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ABSTRACT

Northern Virginia Community College (NVCC) and the Extended Learning Institute (ELI) undertook a project to develop the mathematics, science, and engineering courses required to complete an entire Associate of Science degree in Engineering through home study distance education. The project's ultimate goal was to create asynchronous learning networks (ALNs), or interactive resources available at the learner's convenience. In the first phase of the project from January 1994 to December 1995, two engineering, one calculus, and one chemistry course were developed and evaluated. The results of the first phase indicated that students achieved completion and grade distribution rates comparable to other ELI courses and on-campus offerings of the same courses. In the second phase of the project, ALN's have been integrated into five courses offered in spring 1996 with over 100 students enrolled. Focus groups, faculty and staff interviews, and surveys are planned throughout the semester to evaluate these courses. Significant design challenges in the implementation of the project included maximizing access to learners in the areas of mandated computer components, sutdents' computer proficiency, and cost; developing effective physical science and engineering laboratory activities; transmitting graphical content; representing problem-solving processes instructionally; developing faculty competence without requiring universal expertise; and assuring portability of courses to other interested institutions. (TGI)

DELIVERING AN A.S. ENGINEERING DEGREE PROGRAM THROUGH HOME STUDY DISTANCE EDUCATION

Submitted to

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Project Summary

The purpose of this project is to develop the mathematics, science, and engineering courses required to complete an entire Associate of Science degree in Engineering through home study distance education. Funded largely by the Alfred P. Sloan Foundation, the project is being developed by a team of faculty at the Extended Learning Institute (ELI) and the Annandale Campus Division of Math, Science, and Engineering at Northern Virginia Community College (NVCC). It is designed to increase engineering program enrollment by improving access to engineering courses for community college students, many of whom have considerable barriers to participating in campus-based courses, and to improve NVCC and ELI's capabilities to reach local students by utilizing emerging instructional technologies.

The project has consisted of two phases. In the first phase (January 1994 - December 1995), NVCC/ELI developed and offered two engineering, one calculus, and one chemistry course to over 150 students during the spring and summer semesters of 1995. The first phase tested whether ELI could successfully deliver higher-order mathematics, science, and engineering courses in a home study mode. It also enabled ELI to experiment with using a computer-mediated communications (CMC) system to increase interaction and collaboration among learning participants (students, faculty, and tutors). The ultimate goal is to create asynchronous learning networks (ALNs) which provide enhanced learning opportunities through increased access to learning participants and to remote learning resources.

Results of the first phase were positive: students achieved completion and grade distribution rates comparable to other ELI courses and to on-campus offerings of the same courses. Phase I established that higher-order mathematics, science, and engineering courses could be taught in a home study mode, with some modifications necessary to integrate ALNs successfully into the courses. In the project's second phase (July 1995 - December 1997), ALNs have been incorporated into five new or revised courses in engineering, chemistry, calculus, and physics. These courses are being offered to students during the spring semester of 1996, with over 100 total enrollments in the five courses. The remaining courses will be developed during the remainder of 1996, so that the complete Associate in Science engineering degree program will be available starting in the spring semester of 1997.

A number of significant issues have been encountered in developing this program, most notably how to incorporate interactive and collaborative learning experiences into a self-paced, independent learning delivery mode. Other significant design challenges include maximizing access to learners, developing effective physical science and engineering laboratory activities, transmitting graphical content, representing problem-solving processes instructionally, developing faculty competence without requiring universal expertise, and assuring portability of courses to other interested institutions. This report details the progress we have made in these areas.

Project Context

ELI's Home Study Distance Education Model

As NOVA's distance learning administrative unit, ELI has a long track record of success in implementing non-traditional programs and delivery systems, especially technology-based instruction, for independent study or individualized learning. Since 1975, ELI has enrolled over 130,000 students and currently offers 90 college credit courses in a wide variety of academic subjects. ELI averages around 3,000 enrollments per semester (roughly 600 full time equivalent {FTE} students) and around 2,000 summer enrollments (425 FTEs).

Most U.S. college and university distance education programs use a classroom-based model in which students are brought together for group instruction via televised or audio conferencing. Unlike these, ELI is a home study distance education program more akin to the British Open University model. ELI's delivery model supports independent learning in several key ways:

- *self-pacing* -- giving students substantial control over the schedule and pace of their study;
- *continuous enrollment* -- ELI provides students an opportunity to enroll in courses on any day of the year for most of its courses, a policy which helps to maximize access; and
- *multiple media and technologies* -- ELI courses utilize a combination of print materials, videotapes, computer interaction, audiotapes, and voice mail.

These features allow students to do most of their studies from home, although several on-campus visits for tests or laboratories are usually required.

Supporting Interactive and Collaborative Learning via Asynchronous Learning Networks

Increasingly, work in engineering and the physical sciences involves collaboration and teamwork. Most engineering employers are not satisfied with the communication or teamwork skills of recent engineering graduates (Agogins, 1995); engineering educators recognize this need and are calling for appropriate curricular reforms and alternative delivery systems to enact them (National Research Council, 1995; National Science Foundation, 1995; American Society for Engineering Education, 1994). We decided to meet this newly identified need by incorporating interactive and collaborative learning experiences into ELI's self-paced, independent mode of learning delivery.

The guiding concept in meeting this challenge has been the creation of *asynchronous learning networks* (ALNs) to support interactive and collaborative learning. ALNs provide access to remote resources at the learner's convenience, not dependent on synchronous, real-time communication. A resource can be a human (peers, tutors, faculty), a facility (e.g., libraries, laboratories at a distance), or a product (e.g., software-generated simulations, work products of remote collaborators). Assuming that learning follows from access and interaction, ALNs increase the opportunity for interaction and collaboration among participants in the learning process (Mayadas, 1994).

Development by Stages

Developing an entire community college degree program is a broad undertaking. Including a collaborative network to end the isolation of home study students in a technical field is highly innovative; to our knowledge, no associate in science engineering degree program for home-based learners currently exists. In fact, only a small number of courses currently exist for home-based learners in advanced mathematics (e.g., calculus), engineering and the physical sciences. Fewer than 25 programs in the U.S. offer lower-division undergraduate credit courses in engineering to home-study students; lower-division chemistry and physics courses are even more rare (NUCEA, 1993; NUCEA, 1992). Few if any available courses in these subjects offer home-based learners opportunities to interact or collaborate with each other via computer.

Given the scope and pioneering nature of the project, it was necessary to develop the program in stages. The project was split into two phases; the first phase, which involved developing four introductory courses, established a pilot test for the technologies, instructional formats, and the assumptions and strategies underlying them. The initial goal was to ensure viable courses with a sufficiently large enrollment of students to test our assumptions about the best way to design, develop and deliver the courses. The knowledge gained from these activities has been applied during the second phase of the project to developing the entire degree program.

Phase I Development

Phase I development, which occurred during the summer and fall of 1994, had four main goals:

(1) develop an instructional model comprised of video, print, a mix of on- and off-campus laboratories, and computer-supported ALN activities,
(2) configure off-the-shelf technologies for use in instruction,
(3) produce and teach four mathematics, chemistry and engineering courses, and
(4) evaluate the effectiveness of the courses, the instructional model, and the technologies.

Technology and Instructional Model Development

The goal of technology and instructional model development was for faculty and instructional technologists to develop models or formats for instruction using existing ELI instructional technology and to develop new uses of technology as required by courses. These instructional models or formats were determined by:

- reviewing all new courses to determine needed computer and telecommunication capabilities;
- visiting and consulting with other recipients of Sloan Foundation grants at New York University, University of Illinois, and Penn State University to learn about current technologies and instructional models relevant to the NVCC project;

- conducting a focus group meeting with students enrolled in ELI or engineering courses at NVCC to analyze student needs;
- developing the technologies and learning formats in the first four project courses; and
- pilot testing the courses and technologies to determine what revisions were necessary to the formats and technologies.

Development of this model of instruction was intended to produce a similar interface and technology mix for students and faculty while maximizing student access to courses and their resources in accordance with ELI's and the College's mission. Having a similar interface was a divergence from past ELI practice, but was done to give students a sense of continuity from course to course. Any skills they learned in their first course (such as use of computer conferencing software) would be useful in subsequent courses.

The instructional model focused on a lecture, laboratory and recitation model of instruction common to higher education science instruction, and included accommodating all registration, test-taking, and administrative procedures necessary to support a home study student. The model had these components:

Print Materials: The course textbook and other selected instructional materials were supplemented by a syllabus and faculty-produced course guide which provide students with assignments, directions on the use of technology, examination timetable, and overall coordination of the course.

Lecture: Faculty delivered course content in videotaped lectures produced by NVCC; these were distributed to students on videocassette, shown on local cable television, and also made available in Learning Resource Centers at each of NVCC's five campuses.

Laboratory: Students were required to meet the same lab objectives as an on-campus course. In the chemistry course, they executed six laboratory activities during three double lab sessions scheduled on Saturdays throughout the semester. The other six required labs were to be completed off campus, four at home and two by a "field trip" to a hands-on science exhibit at the Smithsonian's Museum of American History. In Engineering Graphics, lab activities were discussed via telephone or computer, completed via computer on campus or at home, and submitted via computer, fax, or U.S. mail.

Recitation: Students, faculty, and tutors discussed course content via computer-mediated communications (CMC). The groupware package Lotus Notes™ was selected to facilitate CMC; Question and Answer databases were set up in Lotus Notes to provide an opportunity for students to explore and apply the concepts presented in the lectures.

Homework Help: Faculty and tutors responded to students' specific homework-related problems. Homework Help databases were established in Lotus Notes and customized for each course to provide a cumulative record of answers to students' inquiries about problems. Engineering Graphics also included video Homework Help in its video lectures, enabling the instructor to address the process of creating graphics plates more effectively while using computer conferencing and other media to address finished products.

Interaction Support: Besides using Lotus Notes to interact with their faculty member, students could telephone or visit their instructor in person during the faculty member's office hours at ELI or on campus, or send messages and assignments via fax, campus mail, or U.S. mail. Voice mail was available for students to contact faculty privately or for faculty to send group voice mail messages to all students. Tutors were also hired to assist students on-line, in-person at a campus tutoring center, or over the telephone.

Course Development

Course development at ELI is faculty-centered; the same faculty member who develops a course also instructs that course. The faculty member's efforts are closely coordinated and strongly supported by a course development team composed of an instructional technologist, a video producer, computer technicians and clerical staff (Lemke, 1995). All faculty involved in the first course development cycle also participated in a series of six meetings during the late spring and early summer of 1994 to focus on various aspects of the course development process, including:

- video production and other lecture delivery options
- evaluation and assessment
- electronic interaction with learners
- developing labs
- developing and coordinating student services
- putting an entire course together

Development of the four courses -- College Chemistry I (CHM 111), Calculus with Analytic Geometry I (MTH 173), Introduction to Engineering (EGR 120), and Engineering Graphics (EGR 115) -- occurred during the late summer and fall of 1994. Print, video, computer conferencing and laboratory materials development for the four courses included:

Print	-	Course Guides and Syllabi for four courses
Video	-	thirteen 1-hour lectures for Calculus with Analytic Geometry I
	-	nine 1-hour lectures for Introduction to Engineering
	-	twenty-six 1/2-hour lectures for College Chemistry I
	-	nine 1-hour lectures and homework help for Engineering Graphics
Computer Conferencing	-	fourteen Lotus Notes Question & Answer, Homework Help, Course Guide, Syllabus, and other customized databases for specific courses
	-	welcome and chat databases for students; quick help database for students and faculty

Lab - laboratory guide, format and schedule for chemistry course
- AutoCAD instructional video and print materials for Engineering Graphics

Coordination of Student Services

The goal of this activity was to ensure that students enrolled in the courses had access to appropriate student development services and learning resources. Student development includes advising, registration, financial aid, and other services provided through NVCC's Student Development office. Learning resources include the library, computing services, audio visual support and other services provided by NVCC's Learning Resource Centers.

Student support services were smoothly integrated into the four courses. Student tutors were hired in chemistry and mathematics; engineering faculty were unable to locate tutors and decided that they were unnecessary for their courses. Based on a fall student survey which indicated that lack of modem access was a significant barrier to student access, ELI also purchased modems and developed procedures for loaning them to students.

Evaluation Activities

A general evaluation plan was developed along with specific evaluation strategies for each course. Evaluation strategies and instruments include:

- pre-/post-test instrument devised for the Introduction to Engineering (EGR120) course;
- mid-course survey of students;
- focus groups;
- telephone interviews with students;
- in-person or online interviews with faculty and tutors;
- lab evaluation questionnaires for chemistry and physics;
- ELI's standard end-of-course student evaluation questionnaire;
- demographic data collection from NVCC's Office of Institutional Research (OIR);
- grade distribution data collected by ELI.

Table 1 on the next page summarizes evaluation activities conducted during the spring and summer of 1995.

Table 1. Spring/Summer 1995 Evaluation Activities

Component	Course	Method	Timeframe
Interaction among Students, Faculty	All	focus groups, faculty interview, mid-course survey	mid-course, end
Interaction w/Tutor	Math	tutor interview, focus groups, ELI questionnaire, mid-course survey	mid-course, end
Lotus Notes	All	mid-course survey, focus groups	mid-course, end
Labs	Chemistry	lab questionnaire, mid-course survey, focus groups	mid/late-course, end
Student Learning	EGR 120	pre/post test	beginning/end
Demographics	all	NVCC OIR data	end of course
Student Success	all	phone interview, grade distribution	mid-course, end
Student Satisfaction	all	ELI questionnaire; faculty interview	end of course

Phase I Results

The following tables summarize Phase I results for course enrollments, success rates, and grade distributions for the spring and summer semesters of 1995. Table 2 summarizes course enrollments for the spring and summer semesters (excluding students who withdrew with refunds before the start of the semester). Tables 3 and 4 on the next page provide specific grade distributions by course. As with many ELI courses, a bi-modal rather than bell-shaped grade distribution occurred.

Table 2. Course Enrollments -- Spring and Summer '95

Course	Spr.'95	Smr.'95	Total
CHM 111	31*	**	31*
EGR 115	24	20	44
EGR 120	15	**	15
MTH 173	34	27	61
Totals	**104***	**47**	**151***

* = includes 1 audit; ** = not offered

Table 3. Spring '95 Grades

Course	A	B	C	D	F	W*	Non-Starters**
CHM 111	4	9	4	1	4	3	5
EGR 115	4	3	1	0	3	0	13
EGR 120	4	2	0	0	2	2	5
MTH 173	10	3	2	1	7	3	8
Totals	**22**	**17**	**7**	**2**	**16**	**8**	**31**

*W = students who withdrew from the course after submitting ≥1 assignment
**Non-Starters = students who withdrew before submitting any assignments

Table 4. Summer '95 Grades

Course	A	B	C	D	F	W*	Non-Starters**
EGR 115***	5	1	1	0	1	2	9
MTH 173	4	2	3	0	4	5	9
Totals* **	**9**	**3**	**4**	**0**	**5**	**7**	**18**

*W = students who withdrew from the course after submitting ≥1 assignment
**Non-Starters = students who withdrew before submitting any assignments
***Excludes one auditing student

Table 5. Success Rates*

Course	ELI * (Spring '95)	On-Campus (Spring'95)	ELI * (Summer '95)
CHM 111	68%	59%	not offered
EGR 115	73%	56%	70%
EGR 120	60%	62%	not offered
MTH 173	58%	53%	50%
All ELI Courses	64%	---	71%

* = Starter Success Rate (= starters who received an A, B, or C grade)

Table 5 summarizes ELI success rates and compares them with success rates for all ELI courses and for the same courses offered on-campus during the spring 1995 semester. ELI uses 'starter success rate' as its principal measure of success; a 'starter' is defined as a student who submits at least one assignment for a course and 'success' is defined as receiving an A, B, or C grade in the course. ELI uses this measure to factor out early student withdrawals since it is impossible to have success with students who withdraw (usually for personal reasons) before they begin their coursework. As Table 5 indicates, ELI's success rates were comparable to on-campus rates although the rates are not precisely comparable since ELI's measure is somewhat different from the one used for on-campus courses.

For unknown reasons, summer semester data indicate a higher percentage of student withdrawals than in the spring semester. These courses will be monitored carefully in future semesters for withdrawal rates to determine causes and implement solutions if a higher withdrawal rate recurs.

Course Development in Progress

Course Development

Three courses have been revised and two new courses developed for piloting during the spring semester 1996:

revised --	College Chemistry I (CHM 111)
	Calculus with Analytic Geometry I (MTH 173)
	Introduction to Engineering (EGR 120),
new --	Calculus with Analytic Geometry II (MTH 174)
	University Physics I (PHY 241)

These new courses were designed so that ALNs could be fully incorporated into them by designing activities that promoted either interaction or collaboration among learning participants. Development of ALN-related instructional activities was guided in part by distinguishing between communication, interaction, and collaboration as follows:

communication	=	one-party information transmission (e.g., course content, announcements, etc.); two- or multi-party information transmission and response
interaction	=	two- or multi-party dialogue focused on a learning activity (e.g., homework problem-solving or other course assignments)
collaboration	=	learners working together as a designated group on specific course assignments

For reasons that are detailed below (see section on Issues Encountered and Lessons Learned) we replaced Lotus Notes with FirstClass™ as our CMC software package. FirstClass is or will be (for courses not yet developed) used to support asynchronous communication ia an integral part of all the courses. However, an asynchronous communications network does not necessarily constitute a learning network. Our design assumption was that for an ALN to be formed, learners need the opportunity to interact or collaborate for learning to occur. Although communication and interaction overlap somewhat, interaction is meant to identify those activities that are specifically structured to promote learning, for instance a tutor offering help with a homework problem or an instructor clarifying a point contained in textbook material. Collaboration is a more intense form of interaction where students work together in identified groups on course assignments.

Table 6 below summarizes how ALN has been incorporated into new or revised courses thus far. Chemistry 111 students can interact with other learning participants through homework help conferences organized by unit. They collaborate on laboratory activities by using the Laboratory conferences to form groups and perform pre-laboratory preparation as a group, partnering with another group member face-to-face to perform the actual experiment on-campus, then preparing group lab reports after the experiment is completed. Introduction to Engineering (EGR 120) students can interact with other learning participants regarding their library projects or course-related questions and answers; they are required to interact and collaborate in a "Mock Meeting", a scenario-based assignment where students role-play various functions in a fictitious corporation, culminating in a face-to-face meeting. Mathematics 173 and 174 students can interact by asking questions and answers about assigned problems or about use of specific graphics calculators; they must interact with their tutor and instructor by designing and submitting several calculus problems and solutions involving practical applications related to an area of their interest. There is no required collaboration for this course since it was decided that collaboration was not instructionally necessary for this subject matter. Physics 241 students use the Collaboration Exercises conference to collaborate on selected course assignments and the Comprehensive Labs conference to form small groups to collaborate on laboratory activities, including three labs conducted on-campus.

Table 6. Incorporating ALN into Courses (Fall '95 Development)

Course	Interaction	Collaboration
CHM 111	Homework Help Conferences	Laboratory Conferences 6 Lab Experiments (face-to-face)
EGR 120	Q & A Conference Library Project Conference	Mock Meeting Scenario Mock Meeting (face-to-face) Computer Program Conference
MTH 173	Q & A Conference Graphics Calculator Conference Practical Applications Conference	none
MTH 174	Q & A Conference Graphics Calculator Conference Practical Applications Conference	none
PHY 241	Introductions Conference Q & A Conference	Collaboration Exercises Conference Comprehensive Labs Conference 3 Lab Experiments (face-to-face)

Evaluation Activities

A general evaluation plan has been developed along with specific evaluation strategies for each course. Evaluation strategies and instruments are similar to those used previously. Table 7 below summarizes planned evaluation activities for the Spring '96 semester.

Table 7. Spring 1996 Evaluation Activities

Component	Course	Method	Timeframe
Interaction among Students, Faculty	All	focus groups, faculty interview, survey	mid-course, end
Interaction w/Tutor	Math	tutor interview, ELI questionnaire, focus groups, survey	mid-course, end
First Class	All	survey, focus groups	mid-course, end
Expressionist	Math	focus groups, tutor interview	mid-course, end
Labs	Chemistry and Physics	lab questionnaire, focus groups, survey	late-course, end
Student Learning	Engineering 120	pre/post test	beginning/end
Demographics	all	OIR data	end of course
Student Success	all	phone interview, grade distribution	mid-course, end
Student Satisfaction	all	ELI questionnaire; faculty interview	end of course
Withdrawals	all	phone interview	periodic
F's, reasons for	all	phone interview	end of course

Issues Encountered and Lessons Learned

Several major design and development issues have been encountered during the course of the project. Many of these issues were anticipated and specific assumptions related to them were tested; other issues emerged during the course of the project.

Maximizing Student Access to Courses

Providing maximum access to courses is central to the mission of community colleges. ELI students are not geographically isolated from NVCC's five campuses, but work and family responsibilities along with external obstacles such as the region's notorious traffic congestion prevent many of them from regularly attending on-campus classes. While ELI had already developed strategies for providing maximum access to courses for these students, this project introduced several new access issues:

- *computer access* -- Integrating mandated computer interaction into courses serving home-based learners means being restricted by the minimum computer configuration to which students are likely to have access, and also providing access for those students who cannot obtain computer access otherwise.
- *computer proficiency* -- Students' level of computer competence varies widely and in many cases is relatively low. Although we informed students of minimum computer proficiency requirements, as an open access institution we cannot prevent students who lack such proficiency from enrolling.
- *cost-sensitivity* -- ELI is not authorized to charge course fees or raise tuition to pass on technology costs to students. Like most community college programs, it serves many cost-sensitive students who cannot afford most higher-end software applications. This necessitates a reliance on technologies that are relatively simple, reliable, affordable, and widely available.

Selecting an effective computer-mediated communications (CMC) software package was a crucial related issue. In the first phase of our project we experimented with the use of the groupware package Lotus Notes™. Phase I tested whether Lotus Notes was sufficiently reliable and beneficial to justify its long-term use. Lotus Notes passed the 'access test', as a survey of enrolled students indicated that approximately 90% had access to the minimum configuration required by Notes. For those students who did not have access to a suitable computer, a total of nine workstations were set up on the five NVCC campuses exclusively for students enrolled in these courses. Five additional criteria were employed to decide on continued use of Notes:

(1) technical capabilities and usefulness of the system;
(2) system administration costs;
(3) learning curve for faculty and students;
(4) costs to be paid by the student or ELI; and
(5) capability to interface with the Internet for communication with other Virginia institutions of higher education.

Although Lotus Notes is a powerful system with many useful features, it was too expensive, difficult to learn, and complex to administer for our purposes (Sener, 1995). Consequently, it was decided to replace Lotus Notes with FirstClass™ as our CMC software package, as it appeared to present an alternative that would be easier to use and administer, less expensive for the institution and students, and equal to Notes for our instructional purposes. Since First Class requires a less powerful configuration, using FirstClass would not present a serious access issue.

Developing Physical Science and Engineering Laboratories for Home Study Students

A prime concern in developing engineering and physical science courses for majors who are home-based learners is how to create laboratory activities of acceptable quality. Designing laboratories for these courses requires thinking through what and how students need to learn -- what must be learned by hands-on experience, what kind of equipment and materials these experiences require, and what are effective alternatives for hands-on learning experiences. Our engineering and physical science courses use a variety of strategies to achieve this aim:

On-campus labs -- Chemistry and physics courses require some of their laboratory activities to be performed on-campus to ensure access to laboratory equipment. On-campus time is reduced by structuring pre- and post-lab activities so that they can be done at home or on-line in collaboration with fellow students.

Field trips to museums and other facilities -- two chemistry laboratory activities are performed at a hands-on science exhibit at the Smithsonian Institution in Washington, D.C..

Video -- Chemistry students are required to view an American Chemical Society-produced video on lab safety and pass a quiz on its contents before participating in an on-campus lab. Elaborate laboratory science demonstrations available on commercial videodisc are also used in video lectures to save setup time and expense. The physics course uses NVCC-produced video laboratory demonstrations, while video demonstrations of how to perform operations in software programs such as AutoCAD are used in the engineering graphics course.

Development and design of chemistry labs appears to have been successful, based on course results and student questionnaire responses.

Transmitting Graphical Content via Computer

NVCC engineering courses require use of computer- and graphics-intensive applications such as AutoCAD and FORTRAN. Composing and transmitting equations and formulas electronically is still notoriously difficult, especially with technology available to home-based learners. Software products such as Mathematica or Maple V are too expensive for our use, so we are using FirstClass to enable users to attach graphics files to text documents, which can be accessed by recipients with the related application at their workstation. FirstClass also has limited capabilities for direct transmission of graphics messages.

Faculty, students, and tutors can compose and send documents to each other containing equations, formulas, and text by using a procedure combining the use of FirstClass and an equation typesetter product called Expressionist™. Expressionist enables users to compose equations and formulas relatively easily by pointing and clicking from a palette of common symbols and characters. While still not as easy as drawing equations or symbols freehand, it shows promise in reducing a laborious task to a more manageable one.

Demonstrating Problem-Solving Processes

Supporting demonstration of *processes* such as how to create a drawing or how to arrive at a correct solution is even more important for effective instruction. While video is an adequate medium for demonstrating problem-solving processes, finding an affordable way to represent and transmit problem-solving processes via computer would increase the courses' ALN capability. Whiteboard and other videoconferencing technologies are not yet sufficiently cheap and widely available for us to use with home-based learners. Current plans are to experiment with using screen activity recorders such as Lotus ScreenCam™ and CameraMan™ to record process sequences for instructional and training purposes.

Developing Faculty

During the course development process, it became apparent that the magnitude of development required for faculty to become fully competent was even greater than originally anticipated. Five faculty development domains were identified: collaboration, computer-mediated communication, ELI course delivery, distance learning, and video production (see Table 8 below).

Table 8. Faculty Development Domains and Principal Knowledge, Skills, and Attitudes (KSAs) Required

Faculty Development Domains	Principal KSAs Required
collaboration	- knowledge of available collaborative methods and techniques - desire to utilize collaborative methods - ability to use collaborative methods in a CMC setting
computer-mediated communications (CMC)	- basic access to computer - general computer skills - use of computer applications (e.g., FirstClass) - skills in on-line communication (e.g, moderating conferences, providing timely feedback)
ELI course delivery	- knowledge of ELI's policies and procedures - coordination of course components

distance learning (development and delivery)	- advance organization and production of print materials - knowledge of needs of home-based learners
video production	- on-camera delivery skills - advance organization of content - advance production of on-camera graphics

ELI followed its usual method for developing courses in Phase I, which was quite successful for the skill areas in which ELI had substantial prior experience (ELI course delivery, distance learning development and delivery, and video production). It was not as successful for enabling faculty to develop collaboration and CMC skills, those required to develop ALN activities. The work required to produce viable courses was simply too much for faculty to develop sufficient competence in all areas. As a result, it was decided to develop the courses in stages, with less emphasis on ALN development for the first four courses and increased emphasis on ALN development in subsequent development cycles. We also identified several strategies to enable faculty to develop courses that fully integrate ALN into their courses:

- shift course development emphasis away from pre-produced material and toward materials and activities developed during the course in response to students' needs and distributed via CMC;
- provide more structured, prescriptive upfront hands-on training in CMC and video production;
- provide more individual assistance with developing collaborative instructional activities;
- rely on CMC as a primary means for everyday communication so that faculty can learn how to instruct with the system by using it;
- draw on the accumulated experience of Phase I faculty to support new Phase II faculty;
- use each iteration of a course to gain knowledge for revising or refining subsequent offerings;
- allow faculty more discretion in designing their individual courses rather than following a single instructional model.

Maintaining Continuous Enrollment

Almost unique among U.S. higher education institutions, ELI provides students an opportunity to enroll in courses at any time during the year for most of its courses. An open question was whether or not ELI could develop ALN opportunities that would work within its continuous enrollment policy. Given anticipated enrollment levels, there would not be sufficient numbers of students to form collaborative cohorts if continuous enrollment were used. So, we decided to suspend the continuous enrollment policy for these courses and establish fixed enrollment periods to facilitate design of activities that promote student interaction and collaboration.

Expanding Program Offerings Beyond NVCC

Another principal project objective is to enable other institutions in the Virginia Community College System (VCCS) and elsewhere to adopt the degree program and its individual courses for offering to their students. Since ELI students are neither remote nor campus-based, courses may require 4-12 trips to a NVCC campus. Our experience and explorations have suggested two avenues to spread the effect of this project:

(1) Offer some courses through ELI and share with other VCCS institutions through the Virginia Distance Education Network (VDEN). Course video could be delivered to students on videotape while computer-mediated communications could be done over the Internet using FirstClass. Supervised laboratory activities, testing, and on-campus computer access issues have not yet been resolved but feasible solutions are available.

(2) Share course materials and expertise with other Virginia community colleges so that they can start similar projects without having to invent the instructional model and materials.

Plans for Project Completion

As Table 9 below indicates, the remaining courses will be developed during the remainder of 1996, so that the complete Associate in Science engineering degree program will be available starting in the spring semester of 1997. Currently scheduled to be developed are:

College Chemistry II (CHM 112)
Computer Programming for Engineers (EGR 126)
Engineering Mechanics -- Statics (EGR 140)
Engineering Mechanics -- Dynamics (EGR 245)
Basic Electric Circuits I (EGR 251)
Vector Calculus (MTH 277)
Differential Equations (MTH 291)
University Physics II (PHY 241)

Table 9. Course Development Schedule

Courses	7-1 to 12-31-95	1-1 to 6-30-96	7-1 to 12-31-96	1-1 to 6-30-97	7-1 to 12-31-97
CHM 111, MTH 173, EGR 120	Revise	Teach	Teach	Teach	Teach
MTH 174, PHY 241	Design	Pilot	Revise and teach	Teach	Teach
EGR 115		Revise	Teach	Teach	Teach
MTH 277, EGR 126, MTH 291, EGR 140		Design	Pilot	Revise and teach	Teach
CHM 112, PHY 242, EGR 245, EGR 251			Design	Pilot	Revise and teach
Project Wrap-up and Transition to NVCC Support					Start and Complete

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