PROJECT NARRATIVE:

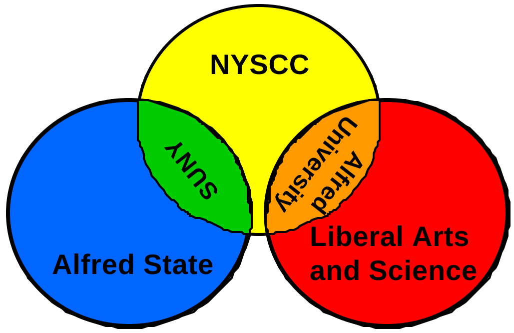
"Bridging Institutions and Disciplines Using Shared Instrumentation"

1) Project Overview

Major Participants: Alfred University (AU) is a residential, coeducational institution that is home to 2,300 students. The University is comprised of the privately endowed Colleges of Business, Liberal Arts and Sciences (LAS), and Engineering and Professional Studies. In addition, Alfred is home to the publicly endowed New York State College of Ceramics (NYSCC) as a statutory college of the State University of New York (SUNY) system. NYSCC is comprised of the School of Ceramic Engineering and Materials Science (CEMS) and the School of Art and Design. The University's academic diversity is enhanced by its student population, which represents 43 states and 20 nations. Bachelors, masters and doctoral degrees are awarded as the culmination of Alfred University's academic and professional programs (1,2).

Alfred State College is one of the five University Colleges of Technology within the SUNY system, which has an enrollment of 3500 students. It offers outstanding educational opportunities for students in its nearly 60 associate degree programs, seven bachelor of science degree programs, one bachelor of technology degree program, and several certificate programs.

The four units directly involved in the project are the School of Ceramic Engineering and Materials Science in the New York State College of Ceramics, Chemistry and Geology Departments in the College of Liberal Arts and Sciences at Alfred University, and the Physical and Life Sciences Department at Alfred State College. The following diagram depicts the overlap between each of these units.



Goals and Objectives: The goal of this project is to adapt the concept of an extended and shared laboratory between otherwise non-interacting academic units. The project was modeled after the extended laboratory system used by Wofford College, Converse College and the University of South Carolina at Spartansburg (3,4,5). The objectives of this project include increasing interactions between two institutions (AU and Alfred State) and four disciplines (Materials Science, Chemistry, Geology and Environmental Sciences) using shared instrumentation and collaboration among the students.

Implementation and Adaptation: The four units making up this consortium are within a two-mile radius from one another, but due to the unique setting at AU with both public and private colleges, our interactions have been limited. Collaborations between Alfred State and AU have also been limited. Our consortium intends to break through these invisible boundaries to improve the education of all of our students. We understand and grasp the need for students to work in teams, be exposed to state of the art instrumentation, and to be able to tackle problem-solving situations with confidence. These needs are most effectively provided in hands-on learning environments, as emphasized by accreditation programs for engineering and chemistry (6,7,8). We also understand the lack of breadth in the sciences for many programs. Our program has been developed to fulfill all of these needs through cross-disciplinary laboratory modules using shared equipment. They are designed based on the acquisition of a thermal analyzer, gel permeation chromatography unit, and a remote sensing FTIR probe used with existing equipment.

Expected Outcomes: The project is designed to create a unique interaction of students and faculty between disparate institutions and disciplines. The main goal is to expose our students to a team oriented approach to problem solving based on real life examples. As stated in the students' reviews of a previous NSF project, (they) repeatedly say they like doing relevant activities -- “real-world” problems -- rather than “canned” experiments (9). The extended team effort is similar to many government and industrial facilities, where a variety of support teams work on different parts of a project. A list of expected outcomes is given.

- ✓ Develop a team oriented relationship between students and faculty from multiple disciplines for shared problem solving situations
- ✓ Students will be prepared to think objectively when dealing with real life situations (experimental and group dynamic)
- ✓ Students and faculty will have extended knowledge in order to provide a holistic approach to problem solving
- ✓ Students will be comfortable with using of state of the art instrumentation
- ✓ Students will be comfortable with using electronic data transfer and communication to share their data and ideas

2) Project Description

Two modules were designed to broaden the interaction between chemistry students at Alfred State and materials science students in the College of Ceramics at Alfred University. The first experiment focuses on the preparation and chemical characterization of a polymeric material, while the second experiment focuses on the thermal properties of the same material. Students will work as groups made up of both chemists and materials scientists. The groups will need to work together in order to understand the full range of information brought to them, independent of their discipline. The courses impacted by this collaboration are Polymer Science (CES 306) 30 students, Polymer Characterization (CES 402) 5-10 students, Chemistry 3614 and 4624 (Chemical Instrumentation I, II) 5-10 students, and Chemistry 3514 and 4524 (Organic Chemistry I, II) 10-20 students.

A third experimental module was designed to look at the synergism between synthetic materials and the environment. In one aspect, it is important for engineers to understand the effect that the environment has on a material, but the reverse notion is to understand the effect the material has on the environment. Therefore, students and faculty from Materials Science, Chemistry and Geology will share information gathered in their respective courses from the same project. This exercise extends the concepts of programs started by Hluchy, Godshalk and Pipal, "Integration of Analytical Chemistry into Environmental Progams at Alfred University", and by Amey, Spain, Craney, and Dea, "FTIR, Thermal Analysis and Molecular Modeling Systems for Materials Science Enhancement of the Undergraduate Physical Chemistry Laboratories" (10,11). An overall assessment of the experiment will be done after all the data is collected. The courses impacted from this module include Polymer Characterization (CES 402) 5-10 students, Environmental Biogeochemistry (ENS 351) 5-10 students, Instrumental Analysis (CH 423) 5-10 students, and Environmental Chemistry and Microbiology (ENVR 4424) 8 - 10 students.

Currently we use a web-based tool called TopClass in order to provide data, notes and general information about the courses to our students. It also provides a mechanism for students to provide feedback, ask questions and discuss their results with other students. It will be adapted into the program for all students involved in order to provide an easy to use and access communication tool. Facilities and other major equipment that will be used with these modules are presented in the Facilities, Equipment, and Other Resources form on FastLane.

The use of the instrumentation will not be limited to the three modules outlined below. Several other uses are intended within each discipline. Examples of other exercises are given in Appendix I provided in the Appendix form on FastLane.

<u>Experimental Module One</u>: Low Temperature Condensation Polymerization (joint laboratory with CEMS at Alfred Univ. & Chemistry at Alfred State)

The Polymer Characterization course is mainly composed of experiments that measure and analyze the properties of a polymer. Synthesis and chemical composition of polymers are added as an overview to the Polymer Science course and are not covered in any detail. The same is true for Organic Chemistry I&II and Chemical Instrumentation I&II. All of the students involved in this project will obtain a greater exposure to polymer chemistry and characterization by incorporating a synthesis laboratory with real-time chemical analysis, as will be done in this laboratory. They will also learn how to share information with a team of scientists (or engineers) in order to solve a problem.

This experiment is Part I of a two-part laboratory. Two types of polymerization mechanisms are most common for polymer formation. They are condensation and free radical. The main difference between the two mechanisms is that free radical polymerizations occur very quickly with formation of high molecular weight polymers right away. Condensation polymerization takes place slowly and high molecular weight species are not formed until the end of the polymerization. This makes condensation polymerizations easy to follow using FTIR analysis and end group determination. One of the simplest condensation polymerizations is of polyimides (12). Polyimides are commonly used as adhesives, insulating coatings for cables exposed to high temperatures, and coatings for fiberglass. They are made by the reaction between dianhydrides and diamines. They are formed by a two-stage process. During the polymerization, which takes place at or below room temperature, a precursor of polyamic acid is formed. In the second stage, polyimides are created by heating the polyamic acid to temperatures extending beyond 200 °C. The result is a polymer with very high thermal stability and high mechanical durability.

In this laboratory experiment, the low temperature condensation polymerization of a polyamic acid (precursor to a polyimide) will be followed using a mid-infrared spectrometer equipped with a remote sensing module (13,14). The MIR analysis will be used to monitor the progress of the polymerization over a one hour period (time required to complete the polymerization). The students will be required to identify the FTIR peaks that correspond to the "endgroups" and to the newly formed bond. From this information they will be able to determine the extent of the reaction and an estimate of the molecular weight.

Experimental Module Two: Thermal Analysis of Polyimide Thin Film
(joint laboratory with CEMS at Alfred Univ. & Chemistry at Alfred State)

This experiment is part II of a two-part laboratory. The selection of a polymer for a specific application is ultimately dependent on three properties, the chemistry of the material, its molecular weight and its thermal properties. In this exercise, the students will study the thermal properties of the material that they made in Experimental Module One. Some of the characteristics that one can measure based on the thermal properties are the glass transition temperature (T_g), melting temperature (T_m), degree of crystallinity, phase separation behavior (polymer blends), contamination, and degradation temperatures. The glass transition temperature is believed to be "the most important single parameter that one needs to know before one can decide on the application of non-crystalline polymers"(15). It is defined as the point at which local segmental motion begins. Above this temperature, a polymer will behave as a rubbery material, below the T_g it is in a glassy state where the chains are "frozen" in place.

In this exercise, the thermal properties of the polyimide synthesized in the previous exercise will be measured (16,17). The thermal analysis will provide an imidization temperature, glass transition temperature and degradation temperature for the high performance polyimide.18 The students will follow ASTM standards to conduct the experiments. They will run the same experiment on poly(methylmethacrylate) [PMMA], a common polymer also known as Plexiglas®. PMMA has T_g and degradation temperatures much lower than a polyimide. The application and upper use temperature of the two types of polymers will be compared based on their thermal properties. A simultaneous differential scanning calorimeter - thermal gravimetric (DSC/TGA) analyzer will be used to conduct the experiments.

<u>Experimental Module Three</u>: Accelerated degradation of Polystarch® (biodegradable plastic bags)

(joint laboratory with CEMS (NYSCC), Geology (LAS) and Chemistry (LAS), and Environmental Chem. & Microbiology at Alfred State)

Social concerns and environmental awareness has increased the demand for more environmentally friendly materials (19). One example industry is biodegradable polymers, which resulted in materials such as Polystarch®. This is a commercially available biodegradable polymer blend of starch and polypropylene or polyethylene. It is a common material used for leaf bags or compost bags. The incorporation of starch into the blend controls the final degradation of the system (20). The purpose of biodegradable plastics is to provide an environmentally sound approach to waste disposal, for instance, through composting.

In this exercise, for Polymer Characterization (CES 402), the accelerated degradation of Polystarch® films through ultra-violet and condensation cycling is compared to real time degradation in biologically active soil (21,22). Analysis of neat and degraded system will take place using GPC analysis and FTIR analysis (23,24,25,26).

The soil around the samples will be analyzed in the Environmental Biogeochemistry (ENM 351) and Environmental Chemistry (ENVR 4424) before, during and after degradation of the polymer begins. Soil analysis will be done using the remote sensing FTIR to determine if the soil adsorbed any of the degraded polymer. Atomic absorption spectroscopy and ion chromatography will be used for inorganic ion analysis to determine any stray contaminants in the soil (27).

Finally, a laboratory class in Instrumental Analysis (CH423) will examine the degradation products in the environment (28). They will answer the questions: Are the polymers and its by-products adsorbed onto mineral surfaces or are they released into the interstitial water in the soil and/or ground water? These analyses will be done using the remote sensing FTIR and ion chromatography. The water run-off during the accelerated testing in a cyclic UV/Condensation chamber will be analyzed using the same methods. The data will be collected in order to correlate the real time degradation with the accelerated degradation based on by-product content in the water.

Project Timetable

Summer 2001	Purchase Equipment Conduct faculty, TA, technician training Develop details for laboratory modules
Academic Year 2001 - 2002	Conduct 1st round of exercises Start formative evaluation
Summer 2002	Adjust exercises Develop new modules
Academic Year 2002 - 2003	Conduct 2nd round of exercises Finish formative evaluation Start summative evaluation Prepare results for dissemination

Equipment

We intend to purchase three pieces of equipment to support our shared laboratory project. A detail of the cost and components are given in the Budget and Budget Justification form on FastLane. First, a remote-sensing probe to be attached to an existing FTIR will be purchased. This module will allow us to analyze samples that would otherwise be difficult to analyze using other FTIR sampling techniques. Second, a simultaneous thermal analyzer will be purchased. The temperature range that the analyzer covers will be suitable for low-temperature polymer work and high-temperature inorganic materials work. The third piece of equipment is a gel permeation chromatography unit (GPC). This piece is an essential laboratory component used for the analysis of polymer molecular weights. Specific companies have been listed as the suppliers for the instruments, but further interaction with colleagues in industry will be used to make the final selection.

Maintenance of Equipment

The College of Ceramics will take primary responsibility for the maintenance and support of the equipment. All three units will be involved in the acquisition of the listed instruments through purchase of necessary materials and chemicals for operation, and proper training of selected individuals (technicians and graduate teaching assistants) to monitor each instrument's use and operation.

Experience and Capability of the Principal Investigator(s)

The four principal investigators working together on this project share the same principles of educating students in the sciences to the best of their capabilities. Michele Hluchy has demonstrated outstanding effort in the development of new ideas to bring into the classroom. Jerry Fong and Garrett McGowen are outstanding chemistry professors with two distinctly different groups of students to work with. Rebecca De Rosa, acting as the coordinator for this project is enthusiastic and energetic about the new collaborations and is working on new ways to increase the collaborations between the three units involved. The details of our background and experience are provided in the biographical sketches form through Fastlane.

Evaluation

The formative evaluation used to give direction to our project while it is in its development stages will be done through student feedback, faculty feedback, and quality of the data. Since two of the laboratory modules will be done by combining classrooms, student evaluations will be collected after those collaborations. The faculty and teaching assistants will provide feedback on the amount of hands-on time that each student had during the exercise, the interaction between the groups of students using electronic communication, and the ability of the students to work together in a team setting. The laboratory module will be reorganized accordingly for the second year of the project. The compilation of results at the end of the first semester that the courses are taught will provide feedback on the quality of the results. Student feedback forms will include questions specifically asking about the shared laboratory. The use of the web based communication tool (TopClass) will provide the faculty members a way to monitor student interaction between classrooms. The depth and amount of information provided in the laboratory reports written by the students will provide additional feedback concerning the strength of the "bridges" that are being formed.

A summative evaluation will be done at the end of the project. This evaluation will include the results from the formative phase as well results from alumni surveys. The alumni surveys are currently in use and will be modified to include questions specific to the project. An outside evaluator will be used to provide an objective opinion of the success of the project.

Dissemination

We intend to present the outcomes of this project at regional and national meetings. The American Society of Engineering Education and the Divisions of Education in the American Chemical Society and the Geological Society of America provide ideal forums to present the results of the project. We will also build a web site detailing the project's goals and its outcomes. A good web site example is the one posted by David Whisnant from Wofford College for their joint physical chemistry lab project that is supported by the NSF (29). The web site will be used to help educate students and faculty at other schools (both college level and K-12) about the project and unique interactions between Alfred University and Alfred State.

3) Results of Prior NSF Support

Title: Introductory Course to Teach Methods in Environmental Science
Principal Investigators: Michele M. Hluchy and Gordon L. Godshalk
NSF Award Number: DUE-9254104 **Program:** DUE - CCLI
Total Project Amount: $73,638 **Period of Support:** 4/93-8/97

A new course called "Exploring the Natural Environment: Methods in Environmental Science" is now being taught for undergraduates. The course is offered as ENS 110 to first- and second-year students who are considering majors in Environmental Studies (ENS). Without expecting students to be science majors or to have a strong background in science, the course is designed to get students *doing* science. Students work in teams to accomplish four projects in a semester, one each on the atmosphere, lithosphere, hydrosphere, and biosphere. They are given general guidelines or a specific task, but they have to define their own question, design their own experiments, collect and interpret their own data, and draw and present their own conclusions. In addition to team research and active learning, the course relies heavily on fieldwork and use of computers to analyze quantitative data.

After four iterations, we are convinced that our motives and strategies were correct. Students repeatedly say they like doing relevant activities -- "real-world" problems -- rather than "canned" experiments. There is no doubt that they are more facile (and comfortable) with computers and with crossing traditional boundaries separating traditional disciplines. Our observations confirm that students are meeting our initial specific goals.

What we are surprised with is the fabulous response of juniors and seniors to the mentoring experience. They like working with younger students, they admit they really learn when they are confronted with teaching, and they are proud to describe their experience on their applications for jobs and graduate school.

In 1997, we employed an external evaluator to assess this project. He summarized his evaluation as follows:

> "By any measure, but particularly as judged by the commentary provided by the students themselves, ENS 110 is a critically important course for the Environmental Studies Program at Alfred University. As conceived and taught, it is an enriching experience for ENS 110 enrollees and, most importantly, for the teaching faculty as well. Refinements can be made, but only if they do not interfere with the present course structure and aims."

Each of us has presented papers about this course at national meetings of our respective disciplinary societies (Ecological Society of America, Geological Society of America) (30,31,32,33,34). Both presentations were well-received by our colleagues and many of those who attended the presentations ask us for additional information on the course so that they may try to teach similar courses at their own institutions.

Title: Integration of Analytical Chemistry into Environmental Programs at Alfred University
Principal Investigators: Michele M. Hluchy, Gordon Godshalk, J. Robert Pipal
NSF Award Number: DUE-9551773 **Program:** Undergraduate Education - ILI
Total Project Amount: $83,757 **Period of Support:** 8/1/95-7/31/97

We purchased and installed an atomic absorption spectrophotometer and an ion chromatograph with funds from this grant to provide contemporary analytical experience to undergraduates in several extant courses and a new one. Students in Environmental Studies, Geology, and Chemistry routinely use both instruments.

Our new course, ENS 351 Environmental Biogeochemistry, was offered for the first time during the Spring 1996 semester and again during the Spring of 1998. In this class, students designed their own investigations to learn their topic, in this case environmental chemical cycles and global change.

Fifteen undergraduate students have worked directly with the P.I.'s on independent research projects which required use of the ion chromatograph and atomic absorption spectrophotometer. Two of those students presented the results of their research at the Northeast Sectional Meeting of the Geological Society of America in March 1999 and a third student, who worked on the geochemistry of our local watershed presented the results of her research at the Northeast Sectional Meeting of the Geological Society of America in March 2000(35,36).

Title: Investigative Science at Alfred: How the World Works

Principal Investigators: J. Blauth, S. Boersma, J. Crane, D. DeGraff, G. Godshalk, and M. Hluchy

NSF Award Number: DUE-9653164 **Program:** Undergraduate Education -CCD

Total Project Amount: $114,930 **Period of Support:** 8/1/97-7/31/99

This grant supported a year-long, introductory, interdisciplinary course entitled SCI 123-124: "How the World Works", which is team-taught by six faculty members in the sciences and mathematics at Alfred. The purpose of the course was to introduce non-science majors to the *fun* and creative side of science, so often missing from traditional disciplinary courses, by having our students actually *do* scientific experiments to answer questions that they themselves pose related to an overall course theme or umbrella topic.

The course is currently in its third iteration, and the enrollment has increased steadily since its initial offering. An external evaluator visited campus during the Spring 1999 semester to help us with our assessment of this project.

Several of us have presented papers about this course at professional meetings(37,38,39,40,41). Additionally, one paper has been accepted for publication by the *Journal of College Science Teaching* and two others are currently in preparation(42).

Title: A Field Site for Studying Surface and Subsurface Water
Principal Investigators: Michele M. Hluchy
NSF Award Number: DUE-9751265 **Program:** Undergraduate Education -ILI
Total Project Amount: $18,298 **Period of Support:** 6/1/97 – 5/31/99

This grant funded an expansion of Alfred University's Hydrologic Field Site for studying surface and subsurface water, providing financial support to install new groundwater wells, instrumentation, and a stream gauging station on campus. Equipment installation has been completed (as of Fall 1998), and data are currently being collected both manually and automatically (by data loggers).

The field site has been the focus of many teaching and research activities in the Division of Environmental Studies and the Department of Geology at AU. Additionally, the site is used by high school students who come to Alfred for summer workshops on science and engineering. The facility is also used by area high school classes and by students in Alfred State College's two-year Environmental Technology program.

Students in Geology and Environmental Science have all used the facilities at the field site for laboratories and field demonstrations. Six students have also used field station for undergraduate research projects in the past 3 years. Publications and presentations resulting from this project so far are in references 43, 44 and 45.

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