedule with respect to assignments. The downside is that the on-campus students did not receive timely feedback during the lectures that they would have in previous semesters, when the course was offered in a traditional classroom.

Many students seemed to assume that it was their right to complete assignments on their own schedules, and that they would be entitled to receive an incomplete and to finish the work at their leisure during the subsequent semester. To encourage students to submit assignments on time, several memos were prepared by the instructor emphasizing that all requirements for the course must be met by the end of the semester, and that no incompletes would be given. Incompletes are typically given only in extreme situations in which a student cannot complete the course for reasons beyond their control and not due to their own negligence. A valid reason for an incomplete would be, for example, a death in the immediate family or a serious illness.

In spite of several memos and direct communication to the distance learners from the Industrial Extension Service regarding the course schedule, a few students continued to lag behind by several weeks even as the semester came to a close. Some students did not communicate with the instructor regarding delays in submitting assignments. They did finally submit the last three homeworks, together with the last of three in-class exams and the three hour final exam, at the end of the semester.

Some students asked their site coordinator to intervene on their behalf with pleas for extensions. The site coordinator's function is administrative, not academic. One site coordinator bluntly stated that the instructor's deadlines for submitting assignments were "unreasonable" and negated the "flexibility" of distance learning. However, the flexibility of distance learning is in large part due to the ability of students in the workforce to take a graduate level university course without having to be physically located on a university campus. The notion of flexibility should not extend to disregard for schedules. Students who sign up for a course have a responsibility to make a reasonable effort to complete the course on time. In fact, the instructor did not impose any late penalties on late homeworks.

## **PERFORMANCE IN THE COURSE**

### **Homeworks**

To promote active learning and to encourage students to work together and learn from each other, the on-campus students were asked to work in groups of three on the homework assignments. The group approach to homeworks appeared to be relatively successful for these students. The quality of the homeworks was generally high. However, this approach could not be implemented for most of the distance learners. There were three pairs of students who were taking the course

together at a particular site. These students could work together in groups of two and were encouraged to do so. A few students asked for help in locating other students who might be nearby with whom to collaborate. However, probably due to logistical aspects of trying to contact students at other sites by phone, e-mail, or fax, such interactions did not appear to take place. While some students were successful in doing the assignments on their own, it was clear that a number of students would have benefited from having peers with whom to interact.

### **Tests**

A major concern regarding exams is that on-campus students may have access to material from previous semesters, including graded exams. Thus, it is prudent to make new exams and new assignments each time the course is offered. A related issue is whether the assignments and exams for distance learners should be different than for on-campus students, especially given the typical time lag in when the distance learners receive and complete assignments. In principle, some of the distance learners located nearby the university could interact with students in the class or even come to campus to look for posted solutions. In most cases, there was no reason to believe that the distance learners would or could interact with on-campus students to obtain advance knowledge of solutions. Thus, for the most part, the same assignments were given to both groups of students. A key exception was the final exam, which was substantially different in specifics for the two groups of students.

### **Term Projects**

A few of the distance learners did truly outstanding term projects. Two of the students worked in the electric power industry. They were able to translate the course work into spreadsheet-based computer models to aid in the preparation of mass and energy balances for proposed power plant and air pollution control construction projects and for decision-making regarding NO<sub>x</sub> control technology options. A few others used the term project to focus on studies of emission sources at their companies. Such projects included, for example, evaluation of particulate matter control options for small boilers and evaluation of VOC control options for manufacturing processes. Unlike on-campus students, these students had direct access to real process data and also could more credibly contact vendors and others to obtain supporting data. For example, one student developed cost models of fabric filter and electrostatic precipitator controls, and then contacted vendors to obtain cost quotes. The quotes and the model results were compared and evaluated. The distance learners appeared better able to articulate the shortcomings and limitations of their work than did many of the on-campus students. This may merely reflect additional maturity due to more substantial work experience.

On the other hand, a few of the distance learners did not prepare a formal term paper in accordance with the specifications given to them. Some of the papers were merely a set of calculations, with little documentation, while a few were merely literature reviews, with no original analysis.

While eventually all of the students taking the course for a letter grade completed the term paper, many of them failed to complete some of the intermediate deliverables, which included a term paper proposal and a term paper progress report. The failure to prepare these deliverables is likely due mainly to two causes: (1) administrative delays in distributing materials to the students in the first month of the course; and (2) travel schedules and other work demands on the students. However, the important implication of the failure to submit the term paper proposal or progress reports was that the instructor was not able to provide these students with feedback regarding the topics or focus of their projects. Students who did not complete the proposal or progress report tended to get lower grades on the term paper project, because the term paper contents did not meet all of the requirements for analysis, interpretation, and presentation.

It is commonly heard in mail rooms and elsewhere that engineering students are not good writers, and that employers value writing skills. Approximately one-half of the distance learner papers

were well or even beautifully written. A similar portion of the on-campus papers were well-written, although the sample size (7) was rather small.

One key shortcoming that may have hampered a number of the distance learners in preparing the term paper was lack of access to a research library. On a mid-semester evaluation form, one student wrote:

*It is going to be especially hard to find time to travel to a library to do the research for the term paper... I sometimes don't think professors realize how hard it is to do research for a term paper when you are not living on a campus with a good library*

Another student, during a telephone conversation, asked if I thought it would be worthwhile for him to make a two hour drive to the nearest university library. Many of the students appeared to rely on in-house materials rather than to do a more substantial literature search as might be done at a university library. Lack of access to a research library is a key shortcoming of distance learning. This lack of access is not solved by the World Wide Web, since: (a) many students do not have access to the WWW; (b) the WWW does not contain all of the information that would be found at a research library.

## **GRADES**

Overall, the distance learners did not do as well in the course as did the on-campus students. The graduate students taking the course on campus earned mostly A's, with one C. In contrast, the distance learner's grades were more uniformly distributed between A and C. The quality of the top students in either group was comparable. The five distance learners who earned C's did so most likely because of time pressures. It is hypothesized that in two cases face-to-face interaction with the instructor outside of class may have helped.

## **BENEFITS TO THE INSTRUCTOR**

One key benefit of distance learning is that the instructor has access to colleagues in industry. Through the term papers, assignments, and other interactions, many of the students in industrial or government employment provided the instructor with interesting or useful information regarding the types of problems that are of practical interest. This information can be used, for example, to refine the material in the course for future semesters. Specifically, the instructor can draw upon the distance learners to develop practical examples for discussion in class or to develop new homework assignments. It is hoped that at least some of the contacts made with students in the course will prove to be long-lived. Thus, the interaction with distance learners can be professionally enriching.

## **DISCUSSION**

Distance learning offers a key service to students who would otherwise not be able to attend a university class. However, in some ways it is not as ideal as a learning environmental as attending classes on a campus as a full-time student. While a potential advantage of taking a video-based course as a full-time employee is to be able to relate it directly to the "real world", time pressures, logistics, lack of access to research libraries, and limitations of interactions with the instructor and other students are significant barriers to effective instruction and learning. The inability to take advantage of interactive group learning processes in a video-based environmental is an example.

Offering a course via video or satellite does require significant resources. At NCSU, the IES has developed the infrastructure to offer such courses, including administrative support for distributing and collecting assignments. Thus, the additional load on the instructor typically includes (although may not be limited to): (1) incremental grading associated with increases in the number of

students; (2) modifications to course materials for presentation in a studio environment; (3) adaptation or elimination of teaching styles or methods; (4) accommodation of various means for communication with students outside of class; and (5) some accommodation of stochastic arrival times for assignments from distance learners. The development of new course materials that take advantage of the technology available in a studio can require significant effort. Other resource issues that should be addressed in distance learning is the need for additional teaching assistant support for grading and office hours, the benefit of having contact people at each site who are knowledgeable in the topic area and who can answer questions locally, and the translation of instructional materials into the regular campus classrooms during the off-semester when a particular course is not offered by video.

There are some trade-offs in how to best serve distance learners versus on-campus students. The logistical issues of dealing with solution sets was perhaps the most important concern, and imposed some restrictions on the types of questions that could be addressed during the taping of a lecture. Such logistics may be improved with the accumulation of experience in the delivery of a course by video. A relatively minor difference is the need to occasionally look into the camera, as opposed to the studio audience, which may seem artificial to those present in the studio.

Video-based instruction appears to work very well for good students. However, for students who need some individualized attention, it is often not possible to have the direct face-to-face interactions that would occur on a campus. It is hypothesized that such interaction may have contributed to improving the performance of these students.

The material contained in this paper represents the impressions of one instructor who has taught one semester-long graduate course by video. The material presented is offered as an anecdote. It is hoped that it may raise some useful issues and questions for other instructors who may be contemplating delivery of a course by video. The paper contains mention of many issues which were unknown to the instructor five months ago when the Fall semester was starting. Overall, the information contained here would not have changed the decision to participate in the video-based program, but would have been helpful in preparing for some of the common problems encountered over the course of the semester.

## APPENDIX A: DESCRIPTION OF GRADUATE COURSE IN "AIR POLLUTION CONTROL"

# COURSE ANNOUNCEMENT

COLLEGE OF ENGINEERING  
NORTH CAROLINA STATE UNIVERSITY



## CE 497W & CE 589W AIR POLLUTION CONTROL

### Course Objectives

The student completing this course will be able to: (1) identify, classify, and prioritize major emission sources; (2) categorize and describe major types of regulations; (3) apply mass balance, energy balance, chemical equilibrium, and chemical kinetic concepts to estimate pollutant formation rates for a variety of major stationary and mobile sources; and (4) identify, analyze, design, and evaluate air pollution prevention and control strategies.

### Course Description

Brief overview of air pollutant sources, effects, and regulations. Fundamentals of air pollutant formation and control from stationary and mobile emission sources. Chemical kinetics, mass and heat transfer, and thermodynamics affecting gaseous and particle pollutant formation in combustion systems and chemical processes. Study of sulfur dioxide, nitrogen oxides, particulate matter, volatile organic compounds (VOCs), hydrocarbons, and air toxics formation and control. Principles of VOC control, conventional and advanced flue gas desulfurization, thermal and fuel  $\text{NO}_x$  control, and particle/air toxics emission control will be among the emission topics to be explored.

### Prerequisites

This course is multidisciplinary and can accommodate students with diverse engineering backgrounds. CE 382 or equivalent (hydraulics, fluid mechanics) is a formal prerequisite. Students with background in chemistry, thermodynamics, heat transfer, and related areas will be prepared for this course. Please contact instructor (preferably by e-mail) if you have questions about whether your background is appropriate for this course.

### Instructor

Dr. H. Christopher Frey, Mann Hall 311, (919) 515-1155, [frey@eos.ncsu.edu](mailto:frey@eos.ncsu.edu)

## **APPENDIX B:**

### **DESCRIPTION OF VIDEO-BASED ENGINEERING EDUCATION (VBEE) PROGRAM AT NCSU**

This description is available on the World Wide Web at

<http://www.ies.ncsu.edu/programs/vbee/>

The North Carolina State University College of Engineering offers a graduate engineering education program to help engineers, scientists, and technical professionals stay current and productive in their fields without the constraints of on-campus attendance. VBEE courses are regular classroom courses that are videotaped in specially equipped studios. With rapid change occurring in all areas of engineering practice, it is essential that professionals stay current in their field. VBEE is a quality program designed to help them meet challenges and opportunities in a world marketplace.

VBEE courses are for people with a degree, or extensive experience, in engineering, mathematics, statistics, or one of the physical sciences. Students gain professional development while continuing to be employed.

VBEE courses, when taken for credit or audit or towards a degree, are available mainly to people working/residing in North Carolina. Aquisition of course material for general information is useful for those who want to expand their knowledge basis.

Students should meet as a group at regular, scheduled times at their company. The company is required to provide appropriate video playback equipment and adequate meeting space. The company is also responsible for the proper use and care of the videotapes, which must be returned to NCSU at the end of the semester. The student group will select a person to serve as coordinator and contact person with NCSU.

Convenience and flexibility are key advantages in this unique program. Students can attend every class regardless of travel or work demands as the tapes remain on-site throughout the semester. This also means that portions of or entire lectures can be replayed for review purposes. Periodic visits by the course instructor to sites with five or more students, along with the usual homework and examinations, help maintain instructor/student interaction.

Graduate courses enhance professional development and can be used towards the Master of Engineering degree or, in some cases, as course work required for the Ph.D. degree.

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#### **Additional Benefits**

- Graduate work can heighten your value as an employee and expand the scope of your capabilities and contributions with your company.
- Most students work full-time, and many aspects of course work, including papers, projects, and classroom discussions, will fit into an on-the-job framework.
- Positive participation can establish a progressive and aware perspective, thereby enhancing career potential.

#### **Advantages for Participating Companies**

- Course work can introduce new ideas and improved products and/or methods.

- Participants stay ahead of the competition by maintaining a steady flow of current engineering knowledge.
- Enrollment of working engineers in a graduate program can provide an outstanding incentive to recruit qualified and highly motivated personnel.

### Master of Engineering

The NC State University College of Engineering offers an off-campus, video-based program through which engineers, scientists, and other technical professionals can obtain a Master of Engineering degree while fully employed at sites distant from the university. Videotaped recordings of live classroom presentations are combined with periodic personal and teleconference meetings with instructors. These visits and the usual homework and examinations promote normal interactions between instructors and students and help ensure that off-campus students receive the same quality of instruction as do regular, on-campus students.

Earning a graduate degree provides an individual with enhanced opportunities for professional development and advancement. The individual's company benefits from having a more skilled, more adaptable, and happier employee. Also, promoting and supporting participation in the program gives the company a powerful recruiting tool.

The Master of Engineering program is operated under the direction of the Associate Dean of Engineering for Academic Affairs. Day-to-day operation of the program is supervised by the Director of Graduate Program, who is appointed by the Associate Dean. The Master of Engineering program is primarily for off-campus students who reside or work in North Carolina and do not have easy access to the NC State University campus.