APPLICATIONS OF TECHNOLOGY IN TEACHING CHEMISTRY
An On-Line Computer Conference
June 14 TO August 20, 1993

PAPER 8

USING THE AIRWAVES: A SATELLITE M.S. FOR INDUSTRIAL CHEMISTS.

K.J. Schray, N.D. Heindel, J.E. Brown. and M.A. Kercsmar. Department of Chemistry and Office of Distance Education, Lehigh University, Bethlehem, PA 18015 (KJS0@Lehigh.edu)

SCHEDULE: Short questions on this paper: July 7, 1993
Discussion of this paper: July 16 and 19, 1993

ABSTRACT

The Department of Chemistry at Lehigh University has initiated a master's degree program by satellite for chemists located at industrial sites remote from the University. The need for this program is evident from the response of companies' continuing education groups. This need arises from the decline in not only the number of bachelor chemistry graduates over the last decade, but also the decline in the percentage of students going on for graduate work. Thus, both chemists realizing the need for an advanced degree for mastery of their discipline and for personal advancement and non-chemists doing chemistry without sufficient background are interested in furthering their education without the necessity of quitting their jobs and perhaps moving. Companies support these goals.

The program has completed three semesters of coursework, enrolled 80 students from 10 companies in 10 states. The satellite program duplicates the on-site program, although it has less flexibility in course selection. The curriculum, course sequences, and number of offerings are being evaluated and updated as our experience develops. The background and nature of the students, the maximization of the use of the available technology, and the successes and difficulties of the program are all becoming clear.

Introduction

Distance Education, the delivery of academic courses and training programs by electronic media, have been around for more than a decade, but it has not been widely used for extended programming such as complete ongoing degree programs. This is rapidly changing because of new technology and new demands. High quality and extremely reliable electronic transmission and reception equipment is now readily available, and organizations are seeking ways to provide a wider range of educational opportunity to their employees in the most efficient and cost-effective manner possible.

The Department of Chemistry at Lehigh University is offering its Master of Science Degree via satellite delivered courses to a number of corporate sites. The program was initiated in the spring semester of 1992 so we have gained some experience and begun fine-tuning in various ways based on our findings. This paper will

discuss

I. The background and origins of the program
II. The curriculum and requirements
III. The scope of the program
  A. Corporations participating
  B. Students characteristics

IV. Technology aspects
  A. Uplink/downlink
  B. Studio classrooms
  C. Two-way communication

I. Background and Origins

The Chemistry Department at Lehigh has long had significant contacts with industry. These have included research grants and contracts, short courses, liaison programs with research centers, part-time students from industry, and some experience with off-site research projects. Lehigh is a Ben Franklin Partnership for Advanced Technology site. This is a Pennsylvania state funding mechanism for corporate-academic research.

This background and the acquisition in 1990 of satellite uplink capabilities facilitated the development of this program in collaboration with the Chemical Process Industries Partnership Board. This group consists of Air Products, Alcoa, DuPont, Exxon, General Electric, Kodak and 3M.

It is clear that one factor which has retarded the formulation of such programs in the sciences is the commitment of time and effort maintained over a long period of time in the face of teaching and research commitments. This program is integrated with our current teaching needs and involves a very minor additional teaching load. This is achieved through a two-year course sequence which can be entered in three of the four semesters and yet involves teaching five of the seven principal courses on an every-other-year basis. Our faculty can make and maintain this commitment without erosion of research effort. This is accomplished by alternating spring sequences and partially alternating fall sequences. This restricts the order of those courses requiring prerequisites but allows courses not requiring prerequisites to be taken in differing order depending on the time of entrance into the curriculum.

II. Curriculum and Requirements

The central concept of the Lehigh program is that distance learning students are treated in the same manner, have the same level of instruction, and receive the same degree as on-campus students. They are full-fledged members of the Lehigh community. To that end, Lehigh has not sought to create a new curriculum or a separate faculty for this program. All courses offered via distance education are also offered to on-campus students in the studio classrooms. In short, we are not changing our character or our standards to facilitate distance

learning efforts. Instead, we are using distance learning techniques to deliver courses that reflect that character and level of educational quality to participants who will be as much Lehigh students as those who spend their entire academic careers on campus.

To further this goal of equality, we have arranged the schedule so that students can view the courses on a live basis. We require participating organizations to tape the classes at their downlink sites for review and for students who may miss a class because of illness or travel, but we expect the distance students to participate in those courses in the same manner as on- campus students do.

The program is a full thirty credit hours Master's Degree program in Chemistry. Students may choose a concentration in either Analytical or Organic chemistry. While enough courses will be offered so that students may complete the program in two years, our experience indicates that most students will take somewhat longer. All courses are delivered by satellite. The degree does not require a thesis, but it does require a research component. Such projects may be arranged at the student's work place, assuming joint approval of the company and the student's academic advisor.

These curricula are, thus, structured as research degrees. The six credits of research will be carried out at the corporate site but must meet the following criteria: 1) a Lehigh faculty member must approve of the research and must play a pivotal role in the development of the project, and 2) a thesis report must be written and approved by a three-person committee (the contributing faculty member, a second Lehigh faculty member, and the corporate research supervisor). Students who have taken graduate courses prior to entering this program may transfer in as many as six graduate credit hours in Chemistry from other institutions.

The students have control of the courses selected in our M.S. program with the simple constraints of a 30-credit program requiring a minimum of 18 credits of 400 level courses which includes 6 credits of research. We have outlined a sequence of courses to create a focus on analytical or on organic chemistry which meet these requirements. These courses are shown below. The student is also required to show proficiency in two areas of chemistry (by examination or by a grade of B- or better in the requisite course). The satellite offerings dictate that these areas would be organic and analytical if met by course for all distance students. These courses are made available by satellite in a sequence also shown below. This sequence of courses was designed to allow completion of the degree in two years by taking two courses/semester. This has proven to be extremely difficult for those who tried to do so and currently virtually all students are taking a single course/semester. We are in the process of adjusting the number of courses on the satellite to reflect this reality. Because not all courses in the chemistry program are offered by satellite and are not on the satellite each time they are offered, there is clearly a loss of flexibility in courses taken and when they are taken.

Table 1. Suggested Curriculum for Two Focus Areas

ANALYTICAL CHEMISTRY

Chem 332 (3) Analytical Chemistry
Chem 458 (3) Spectral Analysis
Chem 432 (3) Advanced Analytical Chemistry
Chem 433 (3) Electrochemistry
Chem 358 (3) Advanced Organic
Chem 488 (3) Advanced Topics in Physical Chem-Surface Analysis
Chem 394 (3) Organic Polymer Science I
Chem 475 (1) Topics - Advanced NMR Spectroscopy
Chem 431 (1) Contemporary Topics in Analytical Chemistry
Chem 481 (1) Seminar
Chem 421 (6) Research

ORGANIC CHEMISTRY

Chem 358 (3) Advanced Organic Chemistry
Chem 458 (3) Spectral Analysis
Chem 451 (3) Physical Organic Chemistry
Chem 455 (3) Organic Synthesis
Chem 332 (3) Analytical Chemistry
Chem 394 (3) Organic Polymer Science
Chem 458 (3) Organic Reaction Mechanisms
Chem 475 (1) Topics - Advanced NMR
Chem 475 (1) Topics - Organic Problem Solving
Chem 481 (1) Seminar
Chem 421 (6) Research

Prerequisite: Chem 187 (3) Physical Chemistry I - A "bridge" course for the program. It is being offered for students who did not major in chemistry as undergraduates or who for some other reason did not take a course in Physical Chemistry. Other students may have had Physical Chemistry some years ago and feel the need to take an up-dated course. Physical Chemistry is a prerequisite rather than a part of the degree program, and it does not count toward the 30 required course credits.

Additionally, other courses are offered on an occasional basis. Two courses, Organic Polymer Science II and Clinical Chemistry have been offered thus far to increase options and flexibility and because of faculty interest in satellite instruction.

The courses are taught live with an on-site graduate student class present. The live video to the corporate site is supplemented with live audio access from the remote sites back to the campus site to allow professor-student interactions. Course materials and homework/papers are delivered and returned via express mail. Backup video taping is required for students who miss a class or for repeat viewing by students present at the live class time slot who wish to go over the material.

Table II. Initial Course Sequence

Spring, 1992

Chemistry 394 (3)	Organic Polymer Science
Chemistry 187 (3)	Undergraduate Physical Chemistry (Background course for those needing it)

Summer,

Chemistry 475 (1)	Topics - Advanced NMR Spectroscopy
Chemistry 421 (3)	Research

Fall, 1992

Chemistry 358 (3)	Advanced Organic Chemistry
Chemistry 458 (3)	Spectral Analysis
Chemistry 332 (3)	Analytical Chemistry
Chemistry 489 (3)	Organic Polymer Science II

Spring, 1993

Chemistry 451 (3)	Physical Organic Chemistry
Chemistry 458 (3)	Organic Reaction Mechanisms
Chemistry 432 (3)	Advanced Analytical Chemistry
Chemistry 433 (3)	Electrochemistry

Summer, 1993

Chemistry 475 (1)	Topics - Organic Problem Solving
Chemistry 421 (3)	Research
Chemistry 431 (1)	Contemporary Topics in Analytical Chemistry

A full-time staff member has been hired by Lehigh to oversee the logistical aspects of the program-facilities scheduling, duplication and delivery of exams, notes, texts, homework, trip scheduling -- the myriad of details that arise from any such undertaking, particularly of this size and multi-site character. Admissions is handled by the department Graduate Admissions Committee with the addition of a faculty member to deal with many of the special aspects of this non-traditional pool of students: appropriateness of undergraduate prerequisites, transfer credits, scheduling advice for those out of sequence, etc.

Since this program is designed for students working within a corporate or other organizational structure, it assumes that the organization will be an active and cooperative partner in the educational process. Most corporations either pay or reimburse tuition and fees. Apart from that, the organization must provide the necessary video receiving equipment connected to a room in which the students can view the courses live, make notes, and use either telephone or fax to contact the faculty. Finally, the corporation must be willing to assign a staff member to serve as a "site coordinator." Site coordinators serve as the in-house program coordinators for the program. They work with their counterparts at Lehigh to coordinate the movement of applications and other student paperwork, insure that course materials are properly distributed, coordinate the collection and return of student assignments to the instructors, and monitor examinations.

Site coordinators should be chosen carefully and consistently supported as they are vital to the success of the program. They become the students' link to the University, working in close cooperation with Lehigh staff members to keep courses operating smoothly and to solve the problems of individual students.

III. Program Scope

A. To date 80 students have been admitted to the program. They work at 10 corporations consisting of: Air Products, Alcoa, Armstrong World Industries, Buckman Labs, Dupont-Merck, Eastman Kodak, Exxon, Miles, TVA, and 3M.

This involves 14 sites in Alabama, Colorado, Delaware, Minnesota, New Jersey, New York, Pennsylvania, Tennessee, Texas, and West Virginia.

Because of the live format of the courses and the use of early morning (7:55 AM) starting times, the mountain and pacific time zones do not appear very feasible.

B. Part of the rationale for this program was the demographics of bachelors degree chemists in the last 10-15 years and its affect on corporations needing chemistry trained professionals. The numbers of graduating bachelors chemists declined from 15,000 in 1978 to approximately 6000 today. Concomitant with this decline was a reduction in the percentage of students intending to do graduate work from ca. 60% in the late sixties to 20% in the late 80's. This has led to a shortage of Masters trained chemists and an influx of non-chemists into positions requiring a chemistry background.

We had thus anticipated significant numbers of students lacking the requisite background in chemistry, most probably physical chemistry. This was the reason for including an undergraduate course in physical chemistry in the satellite courses offered to allow such students to acquire that background prior to admission to the graduate program.

However, to date of some 80 students admitted to the program, 90% hold bachelor's degrees in chemistry. The other 10% include environmental science, biology, food science and medical technology.

The average time after graduation is 7.4 years (at the time of admission) with a range of 1-22 years. The question of the significance of undergraduate grades as a evaluator for admission of students who have matured considerably and gained a considerable amount of experience in chemistry rises, of course. Minimum GPA for admission to the Graduate School is 2.75/4.00. Associate admission, a probationary status has been granted to a number of applicants with grade point averages below this. A preliminary evaluation of this associate admission policy may be made by comparing the regular admission and associate admission distance

students and comparing distance students to on-campus students. This shows that the satellite group as a whole is indistinguishable from the on-campus students. In the satellite group the percentage of grades below B- received by regular admission students was 13% while the associate students' percentage was 37%. This is clearly a significant difference but also indicates a significant success rate for those students whose undergraduate grades would have suggested failure.

IV. Technology aspects.

A. The heart of the Lehigh distance learning system is a Ku-band earth station. This uplink facility features a 4.5 meter transmit-receive dish, a fully computerized transmitter capable of operation in both digital and analog format, a centralized control room, and three fully equipped studio classrooms. The system can acquire and transmit to all domestic Ku-band satellites.

All courses are transmitted in digital format. This permits the best possible picture and sound quality, and greatly reduces the sensitivity of the transmission to weather or other forms of interference. The digital format is also far more flexible and economical than the older analog format and will allow the systems to accept the latest adaptations as they become available.

Lehigh currently rents a channel on G Star 1 but will be moving to AT&T's Telstar 401 within the year.

The equipment thus required for a downlink is: a Ku-band satellite downlink dish; a Compression Laboratories, Inc. Spectrum Saver integrated receiver/decoder; and a room equipped with a 19" or larger monitor, a phone, and reasonably close access to a Fax machine. The average cost for a site without any present capability is approximately $11,000. To add the Spectrum Saver IRD to an existing downlink is approximately $2,500.

B. Lehigh has three studio classrooms but only one uplink. With the times favored by industry being early or late, scheduling increasing numbers of courses becomes more difficult. The studio classrooms are equipped with electronic podiums allowing presentation of prepared materials (variable zoom) and light pen overlay. Monitors and whiteboards are present allowing a choice of presentation style (white board or direct camera presentation). Both formats are thus visible by both groups of students (classroom and distance sites). Surveys indicate that classroom students prefer whiteboard presentation while distance students prefer camera presentation. The lecturer is equipped with a radio throat microphone and the classroom is equipped with multiple microphone pickups for student questions. Distance students use an 800 number phone link to the uplink facility where

calls can be queued for delivery to the classroom. All questions can thus be heard by all students. One quickly noticed benefit is that background noise in a classroom full of on-site students falls to zero in comparison to regular classrooms. Nor do students fall asleep even at eight in the morning for fear of discovery by a roving camera eye. Classrooms are equipped with three remote-controlled cameras in addition to the overhead camera for prepared materials.

C. Return communication is by way of the 800 number line into the classroom audio system. For written materials a fax machine is currently used. While adequate, both of these methods leave something to be desired in terms of convenience and speed. One area where this becomes particularly noticeable is in the area of interactive problem solving often used in a graduate level chemistry course. We are presently exploring and adapting Audiographics systems to enhance these interactive capabilities. These systems use a phone for voice communication and multiple computers connect via modems to create an interactive "chalkboard" and presentation system. The latest systems are Microsoft Windows based, easy to use, and can be used either point-to-point, or multipoint with a data bridge. The system can be used during class, between students in work groups, or for additional help from the instructor after class.

The addition of this PC platform at each distance site, combined with high speed modems, digital satellite transmissions, ISDN, Internet, and other connectivity solutions make it now possible to develop an integrated solution to some of the no delay integration problems which occur with current methods.

These will require 486 DX33 computers with 8 megabytes of RAM and 234 meg hard drives and, of course, modems, and connected speaker phones. Hardware and software are expected to add $5,000 per site to facilities costs. Outside class, both phone and E-mail are routinely used.

V. Questions

Several areas remain to be explored and developed.

1. The electronic palette (chalkboard, whiteboard) with accompanying audio will undoubtedly be a valuable asset to interactive work. Questions remain concerning computing systems, multi-site interaction, incorporation into the classroom/seminar format. Any comments from people with experience with such systems would be especially welcome.

2. Why has the student population been almost entirely chemists? Have we misread the need? Are non-chemists being cautious early in the program?

3. What kind of attrition rates can be expected? Experience with on-site part-time students indicates lack of completion of program in the 25-30% range, much higher than on-site, full-time students.