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ABSTRACT

This document describes the development of a project called "Connections," at the Colorado School of Mines. "Connections" is an integrated series of active-learning courses and seminars that allow first-year engineering and science students to connect studies in engineering, physical science, social science, and humanities via a series of interdisciplinary modules and seminars, and is also intended to help them discover relationships among first-year core subjects, enhance higher-order thinking abilities, develop ethics and values, and improve communication skills. Three modules were developed (passive solar collector design, remediation of groundwater contamination, and analysis, evaluation, and ramifications of pollution data) and taught over 2 semesters to 83 first-year students; 80 students persisted into the sophomore year. The retention rate for students taking the "Connections" program was reported to be far above the school's average for first-year engineering and science students. Report sections discuss background and origins of the project, faculty and curriculum development, modules and seminars, the pilot courses, evaluation, and conclusions. Appendixes include: "Connections" modules; seminar syllabi; a perception questionnaire and student responses; and reports from the external evaluator. (Contains 16 references.) (CH)

Cover Sheet

Connections: A Model for Integrated Freshman Year Studies.

Grantee Organization:

Colorado School of Mines
1500 Illinois Street
Golden, CO 80401

Grant Number:

P116B30031

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Ending Date: December 31, 1996
Number of Months: 36

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Summary Paragraph

In this project, we developed the *Connections* program, an integrated series of active-learning courses and seminars which allow first-year engineering and science students to develop significant connections among their studies in physical science, engineering, humanities, and social science. By connecting first-year courses via a series of interdisciplinary modules and developing the connections further in a seminar series, we allow students to discover meaningful relationships among the disciplines they are studying. During the project, two versions of *Connections* pilot courses and seminars were successfully developed and taught to a total of 83 first-year students; 80 of these students persisted into the sophomore year (96%).

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Executive Summary

Project Title: Connections: A Model for Integrated Freshman Year Studies

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Project Overview

This report summarizes our activities and accomplishments during a three-year project to develop and implement the *Connections* program, an integrated series of active-learning courses and seminars which allow first-year engineering and science students to develop significant connections among their studies in physical science, engineering, humanities, and social science. By connecting first-year courses via a series of interdisciplinary modules and developing the connections further in a seminar series, we allow students to discover meaningful relationships among the disciplines they are studying. During the project, two versions of *Connections* pilot courses and seminars were successfully developed and taught to a total of 83 first-year students; 80 of these students persisted into the sophomore year (96%).

Purpose

The state of engineering education in this country has come under intense scrutiny in recent years, particularly as it influences our ability to compete in global high-technology markets. Several well-respected groups, including the National Science Board's Task Committee on Undergraduate Science, Mathematics, and Engineering Education, the American Society for Engineering Education Task Force, the National Congress on Engineering Education, the Sigma Xi National Advisory Group and the Association of American Colleges (AAC) have called for changes in ways we prepare engineers for the future. Two themes arise in many of these reports: 1) undergraduate engineering curricula generally do a poor job of integrating humanities and social science in any meaningful way, and 2) freshman instruction in humanities, social science, physical science, and engineering is often delivered in ways that discourage students from pursuing careers in science and engineering.

In response to these problems, the Colorado School of Mines (CSM) developed the *Connections* program and received FIPSE funding to help support our efforts. The intellectual rationale for this program is simple: we try to provide our students with a more meaningful first-

year experience by allowing them to discover and explore important connections among the humanities, physical and social sciences, and engineering subjects they study in their first year at CSM. As a result, *Connections* students acquire a deeper appreciation of the importance of these subjects and their interrelatedness in their upper division courses, their professional engineering work, and their lives.

Background and Origins

Faculty, students, and administrators at CSM have recently developed a new academic plan which describes how the school will respond to increased challenges in the resource industries. A major portion of the plan focuses on the need to educate students who are "good stewards of the earth and its resources." We expect that our graduates will be committed to the "mitigation of environmental damage caused by the production and utilization of minerals, energy, and materials and to development of processes and technologies that will minimize such damage in the future."

Achieving these goals will, by necessity, require an interdisciplinary approach involving the physical and social sciences, humanities, and engineering. The *Connections* program begins this process by allowing first-year students to: 1) discover and develop significant connections among their first-year core subjects; 2) enhance their higher order thinking abilities and apply these abilities in humanistic, scientific, and engineering contexts; 3) understand the historical and cultural contexts which have influenced developments in science, humanities, and engineering; 4) struggle with some of the world's great ideas and issues; 5) further develop their sense of ethics and values, particularly concerning the applications and limitations of technology in the modern world; and 6) improve their oral and written communication skills.

Project Description

To achieve the objectives of *Connections*, we modified our existing required first-year courses (mathematics, chemistry, physics, economics, geology, EPICS [Engineering Practices Introductory Course Sequence], and Crossroads [introductory humanities/social science course]) to feature a series of integrated project modules which allowed students and faculty to explore appropriate connections among these disciplines and taught a two-semester *Connections* interdisciplinary seminar series in which students and faculty further developed and explored the interconnectedness of appropriate topics from each of the first-year science, humanities, and engineering courses. Overall, we transformed the CSM first-year curriculum from a collection of unconnected courses to an interconnected web of concepts centered around the *Connections* seminar.

Connections integrated project modules allow students to apply what they are learning in individual courses to interdisciplinary problems and issues posed in each module. We have developed the following modules which were piloted in *Connections* courses: 1) passive solar collector design, 2) remediation of groundwater contamination, and 3) analysis, evaluation, and ramifications of pollution data. Each module was carefully designed to allow students to immediately apply knowledge from their first-year courses in interdisciplinary contexts.

The *Connections* seminar used small group discussions to help students reinforce connections introduced via the modules described earlier and to develop additional connections across traditional disciplines. Themes discussed in the *Connections* seminar included biography and role models; method in humanities, physical and social sciences, and engineering; history of science and technology focusing on the scientific, industrial, and Darwinian revolutions; and an interdisciplinary analysis of the "limits to growth" argument originally posed by the Club of Rome. In addition to academic work, the seminar was used to mentor students and help them develop a peer support structure.

Forty-nine CSM first-year students were admitted into the first pilot courses (1994-95 academic year) from an initial pool of approximately 250 eligible students (those incoming students who did not have deficiencies or advanced placement credit for any of the first-year core courses). To help improve mentoring in *Connections*, the second pilot group (1995-96 academic year) was reduced to 34. As a rule, our students attended specially designated sections of each first-year course which were closed to non-*Connections* students. The only exceptions to this policy were large lectures in economics, chemistry, physics, and geology. For these courses, our students attended lectures with other CSM first-year students, but worked in "*Connections* only" recitations and laboratory sections. Modules were introduced into the appropriate courses according to an established timetable developed by the *Connections* faculty.

Evaluation/Project Results

While *Connections* students from both pilot groups performed only slightly better academically during their freshman year then non-*Connections* students, *Connections* students are remaining at CSM at a far higher rate after two semesters (avg. of 96.4% vs. 85.0%) and four semesters (avg. of 91.6% vs. 69.0%). In addition, the retention rate of the second pilot *Connections* group is significantly higher than that of the first group, indicating a positive effect of our increased emphasis on student support and mentoring.

Perception questionnaire data suggested that, relative to their non-*Connections* peers, *Connections* students generally became more aware of their ethical responsibilities to consider the ramifications of their technological solutions, the existence and value of diverse methodologies in different disciplines, and the importance of a multidisciplinary team approach to solving most problems. However, we saw little change in either the *Connections* or non-*Connections* students' beliefs about the importance of studying historical and cultural contexts of their chosen disciplines, or about how studying the lives and accomplishments of great engineers, scientists, or humanists should be an important part of their educational experience.

Dr. Gloria Rogers from Rose-Hulman Institute of Technology visited the CSM campus during April 1995 and April 1996 to conduct focus group interviews with *Connections* and non-*Connections* students and to meet with other project stakeholders. *Connections* students praised the dedication and expertise of the faculty, the opportunity to make friends with other students early in their college careers, and several of the seminar and classroom modules.

Summary and Conclusions

We have developed the *Connections* program, an integrated series of active-learning courses and seminars which allow first-year engineering and science students to develop significant connections among their studies in engineering, physical science, social science and humanities. By connecting topics via a series of interdisciplinary modules and developing the connections further in a seminar series, we allow students to discover relationships among the disciplines they are studying. We also help our students develop interpersonal "connections" with their peers and *Connections* faculty which result in a retention rate far above the CSM average for first-year engineering and science students.

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Project Overview

This report summarizes our activities and accomplishments during a three-year project to develop and implement the *Connections* program, an integrated series of active-learning courses and seminars which allow first-year engineering and science students to develop significant connections among their studies in physical science, engineering, humanities, and social science. By connecting first-year courses via a series of interdisciplinary modules and developing the connections further in a seminar series, we allow students to discover meaningful relationships among the disciplines they are studying. During the project, two versions of *Connections* pilot courses and seminars were successfully developed and taught to a total of 83 first-year students; 80 of these students persisted into the sophomore year (96%).

The remainder of this report describes in more detail our accomplishments during this project including results of our project evaluation and dissemination activities; we will also discuss how our experiences during the project are influencing on-going curricular revision activities at the Colorado School of Mines.

Purpose

The state of engineering education in this country has come under intense scrutiny in recent years, particularly as it influences our ability to compete in global high-technology markets. Several well-respected groups, including the National Science Board's Task Committee on Undergraduate Science, Mathematics, and Engineering Education (1), the American Society for Engineering Education Task Force (2), the National Congress on Engineering Education (3), the Sigma Xi National Advisory Group (4,5) and the Association of American Colleges (AAC) (6) have called for changes in ways we prepare engineers for the future.

Two themes arise in many of these reports: 1) undergraduate engineering curricula generally do a poor job of integrating humanities and social science in any meaningful way, and 2) freshman instruction in humanities, social science, physical science, and engineering is often delivered in ways that discourage students from pursuing careers in science and engineering.

The first theme was addressed by AAC in a major study of the quality and coherence of humanities coursework completed by engineering students (6). They note:

> The concern that prompts our project is that undergraduate engineering education is not effective enough. Continuing improvements in the teaching of science, mathematics, and engineering alone, moreover, cannot solve the problem, as essential as these improvements are to maintaining quality. Another area of the engineering curriculum must be reformed, one that is by contrast neglected and seriously in disarray. We refer to the humanities and social sciences.

This view is shared in a National Science Foundation (7) report which highlights the need for a "broadly based undergraduate curriculum" emphasizing "stronger nontechnical education." Similar concerns are expressed in a National Research Council study (8), where a strong case is made for improving U.S. economic productivity by educating well-rounded engineers capable of solving problems in the broadest possible contexts rather than within the limited confines of technical analysis. The second theme was studied by the Sigma Xi National Advisory Group (4) which summarized several characteristics of lower division curricula that drive away potential engineering and science students. These characteristics include:

- large, impersonal classes
- failure to stimulate and engage students
- emphasis on memorizing irrelevant course content, with no attention to the processes of investigation (analysis, synthesis, critical reasoning)
- fragmented course offerings with no indication about why the courses are important to an engineer or how they are related to each other
- no introduction to engineering problem-solving methodologies and thus no indication of what engineers can and cannot achieve

Hewitt and Seymour (9) report that the leading reasons cited by a sample of about 150 lower division students switching out of engineering majors were: 1) non-technical majors offer a better education, 2) loss of interest in science, and 3) rejection of technical careers. Poor teaching and unapproachable faculty were also cited as important reasons for opting out of engineering.

The net result of poor freshman instruction is fewer students in the engineering "pipeline" and lower graduation rates. Kenneth Green (10) notes that "freshmen interest in technology careers has experienced a dramatic decline in just the past six years. Between 1982 and 1988, the proportion of freshmen planning to pursue careers as engineers fell by almost one-quarter." In 1988, only about 8.6% of first-time, full-time entering freshmen elected engineering as a major, and, based on past trends, only about 50% of those can be expected to eventually earn a B.S. engineering degree.

Clearly, engineering schools in this country cannot continue to ignore a sizable portion of our intellectual talent if the United States is to maintain a leadership role in engineering and technology. Simply put, we must do a better job of attracting, retaining, and graduating the best engineering students available. Just as clearly, these efforts must be concentrated in the lower division (particularly freshman) courses where many students with interest and aptitude in science and engineering are lost.

In response to these problems, the Colorado School of Mines (CSM) developed the *Connections* program and received FIPSE funding to help support our efforts. The intellectual rationale for this program is simple: we try to provide our students with a more meaningful first-year experience by allowing them to discover and explore important connections among the humanities, physical and social sciences, and engineering subjects they study in their first year at CSM. As a result, *Connections* students acquire a deeper appreciation of the importance of these subjects and their interrelatedness in their upper division courses, their professional engineering work, and their lives.

Background and Origins

The Colorado School of Mines is the second oldest and one of the largest colleges of mineral engineering and applied science in the country. Our mission focuses on educating engineers to be leaders in the fields of minerals, energy, and materials. As discussed below, the school has distinguished itself as an innovative leader in undergraduate engineering education. Our undergraduate student body of approximately 2000 is extremely talented with the average freshman ranking in the 90th percentile in mathematical skills and 80th percentile in verbal skills on the SAT and ACT examinations. Entrance requirements are among the highest in the nation for public institutions of higher learning. Such capable students are ideally suited for participating and thriving in the *Connections* program.

Faculty, students, and administrators at CSM have recently developed a new academic plan which describes how the school will respond to increased challenges in the resource industries. A major portion of the plan focuses on the need to educate students who are "good stewards of the earth and its resources." We expect that our graduates will be committed to the "mitigation of environmental damage caused by the production and utilization of minerals, energy, and materials and to development of processes and technologies that will minimize such damage in the future." We also expect that our graduates will be committed to developing technologies which rely on renewable resources such as solar energy and biomass. As part of the plan, CSM is also committed to strengthening the humanities component of each student's education to ensure that our graduates have the intellectual vision and perspective to act responsibly in today's complex global economy.

Achieving these goals will, by necessity, require an interdisciplinary approach involving the physical and social sciences, humanities, and engineering. In the future, our graduates will need to better understand the interrelatedness of human knowledge and be capable of applying knowledge and skills from numerous disciplines to solve problems and improve the quality of life for the world's inhabitants. To graduate engineers with these attributes, we need to provide an integrated educational experience in which students explore the connecting points among disciplines as they become more proficient in those disciplines. Thus, the *Connections* program directly relates to the mission and academic plan of CSM by allowing first-year students to:

- discover and develop significant connections among their first-year core subjects.
- enhance their higher order thinking abilities and apply these abilities in humanistic, scientific, and engineering contexts.
- understand the historical and cultural contexts which have influenced developments in science, humanities, and engineering.
- struggle with some of the world's great ideas and issues.
- further develop their sense of ethics and values, particularly concerning the applications and limitations of technology in the modern world.
- improve their oral and written communication skills.

Project Description

This section of the report describes the work we completed to develop and pilot the *Connections* program. During the first year of the project, we conducted extensive faculty development and course planning activities to prepare for the first *Connections* pilot courses where were taught during the 1994-95 academic year. As the pilot courses were taught (second year of the project), we began project evaluation and dissemination activities and worked to improve the *Connections* courses. During the 1995-96 academic year (third year of the project), we taught and evaluated the second version of *Connections* pilot courses.

Faculty development. To help *Connections* faculty prepare to teach the *Connections* pilot courses, each project faculty member attended at least one freshman course taught by another *Connections* faculty member; as we sat in each other's classes, we became aware of the course content, skills, pedagogies, and issues emphasized in each course. Courses attended by each project faculty member are listed below:

- Barbara Bath [Mathematics] -- EPICS 101 (fall) and Physics I (spring)
- Ronald Miller [EPICS] -- Geology I (spring)
- Barbara Olds [Humanities] -- Economics I (fall)
- Michael Pavelich [Chemistry] -- Crossroads (fall)
- Samuel Romberger [Geology] -- Economics I (spring)
- John Tilton [Economics] -- Crossroads (spring)
- John Trefny [Physics] -- Calculus I (fall) and Calculus II (spring)
- Karen Wiley [Social Science] -- Chemistry I (fall) and Chemistry II (spring)

As part of this task, we attended classes regularly and completed much of the coursework (readings, homework, laboratory exercises). All of us concentrated on observing the "big picture" in the course and watching for possible connections with our other courses. In addition, some of us also worked diligently to learn the course content to better help us in our own *Connections* courses and the *Connections* seminar. Our observations have been published elsewhere (15) and are summarized here. We all agreed that we had misperceptions about each other's freshman courses on at least two levels -- faculty and students. Among the faculty, we noted disagreements about appropriate and effective pedagogies, our expectations of the students, student maturity, effective testing and the goals of education.

We also clearly perceived the courses we audited differently than our students did. We found intrinsic value in the material presented while they worried whether it would be on the test; we saw the "big picture" while they were often bogged down in irrelevant details; we respected each other while they often had a "show me" attitude. We expected them to be mature learners while they reminded us in their actions and words that they were just out of high school and not nearly as adult as we assumed. Overall, the experience was very worthwhile and provided useful input to our course planning activities during the project's first year.

Curriculum development. To achieve the objectives of *Connections*, we modified our existing required first-year courses (mathematics, chemistry, physics, economics, geology, EPICS [Engineering Practices Introductory Course Sequence], and Crossroads [introductory humanities/social science course]) to feature a series of integrated project modules which allowed students and faculty to explore appropriate connections among these disciplines and taught a two-semester *Connections* interdisciplinary seminar series in which students and faculty further developed and explored the interconnectedness of appropriate topics from each of the first-year science, humanities, and engineering courses. Overall, we transformed the CSM first-year curriculum from a collection of unconnected courses to an interconnected web of concepts centered around the *Connections* seminar as shown in Figure 1 on page 8.

It is important to note that the curricular structure shown in Figure 1 maintains the disciplinary integrity of each first-year course. Thus, we believe our model could be modified to fit a variety of core curricula at other educational institutions.

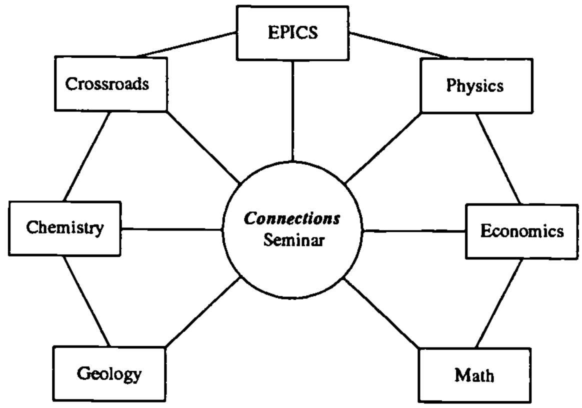

Figure 1 - *Connections* First-Year Pilot Curriculum

***Connections* modules.** *Connections* integrated project modules allow students to apply what they are learning in individual courses to interdisciplinary problems and issues posed in each module. We have developed the following modules which were piloted in *Connections* courses [brackets indicate which courses are connected in the module]:

- passive solar collector design [mathematics, EPICS, Crossroads]
- remediation of groundwater contamination [chemistry, geology, EPICS, Crossroads]
- analysis, evaluation, and ramifications of pollution data [chemistry, geology, Crossroads]

Each module (located in Appendix A) was carefully designed to allow students to immediately apply knowledge from their first-year courses in interdisciplinary contexts.

For example, the groundwater remediation module allowed students to explore connections among geology, chemistry, humanities, and social sciences by studying the process of groundwater flow and contaminant transport in an established mine tailing site. Students developed a simple remediation plan for the site using geological, mathematical, and chemical principles to analyze groundwater flow and contaminant transport processes. Social and political issues related to the existence and maintenance of polluted sites in populated areas were discussed, and we examined the kinds of constraints and considerations which govern how we choose to utilize the earth's renewable and non-renewable resources and the effects of utilization on the environment.

We also discussed potential trade-offs required to balance quality of life and environmental quality and the implications of these trade-offs for the future. Alternative methods for evaluating the economic costs associated with remediation of contaminated sites were analyzed and the cleanup costs of the site remediation plan being developed were estimated using two economic models (cost/benefit analysis and least cost analysis). Completion of this module helped students understand that effective environmental protection strategies require an interdisciplinary approach involving science, technology, humanities and social science.

***Connections* seminar.** The *Connections* seminar used small group discussions to help students reinforce connections introduced via the modules described earlier and to develop additional connections across traditional disciplines. Themes discussed in the *Connections* seminar included biography and role models; method in humanities, physical and social sciences, and engineering; history of science and technology focusing on the scientific, industrial, and Darwinian revolutions; and an interdisciplinary analysis of the "limits to growth" argument originally posed by the Club of Rome. Syllabi for each of the pilot *Connections* seminars are located in Appendix B.

For example, as students explored the concept of "method" in various disciplines, they read excerpts from Kuhn (11) [scientific method], Koen (12) [engineering method], Hoover (13) [social science method], and Ciardi (14) [humanities method]. After discussing these selections, students developed hypotheses about the kinds of problems posed and solved by professionals in different disciplines and about how evidence is valued and utilized in different ways. Students later tested their hypotheses by interviewing faculty members willing to discuss their personal approaches to problem-solving methods. These findings were shared with other students in the seminar who ultimately gained a better understanding of the similarities and differences among problem-solving methods in the disciplines. Perhaps more importantly, our students began to understand why we should know something about methods in disciplines other than our own.

Connections students also read from the biographies of physical scientists [Curie, Feynman, Priestley, Kovalevskaya, Hutton], social scientists [Benedict, Keynes], an engineer [Amman], and a humanist [Shelley] as they learned about the human dimension of professional role models. They read from Whitehead, Lewis, and Ferris [scientific revolution], Toynbee [industrial revolution], and Darwin and Mayr [Darwinian revolution] as they discussed the impacts of these revolutions on our lives and predicted future revolutions. Finally, they studied the writings of Myers and Simon as they debated the "limits to growth" issue.

The *Connections* seminar was our primary vehicle for encouraging inquiry beyond the level of integration obtained using project modules in the first-year courses. Each seminar group consisted of 15-18 students and two or three faculty members who were involved in teaching *Connections* courses. Students were required to keep a journal throughout the year in which they recorded their reflections on readings, discussions, and coursework.

Pilot courses. After a year of intense planning and curriculum development, we offered the first pilot *Connections* courses during the 1994-95 academic year. Forty-nine CSM first-year students were admitted into the program from an initial pool of approximately 250 eligible students (those incoming students who did not have deficiencies or advanced placement credit for any of the first-year core courses). As a rule, our students attended specially designated sections of each first-year course which were closed to non-*Connections* students. The only exceptions to this policy were large lectures in economics, chemistry, physics, and geology. For these courses, our students attended lectures with other CSM first-year students, but worked in "*Connections* only" recitations and laboratory sections. Modules were introduced into the appropriate courses according to an established timetable developed by the *Connections* faculty who continued to meet bi-weekly to coordinate course schedules and deal with problems and issues. Each faculty member also participated as a seminar moderator or co-moderator so that we met with our students in both a disciplinary context in our classes and an interdisciplinary context in the seminar. We have found that the combination of modular work in classes combined with further exploration of relevant issues in a discussion-based seminar environment enhanced our interactions with students and their ability to make meaningful connections among topics in many disciplines.

Many of our students commented that an important motivation to participate in *Connections* was the opportunity to meet and work closely with faculty and fellow students. They were less concerned about the scholarly connections than the social ones. We observed many of our students forming closely knit study groups and friendships during their first year in the program, friendships that have continued as the students moved into upper-division courses. *Connections* students also tended to talk to the faculty or communicate by e-mail more than do traditional first-year students. Overall, we have been able to get to know our students much better and this has helped create a meaningful context for all of us to learn from one another in our classes and seminars.

Based on preliminary evaluation data, student feedback, and input from Dr. Gloria Rogers (our external evaluator), we made several changes in course philosophy, structure, and content before delivering updated *Connections* pilot courses during the 1995-96 academic year. These changes included a major revision of the seminar to focus on developing the proper support structure for student success before concentrating on developing connections among academic topics and courses (see Appendix B for seminar syllabi). We also made available to the students more explicit mentoring and tutoring help in addition to formal seminar sessions.

We utilized a new text by Dr. Raymond Landis entitled "Studying Engineering: A Road Map to a Rewarding Career" (16) for this portion of the seminar. The *Connections* section of Crossroads (the first-year introductory humanities/social science course) was also completely restructured to include readings and discussions directly relevant to our seminar work and work in other courses.

Thirty four first-year students were admitted into the second version of *Connections* courses beginning fall semester 1995. Once again, our students attended specially designated sections of each first-year course. The modules on remediation of groundwater contamination and passive solar collector design were revised and introduced into the appropriate courses. *Connections* faculty continued to meet bi-weekly to coordinate course schedules and deal with problems and issues. Once again, each faculty member participated as a seminar moderator or co-moderator so that we met with our students in both a disciplinary context in our classes and an interdisciplinary context in the seminar.

Student feedback and evaluation of the 1994-95 and 1995-96 pilot courses is presented in the "Evaluation/Project Results" section below.

Evaluation/Project Results

In this section, we present project evaluation data including measures of student success (grade point average and retention rates), measures of student attitudes and perceptions towards issues addressed in *Connections* courses, and student feedback acquired by our external project evaluator, Dr. Gloria Rogers from Rose-Hulman Institute of Technology. We also discuss in this section how results from the project were disseminated and how these results have impacted a school-wide curricular revision at the Colorado School of Mines.

Project evaluation. Table 1 summarizes retention rate and grade point average data for each *Connections* pilot student group and their non-*Connections* peers. While *Connections* students from both pilot groups performed only slightly better academically during their freshman year then non-*Connections* students, *Connections* students are remaining at CSM at a far higher rate after two semesters (avg. of 96.4% vs. 85.0%) and four semesters (avg. of 91.6% vs. 69.0%). In addition, the retention rate of the second pilot *Connections* group is significantly higher than that of the first group, indicating a positive effect of our increased emphasis on student support and mentoring.

Using the questionnaire shown in Appendix C, we measured changes in perceptions and attitudes among *Connections* and non-*Connections* students about the importance of humanistic, scientific, and engineering achievements to their education, their professional careers, and their lives. We also measured differences in student attitudes about the importance of multi-disciplinary team-based approaches to problem-solving, the value of understanding different disciplinary methodologies, ethics and value judgments related to technological progress, and understanding the historical and cultural contexts which influence developments in humanities, social and physical sciences, and engineering. The questionnaire was administered to each *Connections* pilot group at the beginning of the fall semester and again near the end of the spring semester to measure longitudinal changes in student perceptions and attitudes during their first year at CSM. To obtain baseline data, we also administered the questionnaire to a randomly selected group of 50 non-*Connections* freshmen near the beginning and end of the 1994-95 academic year. A compilation of all survey results is provided in Appendix C.

As shown in Figures 2-4, *Connections* students generally became more aware than non-*Connections* students of their ethical responsibilities to consider the ramifications of their technological solutions (Figure 2), the existence and value of diverse methodologies in different

Table 1
Comparision of Retention Rate and GPA Data Between *Connections* Students and Their Non-*Connections* Peers

	Retention after 2 semesters	Retention after 4 semesters	Retention after 6 semesters	Grade Point Average after 2 semesters
Connections Students (1994-95 pilot group)	93.9%	87.8%	81.6%	3.01
Non-*Connections* Students (1994-95 freshman class)	85.0%	69.0%	61.2%	2.95
Connections Students (1995-96 pilot group)	100.0%	97.1%	---	3.21
Non-*Connections* Students (1995-96 freshman class)	85.0%	69.0%	---	2.92

disciplines (Figure 3), and the importance of a multidisciplinary team approach to solving most problems (Figure 4). However, we saw little change in either the *Connections* or non-*Connections* students' beliefs about the importance of studying historical and cultural contexts of their chosen disciplines, or about how studying the lives and accomplishments of great engineers, scientists, or humanists should be an important part of their educational experience at CSM. Overall, these data suggest that *Connections* does help students begin to develop a broader view of their educational experience and chosen profession, but clearly we are not sufficiently convincing them about the importance of developing complex connections among science, engineering, and humanities as they study these subjects.

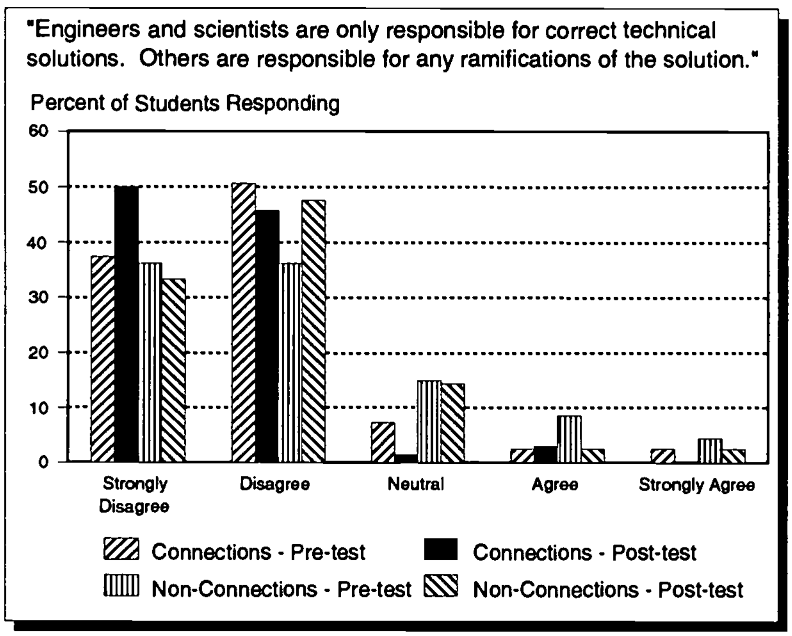

Figure 2 -- Comparison of Pre- and Post-test Responses for *Connections* and Non-*Connections* Students: "Engineers and scientists are only responsible for correct technical solutions. Others are responsible for any ramifications of the solution."

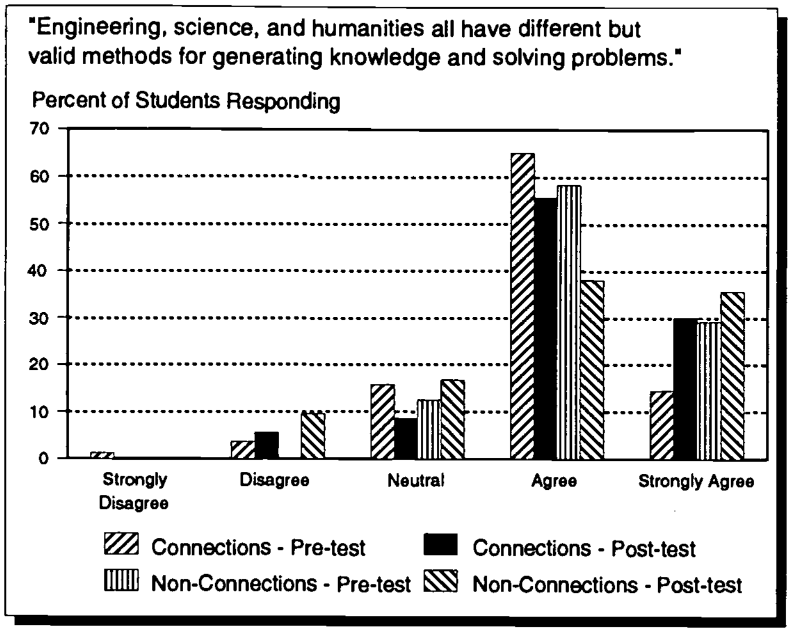

Figure 3 -- Comparison of Pre- and Post Test Results for *Connections* and Non-*Connections* Students: "Engineering, science, and humanities all have different but valid methods for generating knowledge and solving problems."

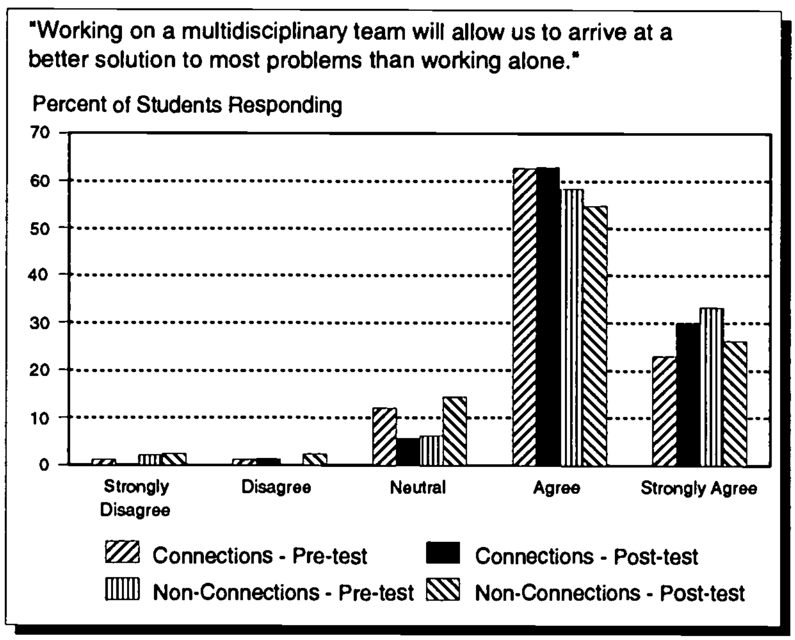

Figure 4 -- Comparison of Pre- and Post Test Results for *Connections* and Non-*Connections* Students: "Working on a multidisciplinary team will allow us to arrive at a better solution to most problems than working alone."

Dr. Gloria Rogers from Rose-Hulman Institute of Technology visited the CSM campus during April 1995 and April 1996 to conduct focus group interviews with *Connections* and non-*Connections* students and to meet with other project stakeholders. Her reports (located in Appendix D) provided valuable formative assessment data for us during the project. Her findings agree closely with feedback we received from students when we asked them to write end-of-the-year essays on their *Connections* experience. Most of the students agreed that they would recommend *Connections* to a friend coming to CSM, but only with modifications. They praised the dedication and expertise of the faculty, the opportunity to make friends with other students early in their college careers, and several of the seminar and classroom modules. However, they believed that the first pilot courses required too much "busy work," that some of the modules were ineffective and/or irrelevant, and that they did not receive as much individual attention from their faculty mentors as they would have liked. These issues were addressed in the second pilot courses. Students consistently mentioned faculty mentoring and peer support as the most important and effective aspect of *Connections*, an observation which agrees well with the retention data reported in Table 1.

Project dissemination. We viewed effective dissemination of results and experiences from this project as not only a professional obligation but also as an opportunity to help improve the quality of first-year instruction at engineering and science schools across the nation. Throughout the project, we reported our findings at the regional and national education, engineering, and scientific conferences listed below. We also published several papers in the education and engineering journals listed below.

Presentations:

"*Connections:* A Model for Integrated Freshman Year Studies," National Science Foundation Conference on Disseminating Innovation in Undergraduate Education, Washington, DC, May 31-June 3, 1994.

"*Connections*: A Model for Integrated First Year Studies," FIPSE National Project Directors' Meeting, Washington, D.C., October 21-23, 1994.

"*Connections*: A New Approach to Integrated First-Year Engineering Education," American Society for Engineering Education Annual Conference, Anaheim, California, June 25-28, 1995.

"Faculty as Students: What We Thought We Knew and What We Learned," American Society for Engineering Education Annual Conference, Anaheim, California, June 25-28, 1995.

"New Ways to Help Engineering and Science Students Make Sense of their First-Year Courses," FIPSE National Project Directors' Meeting, Washington, D.C., October 26-29, 1995.

"*Connections:* Integrated First Year Engineering Education at the Colorado School of Mines," Frontiers in Education Conference, Atlanta, Georgia, November 1-5, 1995.

"Calculus in an Integrated Freshman Curriculum," American Society for Engineering Education Annual Conference, Washington, D.C., June 23-26, 1996.

Publications:

"*Connections*: A New Approach to Integrated First Year Engineering Education," B.M. Olds and R.L. Miller, Proceedings of the American Society for Engineering Education Annual Conference, Anaheim, California, June 25-28, 1995.

"Faculty as Students: What We Thought We Knew and What We Learned," B.M. Olds and R.L. Miller, Proceedings of the American Society for Engineering Education Annual Conference, Anaheim, California, June 25-28, 1995.

"*Connections:* Integrated First Year Engineering Education at the Colorado School of Mines," R.L. Miller and B.M. Olds, Proceedings of the Frontiers in Education Conference, Atlanta, Georgia, November 1-5, 1995.

"Calculus in an Integrated Freshman Curriculum," B.B. Bath, Proceedings of the American Society for Engineering Education Annual Conference, Washington, D.C., June 23-26, 1996.

Project continuation. Overall, the *Connections* project has been a success, particularly in terms of dramatically increasing the retention of first-year CSM students. Although the pilot curricular structure will not continue, several valuable concepts and experiences from the project have already been incorporated into the new CSM campus-wide curriculum reform effort. For example, our new curriculum includes three required "systems" courses ("Earth and Environmental Systems," "Human Systems," and "Engineering Systems"), each of which is designed to help students explore connections across traditional disciplinary lines, much like the topics we discussed in the *Connections* seminar. The EPICS (Engineering Practices Introductory

Course Sequence) has been redesigned to improve integration of open-ended project work with topics from first year physical science, math, humanities, and social science courses, much like the *Connections* modules. Finally, we have begun a campus-wide discussion to develop ways to improve student mentoring and advising, particularly in the first year.

Summary and Conclusions

With FIPSE support, we have developed the *Connections* program, an integrated series of active-learning courses and seminars which allow first-year engineering and science students to develop significant connections among their studies in engineering, physical science, social science and humanities. By connecting topics via a series of interdisciplinary modules and developing the connections further in a seminar series, we allow students to discover relationships among the disciplines they are studying. We also help our students develop interpersonal "connections" with their peers and *Connections* faculty which result in a retention rate far above the CSM average for first-year engineering and science students.

References Cited

1) National Science Board Task Committee on Undergraduate Science and Engineering Education, Undergraduate Science, Mathematics, and Engineering Education, Washington, DC: National Science Board, 1986.

2) A National Action Agenda for Engineering Education, Washington, DC: American Society for Engineering Education, 1987.

3) Engineering Education Answers the Challenge of the Future, Washington, DC: National Congress on Engineering Education, 1986.

4) National Advisory Group of Sigma Xi, An Exploration of the Nature and Quality of Undergraduate Education in Science, Mathematics and Engineering, New Haven, CT: Sigma Xi, The Scientific Research Society, 1989.

5) Sigma Xi Committee on Science, Mathematics and Engineering Education, Entry Level Undergraduate Courses in Science, Mathematics and Engineering: An Investment in Human Resources, Racine, WI: Sigma Xi, The Scientific Research Society, 1990.

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7) Report from the Workshop on Undergraduate Engineering Education, Washington, DC: National Science Foundation, 1986.

8) Engineering Education and Practice in the United States: Foundations of Our Techno-Economic Future, Washington, DC: National Research Council, 1985.

9) Hewitt, N.M., and Seymour, E., "A Long, Discouraging Climb," ASEE Prism, pages 24-28, Washington, DC: American Society for Engineering Education, February 1992.

10) Green, K, "A Profile of Undergraduates in the Sciences." Racine, WI: Keynote Address at the Sigma Xi Conference on Undergraduate Education in Science, Mathematics and Engineering, 1989, reprinted in An Exploration of the Nature and Quality of Undergraduate Education in Science, Mathematics and Engineering, New Haven, CT: Sigma Xi, The Scientific Research Society, 1989.

11) Kuhn, T.S., The Structure of Scientific Revolutions, Chicago: University of Chicago Press, 1970.

12) Koen, B.V., Definition of the Engineering Method, Washington, DC: American Society for Engineering Education, 1985.

13) Hoover, K.R., The Elements of Social Science Thinking, New York: St. Martin's Press, 1992.

14) Ciardi, J. and M. Williams, How Does a Poem Mean?, Boston: Houghton Mifflin Company, 1975.

15) Olds, B.M., and R.L. Miller, "Faculty as Students: What We Thought We Knew and What We Learned," ASEE Annual Conference Proceedings, pages 2295-2299, Washington, DC: American Society for Engineering Education, June 1995.

16) Landis, R.B., Studying Engineering: A Road Map to a Rewarding Career, Burbank, CA: Discovery Press, 1995.

Appendix A

Connections Modules

Connections

Memorandum

To: EP 101 Design Teams

From: Ron Miller and Ron Wiedenhoeft, Team Managers

Date: October 6, 1995

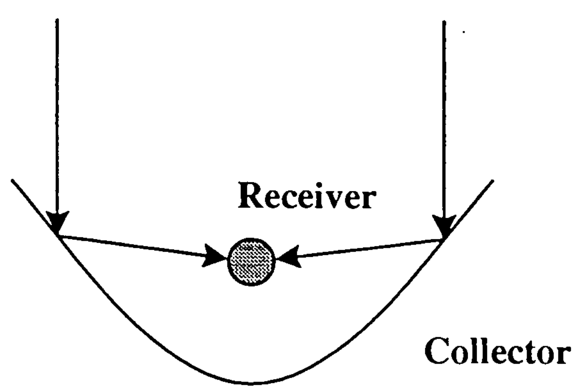
Subject: Solar Collector Design Project for National Renewable Energy Laboratory

You will soon receive a letter from your EPICS project client, the National Renewable Energy Laboratory (NREL), requesting that you design and build a prototype solar energy collector system this semester. The purpose of this memo is to provide you with some background information to help in your design activities.

Items to consider in your work:

1. The objective of your project is to determine the optimum shape of the collector and receiver components so that your design can be used to cook a food item of your choice. Some candidate food items might include hot dogs, hamburgers, pancakes, french toast, coffee, or tea.

2. Mathematical analysis can be performed to test alternative collector and receiver geometries and to develop your optimal collector shape. As shown in the schematic diagram below, the collector assembly reflects and focuses incident solar energy to a receiver so that a higher energy flux (energy/area/time) can be achieved.



3. As you perform your analysis, you may compare alternative designs using a design parameter called the concentration ratio:

$$C_R = \frac{\text{concentrated insolation at the receiver}}{\text{unconcentrated insolation on a flat plate}}$$

where insolation = incident solar energy per unit area per unit time

4. To test your optimal design based on mathematical analysis, you will need to ***build*** one prototype of your solar collector/receiver system and ***test*** its performance by measuring the time required to cook your chosen food. A maximum budget of \$10 will be available to your team to construct your prototype. <u>All prototypes will be evaluated during performance testing tentatively scheduled for Tuesday, December 5, 1995</u>. Client representatives from NREL and ***Connections*** faculty will be present to observe these tests.

5. Your prototype design will have potential applications both domestically and overseas. Please identify at least 5 additional issues (in addition to the technical ones) that need to be addressed to make your project a long-term success. Explain how each of these issues influenced your choice of collector/receiver design.

6. In addition to a working prototype, your team will submit a final written report describing your optimal design, your discussion of the issues listed in #5 above, and suggestions for further improving your design.

7. The quality of your project work will be evaluated using the following criteria:

- creativity and innovation
- prototype performance
- written and oral documentation
- consideration of non-technical issues

8. Background information on solar collector design will be available in MS 183 (the EPICS project room). In addition, the following books will be placed on reserve in the library:

- Ametek, <u>Solar Energy Handbook: Theory and Applications</u>, Chilton Book Co., 1979.
- Cheremisinoff and Regino, <u>Principles & Applications of Solar Energy</u>, Ann Arbor Science, 1978.
- de Winter, Solar Collectors, <u>Energy Storage and Materials</u>, The MIT Press, 1990.
- Duffie and Beckman, <u>Solar Engineering of Thermal Processes</u>, John Wiley, 1980.

National Renewable Energy Laboratory

EP 101 Design Teams
c/o Ron Miller and Ron Wiedenhoeft, EPICS Program Team Managers
EPICS Program Office
Colorado School of Mines
Golden, CO 80401

Dear EP 101 Students,

The National Renewable Energy Laboratory requests your assistance in the design and prototype demonstration of solar energy concentrating collectors for domestic cooking applications. Such collectors can be utilized in the demand side sector to reduce the need for power production on the supply side (i.e. the utility company or electric power producer.) As such, this technology is considered an important component in the efficient use of a renewable resource. The development of such technology serves to reduce our nation's dependence on non-renewable, polluting resources and also generates new industries and businesses which help to strengthen our nation's economy. Work which you perform during this semester term in the way of design, prototype development and demonstration could serve to advance the state of the technology and will, at the same time, provide you with "real world" experience in the engineering arena. We wish you success in your efforts and look forward to working with you in the coming months!

Sincerely,

Timothy J. Wendelin
Staff Engineer
Thermal Systems Branch
Building and Energy Systems Division

cc: John Anderson

National Renewable Energy Laboratory • 1617 Cole Boulevard • Golden, Colorado 80401-3393 • (303) 275-3000
NREL is a national laboratory of the U.S. Department of Energy operated by the Midwest Research Institute

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393
(303) 231-1000

EP 101 Design Teams
c/o Ron Miller and Kathleen Ochs, EPICS Program Team Managers
EPICS Program Office
Colorado School of Mines
Golden, CO 80401

Dear EP 101 Students,

The National Renewable Energy Laboratory requests your assistance in the design and prototype demonstration of solar energy concentrating collectors for the production of domestic hot water. Such collectors can be utilized in the demand side sector to reduce the need for power production on the supply side (i.e the utility company or electric power producer.) As such, this technology is considered an important component in the efficient use of a renewable resource. The development of such technology serves to reduce our nation's dependence on non-renewable, polluting resources and also generates new industries and businesses which help to strengthen our nation's economy. Work which you perform during this semester term in the way of design, prototype development and demonstration could serve to advance the state of the technology and will, at the same time, provide you with "real world" experience in the engineering arena. We wish you success in your efforts and look forward to working with you in the coming months!

Sincerely,

Timothy J. Wendelin

Timothy J. Wendelin
Staff Engineer
Thermal Systems Branch
Building and Energy Systems Division

TW:lmh
epicscov.ltr

cc: J. Anderson

<u>Connections Module</u>:

Remediation of Surface and Ground-Water Contamination

<u>Objectives</u>

This module will allow students to explore connections among geology, mathematics, chemistry, economics, humanities, and social sciences by studying the process of ground-water flow and contaminant transport in an established mine tailing site. Students will develop a simple remediation plan for the site using geological, mathematical, and chemical principles to analyze ground-water flow and contaminant transport processes. Social and political issues related to the existence and maintenance of polluted sites in populated areas will be discussed, while the economic impact of site remediation will be evaluated. Completion of this module will help students understand that effective environmental protection strategies require an interdisciplinary approach involving trade-offs among scientific, technological, and social concerns.

<u>Courses Connected</u>

GEOL 101 - Earth Systems Science (direct connection)
EPIC 102 - EPICS II (direct connection)
MAGN 132 - Calculus II (direct connection)
CHGN 124 - Chemistry II (background connection)
LIHU 100 - Crossroads (background connection)
MEGN 111 - Principles of Economics (background connection)

<u>Readings</u>

Skinner, B.J. and S.C. Porter, 1995, <u>The Blue Planet: An Introduction to Earth System Science</u>, John Wiley, New York.

Montgomery, C.W., 1992, *Physical Geology*, William C. Brown Publishers, Dubuque, IA, pp. 29-38.

Lee, K., G.S. Holden, and S.B. Romberger, 1993, Exercises in Earth System Science, Colorado School of Mines, Golden, CO, pp. 22.1-22.6 and 23.1-23.5.

Dorfman, R., 1993, "An Introduction to Benefit-Cost Analysis," in *Economics of the Environment*, R. Dorfman and N.S. Dorfman, eds., W.W. Norton & Company, New York, pp. 297-322.

Fitchen, J.M., 1987, "Cultural Aspects of Environmental Problems: Individualism and Chemical Contamination of Groundwater," Science, Technology & Human Values, v. 12, n. 2, pp. 1-12.

Passell, P., 1993, "Weighing Alternatives for Toxic Waste Cleanup," in *Economics of the Environment*, R. Dorfman and N.S. Dorfman, eds., W.W. Norton & Company, New York, pp. 288-292.

Wilson, R. and E.A.C. Crouch, 1993, "Risk Assessment and Comparisons: An Introduction," in *Economics of the Environment*, R. Dorfman and N.S. Dorfman, eds., W.W. Norton & Company, New York, pp. 409-420.

Background

Since the beginning of the Iron Age, humans have been recovering valuable metals from the earth by mining and metal extraction from rock. Many countries including the United States owe their economic and political development to the existence of rich metal deposits within their boundaries. Yet the exploitation of these resources has also resulted in the release of many deleterious chemicals, including acids and heavy metals, that are harmful to ecological systems. Past mining and extraction practices by groups unaware of these dangers have resulted in deposits, or dumps, of mined material which was discarded after removal of the valuable metals. When exposed to surface weathering and erosion processes, these dumps have the potential for the uncontrolled release of harmful chemicals. Our society has inherited this legacy produced by uncontrolled metal recovery practices.

Pyrite, FeS_2, is an common but unwanted mineral occurring in metal-rich rocks (ores). This mineral ends up in the material discarded after the metals have been extracted (tailings). The natural weathering of pyrite, by now occurring in a very finely pulverized state in the tailings, results in the formation of sulfuric acid. The resultant acidic waters leach trace amounts of metals remaining in the tailings. The result is a metal-rich acid solution that is harmful to aquatic plants and animals or any other organism that consumes the water. These contaminated waters not only will transport toxic materials in streams but will also seep into the ground, ultimately becoming part of ground-water aquifers. Once the contaminants enter the ground-water system, removal is difficult if not impossible.

Teaching Guide and Assignments

First-year college students often have a sense that protection of the environment is important. However, they may not understand the scientific, technological, economic, political, and societal implications of striving for a clean environment. They may also not be aware that there are tradeoffs in maintaining a clean environment while at the same time maintaining a high standard of living. This module will allow students to begin exploring how scientific and technological considerations must be balanced against societal issues and economic costs in remediating a polluted natural water system affected by a surface waste disposal site. The site remediation plan will be developed in EPIC 102 using knowledge and experiences gained in each of the connected courses described below.

GEOL 101 - Develop physical and mathematical models which describe the nature of ground-water flow in aquifers (Darcy's law) and describe mechanisms for contaminant transport in surface waters (streams and rivers) and in ground-waters. Develop expressions describing the transport of material in surface waters. Investigate the project field site where physical and chemical characteristics of the surface, aquifer, and transporting fluid can be quantified. Explore the effects of various physical, mineralogical, and chemical parameters on contaminant dispersion using the simple model shown below:

$$Q = A * v$$

$$M = Q * C$$

where Q is the flow volumetric discharge, A is the flow cross-sectional area, v is the stream velocity, M is the mass flowrate of transported contaminant, and C is the concentration of contaminant in the stream.

MAGN 132 - Using *Mathematica* in an inquiry-based laboratory environment, solve the one-dimensional transport equation for flow through a porous medium (such as a sediment underlying a contaminated site). This flow is described by Darcy's Law:

$$Q = KA\,(dh/dl)$$

where Q is the flow volumetric discharge, A is the cross-sectional area of the aquifer, dh/dl is the hydraulic gradient, and K is a constant related to the permeability of the sediment (usually termed the hydraulic conductivity). Perform a sensitivity analysis of the parameters identified in GEOL 101 which affect ground-water flow.

CHGN 124 - Discuss how contaminants occur in ground-water and how they behave based on a study of equilibrium chemistry, aqueous solution chemistry, acid-base reactions, and solubilities and complexation of metals.

LIHU 100 - Develop an understanding of the societal effects of living in an area of contaminated ground-water and the public's awareness about these impacts. Evaluate risk assessment and perception and NIMBY (not in my backyard) concepts and issues. Consider possible solutions to these dilemmas.

MEGN 111 - Study alternative methods for evaluating the economic costs associated with remediation of contaminated sites. For the site remediation plan being developed in EPIC 102, estimate the cleanup costs using two economic models (benefit/cost analysis and least cost analysis). Consider who will pay the costs of cleanup, who will benefit, and the political feasibility of cleanup.

Connections seminar - Reflect on student experiences in GEOL 101, EPIC 102, MAGN 132, CHGN 124, LIHU 100, and MEGN 111 by examining the kinds of constraints and considerations that govern how we choose to utilize the earth's renewable and non-renewable resources and the effects of utilization on the environment. Discuss the potential trade-offs required to balance quality of life and environmental quality and the implications of these trade-offs for the future. Compare and contrast past practices of resource consumption with future demands for conservation and sustainable engineering practices.

STATE OF COLORADO

DIVISION OF MINERALS AND GEOLOGY
Department of Natural Resources

1313 Sherman St., Room 215
Denver, Colorado 80203
Phone: (303) 866-3567
FAX: (303) 832-8106

DEPARTMENT OF NATURAL RESOURCES

Roy Romer
Governor

James S. Lochhead
Executive Director

Michael B. Long
Division Director

Mr. Sam Romberger
Department of Geology
Colorado School of Mines
Golden, CO 80401

RE: EPICS Program - Virginia Canyon

Dear Mr. Romberger:

As we have discussed over the phone, the Division of Minerals and Geology is interested in sponsoring an EPICS Project in the Clear Creek Watershed. Virginia Canyon is a major source of heavy metals pollution to Clear Creek. Unlike other sites, Virginia Canyon is primarily a heavy metals source during storm events. However, a significant amount of zinc has been documented by EPA to come from Virginia Canyon through groundwater flow.

The sources of the heavy metals are obvious to anyone who takes a drive up Virginia Canyon. Numerous mine waste rock pile litter the drainages and hillsides. The majority of these mines were gold producers in a sulfide ore body. The pyrite and calcopyrite in the low grade ore and country rock oxidizes to produce sulfuric acid which in turn liberates heavy metals. The heavy metals pollution can be reduced by removing or reducing contact with water. Those waste rock pile in the stream can be removed, capped with topsoil, and revegetated. Those on the hillside can be consolidated and revegetated, or in some cases, simple diversion ditches can be constructed.

The project I envision would be the first step in planning remediation of the heavy metal sources. This involves mapping of the waste rock piles and ranking the environmental hazard of each individual waste pile in Boomerang Gulch, a tributary to Virginia Canyon. The ranking should consider the following items:

1. Proximity to a water course,
2. Erosion by stream flow,
3. Erosion by storm events,
4. Erosion by run-on water (Hillside Areas),
5. Evidence of erosional deposition in a water course,
6. Size of the waste rock pile,
7. Visual evidence of toxicity (No vegetation on pile, denuded area below pile, etc.)

This project will require site visits. Much of the mapping can be done from aerial photographs, which I will provide. There is also a USGS Professional Paper on the mines of Virginia Canyon that would make a good base map. The majority of these waste rock piles are on private land. Viewing during site visits must be done from the public roads. Boomerang Gulch is bisected at three different locations by the roads in Virginia Canyon. Boomerang Gulch is loated in Section 26, T3S, R73W.

If I can provide further information, please do not hesitate to call me at 866-3567.

Sincerely,

Jim Herron
Environmental Specialist

STATE OF COLORADO

DIVISION OF MINERALS AND GEOLOGY
Department of Natural Resources

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Phone: (303) 866-3567
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DEPARTMENT OF NATURAL RESOURCES

Roy Romer
Governor

James S. Lochhead
Executive Director

Michael B. Long
Division Director

Mr. Edward G. Rapp
EPICS Program
Colorado School of Mines
Golden, CO 80401

RE: McClelland Tunnel

Dear Mr. Rapp:

Dennis Wright and I have discussed two potential sites near Central City for the EPICS program. This letter is written to formally request that the Anchor and Pozo tailings sites be included.

The Anchor Tailings are located in Section 13, Township 3S, Range 73W, in Willis Gulch, a tributary to Russell Gulch (See the attached map). The Pozo tailings are located wityhin the townsite of Nevadaville in Section 13, Township 3S, Range 73W (See the attached map). The water quality problems from this site are believed to come from two sources: 1) ersion of tailings into the stream by precipitation events; and 2) leaching of metals by snowmelt and rainfall, contributing to ground water contamination.

These sites are within the Clear Creek Superfund study area, so data on the similar problem is available. The final product of this effort should be project pre-proposals following the EPA guidelines for Demonstration (I & E) projects. A copy of the guidelines is enclosed. Variations of hydrologic controls should be considered, including: 1) Moving tailings to a suitable site; 2) Moving water away from the site; and 3) In-place treatment of the tailings.

If I can provide further information, please do not hesitate to call me at 866-3567.

Sincerely,

Jim Herron
Environmental Specialist

Part 1. Smog

Background Readings:

> *Chemistry*, R.Chang, McGraw-Hill, 5th edition, 1994, pages 550-1, 728-9.

> *Chemistry in Context*, Amer. Chem. Society, Wm. C. Brown Publishers, 1994, pages 13-20.

> *Environmental Chemistry*, N.Bunce, Wuerz Publishing, Ltd, 1991, pages 64-68.

Smog Assignments

(Each team will have two assignments to be reported on orally in class, Nov. 15)

1. Using calculations and words, explain why NO forms to a much larger extent in a hot engine than it does in the air around us. (See page 61 and problem 4, page 88 of Bunce. Also see pages 564-567,581-582,758-760 of Chang.)

2. Why are the hot engine amounts of NO "frozen"? How does a catalytic converter counteract this problem? (See pages 61, 62 and problem 5, page 88 of Bunce. Also see pages 516-522, 538-540, 546-551 of Chang.) See pg 532 $t_{1/2}$

3. What does Bunce mean by "the chemistry of photochemical smog is the same as that (in the natural troposphere)"? This quote is on page 64 of his book. What bearing this has that on the questions posed by SNC? (See pages 59-67 and page 70 of Bunce.)

4. Explain Figure 18.24 in Chang. Give an explanation of what causes each curve to go up and down and explain what bearing this has that on the questions posed by SNC. (See pages 728-9 in Chang and pages 59-67 of Bunce.)

5. Offer an explanation for how Figure 23 in SNC was calculated.

6. An often heard idea in environmental debates is "Even a few pollutant molecules being present is intolerable; we should have clean our environment to a zero concentration of pollutants". Argue for or against this idea, giving your reasoning. (See pages 564-567 of Chang and pages 20-23 of *Chemistry in Context*.

Smog Lecture

Will introduce and clarify the concepts of chemical equilibrium and kinetics. Will also cover main terminology in the background readings (radical, sink, etc.). Will lead a discussion of why EPA limits cannot be zero, e.g. why the idea of "even a few pollutant molecules being present is intolerable" is nonsense. Then setup the assignments showing their links to each other.

Background Readings:

> *Chemistry*, R.Chang, McGraw-Hill, 5th edition, 1994, pages 550-1, 728-9.
> *Environmental Chemistry*, N.Bunce, Wuerz Publishing, Ltd, 1991, pages 64-68.
> *Chemistry in Context*, American Chemical Society, Wm. C. Brown Publishers, 1994, pages 13-20.

Smog Assignments (Each team will have one assignment)

1 Using calculations and words, explain why NO forms to a much larger extent in a hot engine than it does in the air around us. (See problem 4, chapter 3 of Bunce and pages 564-567,581-582,758-760 of Chang.)
2 Why are the hot engine amounts of NO "frozen"? How does a catalytic converter counteract this problem? (See problem 5, chapter 3 of Bunce and pages 546-551 of Chang.)
3 What does Bunce mean by "the chemistry of photochemical smog is the same as that (in the natural troposphere)"? What bearing this has that on the questions posed by SNC? (See section 3.1 through 3.4 of Bunce.)
4 Explain Figure 18.24 in Chang. Give an explanation of what causes each curve to go up and down and explain what bearing this has that on the questions posed by SNC. (See section 3.1 through 3.4 of Bunce.)
5 Offer an explanation for how Figure 23 in SNC was calculated.

Greenhouse Lecture

Will explain how molecules like CO_2, H_2O and CH_4 absorb infrared radiation and convert it to heat. This will be related to their study of quantum levels and energy changes of electrons. Will also discuss the value of this as causing a temperate planet and how the popular press meaning of "greenhouse effect" fits in. Will separate the problem into its theoretical and actual arguments. Will also discuss the sources and sinks for CO_2 on our planet. Set-up the assignments: which are to evaluate the evidence for an actual effect being realized.

Background Readings:

> *Environmental Chemistry*, N.Bunce, Wuerz Publishing, Ltd, 1991, pages 13-22.
> *Chemistry in Context*, American Chemical Society, Wm. C. Brown Publishers, 1994, pages 61-85.

Greenhouse Assignments

Each team will have two scientific studies to work with in the Structured Contrversy mode. One will take a positive stance on the topic, the other will be doubtful.

Possitive:
1. "The Changing Climate", S.H. Schneider, *Scientific American*, Vol 261, pages 70-79, 1989.
2. "Web of Interactions Makes It Difficult To Untangle Global Warming Data" report in *Chemical and Engineering News*, April 27,1992, pages 7-18.

Doubt:
3. "Are Atmospheric Greenhouse Effects Apparent in the Climatic Record of the Contiguous United States?" K. Hanson, T.R. Karl, G.A. Maul, *Geophysics Research Letters*, Vol. 16, pages 49-52, 1989.
4. "Precise Monitoring of Global Temperature Trends from Satellites" R.W. Spencer, J.R. Christy, *Science*, Vol 251, pages 1558-1562, 1990.

Appendix B

Connections Seminar Syllabi

Connections Seminar Syllabus
Fall 1994

Introduction to *Connections*

Week 1: Introduction to ***Connections***, discussion of faculty and student expectations, description of the program, its goals and methods.

Readings:
Whitehead, "The Essence of a Liberal Education"
Einstein, "On Education"

Week 2: Introduction to critical thinking

Week 3: Classroom connections I (emphasis on math and physics)

Theme 1: Biography - Role Models

Noteworthy people from the humanities, social sciences, physical sciences, and engineering disciplines represented in the ***Connections*** program, some famous, some not.

Readings:
Physics: Feynman
Chemistry/Physics: M. Curie
Chemistry: Priestley
Humanities: M. Shelley
Social Science: Benedict
Mathematics: Kovalevskaya
Geology: Hutton
Engineering: Ammann
Economics: Keynes

Week 4: Introduction to biography

Week 5: Timeline and preparation of mini-plays

Week 6: Performance of mini-plays; scripts submitted

Week 7: Classroom connections II

Theme 2: Method in Physical Science, Social Science, Humanities, and Engineering

An introduction to the question of method in various disciplines through readings of representative works and an interdisciplinary project.

Readings:
Scientific method: excerpt from On Being a Scientist; excerpt from Kuhn, The Structure of Scientific Revolutions
Engineering method: excerpt from Koen, The Engineering Method
Social Science method: excerpt from Hoover, The Elements of Social Science Thinking; excerpt from Bagby, Introduction to Social Science
Humanities method: excerpts from Ciardi, How Does a Poem Mean?

Week 8: Introduction to primary questions of method

Week 9: Group work on method

Week 10: Oral and written reports on faculty interviews

Week 11: Introduction to project

Readings:
excerpts from Chang, Chemistry; excerpts from Bunce, Environmental Chemistry; excerpts from Chemistry in Context

Week 12: Oral presentations on group assignments; start structured controversy

Week 13: Finish structured controversy

Week 14: Oral reports from teams

Week 15: Individual written project reports due; celebration of end of semester

Grading

	% of grade
Biography assignment	20
Method assignment	20
Project assignment	20
Journal	20
Attendance/peer evaluation/ prof. evaluation/participation	20

Instructors

Barbara M. Olds
Stratton 109
273-3991/3990

Office hrs. by appt.
(call 273-3990)

Michael J. Pavelich
Coolbaugh 107
273-3612

Office hrs. TBA

Ronald L. Miller
Chauvenet 113
273-3592/3593

Office hrs. by appt.
(call 273-3593)

Connections Seminar Syllabus
Spring 1995

Week 1 -- **Welcome Back and Introduction to Spring Seminar**

In this seminar, we will set the scene for the "revolutions" theme and began laying the groundwork for work in the next two seminars.

Readings:
Lewis, Epilogue from The Discarded Image
Ferris, "The Sun Worshipers," in The Culture of Science

Weeks 2 and 3 -- **Seminars on Revolutions**

Each seminar group will study one of the revolutions shown below and report their findings to the entire class in week 4.

The Scientific Revolution (John Trefny)

Readings:
excerpts from "The Scientific Revolution and Enlightment," in Western Civilizations, 11th ed., vol.2
excerpts from Galileo, Newton, Bacon, Descartes

The Industrial Revolution (Barbara Bath)

Readings:
excerpts from Great Issues in Western Civilization, 3rd ed., vol. II
excerpts from The Industrial Revolution in Britian: Triumph or Disaster?,

The Darwinian Revolution (Sam Romberger)

Readings:
Mayr, "Darwin, Intellectual Revolutionary," in The Culture of Science
excerpts from Darwin, Origin of Species
excerpts from Kuhn, The Structure of Scientific Revolutions

Week 4 -- **Oral Presentations from Groups Studying Each Revolution**

Week 5 -- **The Next Revolution**

Each student selects a reading of his/her choice (subject to moderator approval) and uses it to speculate about the direction the "next revolution" may take. Each student will make a brief presentation on their spectulation and will also write a short paper describing their ideas in more detail.

Week 6 -- Introduction to the "Limits to Growth" Debate

The objective of this theme is to extend the "revolutions" discussion by exploring an issue which will influence all future revolutions -- the debate about potential limitations to economic growth. Briefly review readings and highlight each side's major arguments about the growth issue. Have student teams generate "growth" hypotheses that can be tested.

Reading:

excerpts from Scarcity and Abundance. A Debate on the Environment by Norman Myers and Julian Simon

Week 7 -- Work on "Limits to Growth" Hypotheses

Student teams meet with seminar moderators to report on their progress and discuss issues and problems (absence of data, analysis strategies, etc.). Based on this meeting, work continues or hypothesis is modified to allow students to make progress.

Week 8 -- Team Oral/Written Presentations of Hypothesis Testing

Grading

	% of Grade
Group "revolution" oral	25
Individual oral/paper on "next revolution"	25
Team oral/paper on "growth" hypothesis	25
Attendance/participation	25

Instructors

Barbara B. Bath
Stratton 207
273-3872

Samuel B. Romberger
Berthoud 411A
273-3828

John U. Trefny
Meyer 325A
273-3833

Connections Seminar Fall 1995
Seminar meets Tuesday from 2:30 to 3:30 in Coolbaugh Hall 131 (Breakout rooms Coolbaugh 210 and 212)

Faculty:

Dr. Barbara B. Bath, Mathematics & Computer Science, Stratton 207, x3872, bbath@bubble.mines.edu

Dr. Ronald L. Miller, EPICS, Chauvenet 113A, x3592, rlmiller@mines.edu

Dr. Barbara M. Olds, McBride Honors, Coolbaugh 331, x3991, bolds@mines.edu

Dr. Michael J. Pavelich, Chemistry, Coolbaugh 301A, x3612, mpavelic@mines.edu

Dr. Samuel B. Romberger, Geology, Berthoud 411A, x3828, sromberg@mines.edu

Dr. John U. Trefny, Physics, Meyer 325A, x3833, jtrefny@mines.edu

Dr. Michael Walls, Economics & Business, EH 313, x3492, mwalls@mines.edu

Texts:

Landis, Raymond B. *Studying Engineering: A Road Map to a Rewarding Career*. Burbank, CA: Discovery Press, 1995
Handouts
Journal

Schedule:

Week 1 Sunday, August 20	Initial meeting of *Connections* faculty and students at 2:30 Hand out books, journals; Break into mentor groups <u>Assignment</u>:: For seminar next time read Chapter 1 in Landis; write three key points or questions in journal and come to class prepared to discuss them
.Week 2 August 29	Icebreaker Discussion of Landis, Chapter 1 This week: first meeting between individual students & mentors <u>Assignment</u>: Read Landis, pp. 78-84 for next week.

Week 3 September 5	Discuss value of team approach, collaborative learning Assignment to study groups College Student Inventory Assignment:: Read Landis 71-78, 84-97
Week 4 September 12	Exam preparation #1: Chemistry and Economics
Week 5 September 19	Calculus connections Exams: Sept. 19: Economics Sept. 21: Chemistry
Week 6 September 26	Debrief first round of tests, do Academic Success Skills Survey in Landis Introduce Method Module In study groups brainstorm preliminary definitions of disciplines, methods Assignment:: each student in a study group chooses a biography to read for next week; come prepared to teach others in group. Biographies: Feynman, Keynes, Ammon, Kovalevsky Second conference with mentor this week. Exam: Sept. 26: Calculus
Week 7 October 3	Students teach each other about biographies, refine definitions of method Assign faculty interviews --two page write-up plus oral report due on Oct. 24 Brainstorm list of interview questions in study groups Assignment:: each student in a study group chooses one method discussion to read for next week; come prepared to teach others in group. Methods: scientific, engineering, social science, humanities
Week 8 October 10	Teach articles to each other Reach consensus on definitions of method in groups--full group discussion Develop questions for three-person panel next week Exam: Oct. 19: Chemistry
Week 9 October 17	Guest panel interviewed by students Assignment:: Interview write-ups and oral reports due next week

Week 10 October 24	Collect write-ups Oral reports Wrap-up discussion of method, interviews from previous week Meet with faculty mentor to plan preregistration for spring semester Exam: Oct. 24 (night): Economics
Week 11 October 31	Calculus Connections #2 Assignment:: Read Landis, Chapter 2 in preparation for Option Overviews. Exam: Oct. 31: Calculus
Week 12 November 7	No *Connections* seminar: Students do option overviews on Thursday Assignment:: Journal entry on option overviews.
Week 13 November 14	Time management, exam preparation for Chemistry Exam: Nov. 16: Chemistry
Week 14 November 21	Thanksgiving week
Week 15 November 28	Exam preparation for finals
Week 16 December 5	Celebration! Demonstrations of EPICS projects Box lunches compliments of CSM "Awards" ceremony

Connections Seminar
Spring 1996

Seminar meets alternate Tuesdays from 9:00 to 11:00 in Hill Hall 205

Faculty:

Dr. Barbara B. Bath: Mathematics and Computer Science; Stratton 207; x 3872; bbath@bubble.mines.edu

Dr. Ronald L. Miller, EPICS, Chauvenet 113A; x 3592; rlmiller@mines.edu

Dr. Barbara M. Olds; McBride Honors; Coolbaugh 331; x 3991; bolds@mines.edu

Dr. Michael J. Pavelich; Chemistry; Coolbaugh 304; x 3612; mpavelic@mines.edu

Dr. Samuel B. Romberger; Geology; Berthoud 411A; x 3828; sromberg@mines.edu

Dr. Franklin D. Schowengerdt; Physics; Meyer 334; x 2091; fschowen@mines.edu

Dr. Michael Walls, Economics and Business; EH 313; x 3492; mwalls@mines.edu

Texts:

Landis, Raymond B. *Studying Engineering: A Road Map to a Rewarding Career.* Burbank, CA: Discovery Press, 1995.
Handouts
Journal

Tentative Schedule:

Week 1: Debrief fall semester, prepare for spring, meet with mentors (Olds, Miller)
January 9

Week 2: Math/ Physics connections (Bath, Schowengerdt, Pavelich)
January 23

Physics exam Jan. 23
Chemistry exam Jan. 25
Math exam Feb. 1

Week 3: Exam preparation (Miller, Romberger, Walls)
February 6

Geology exam Feb. 8

Week 4: Math/ Physics connections (Bath, Schowengerdt)
February 20 Introduction to Revolutions Module; selection of teams; distribution of readings (Olds, Romberger, Bath, Pavelich)

Physics exam Feb. 20
Chemistry exam Feb. 22

Week 5: Teams work on Revolutions Module (see separate handout)
March 5

Scientific--Pavelich
Industrial--Olds
Darwinian--Romberger
Information--Bath

This is the major assignment for the spring semester, an opportunity to learn about some of the major revolutions that have affected modern life and to speculate about future revolutions. In teams you will focus on one of the major revolutions--scientific, industrial, Darwinian, information--and report back to the entire group.

Geology exam Mar. 21

Week 6: Teams continue work on Revolutions Module
March 26

Math exam Mar. 26
Physics exam Mar. 28

Week 7: Presentations from teams on Revolutions Modules
April 2

Chemistry exam Apr. 4

Week 8: The "next revolution" and finals preparation (Miller, Walls)
April 16

Math exam Apr. 18

Week 9: Celebration (Olds, all)

Weekly meeting of the Connections faculty group will be on Fridays at 2:00 in the EPICS conference room.

Appendix C

Perception Questionnaire and Student Responses

Colorado School of Mines

Perception and Attitudes Questionnaire #1

We are interested in your response to the following statements using the scale defined below:

|----------------|----------------|----------------|----------------|

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

Remember, there are no "right" or "wrong" answers in a questionnaire like this one; just give us your honest thoughts.

_____ 1. If I work on a team with others who have different skills and knowledge than I do, we will generally arrive at a better solution to most problems than a team composed of members with the same skills and knowledge.

_____ 2. Engineers and scientists need not be well-versed in fields such as humanities [e.g. literature, philosophy, history] or social sciences [e.g. anthropology, economics, political science] to be successful professionals.

_____ 3. Engineering, physical sciences, social sciences, and the humanities all have different but valid methods for generating knowledge and solving problems.

_____ 4. Engineers and scientists are only responsible for correct technical solutions to problems. Others are responsible for any non-technical (environmental, political, economic, cultural, ethical, etc.) ramifications of the technical solution.

_____ 5. To truly understand my chosen discipline of study, I must understand the historical and cultural contexts in which the discipline has evolved.

_____ 6. Studying about famous humanists, social scientists, engineers, and physical scientists will help me understand the subject matter of their disciplines.

_____ 7. Understanding some of the great accomplishments by engineers, physical sciences, social sciences, and humanists is an important aspect of my education, my profession, and my life.

_____ 8. I feel good about my educational experiences and about my decision to attend CSM.

_____ 9. I can see that my freshman year introductory courses are an important part of my CSM education.

10. Each of the following subject areas is <u>important</u> and <u>relevant</u> to my CSM education:

_____ humanities _____ social sciences _____ science _____ engineering

Colorado School of Mines

Perception and Attitudes Questionnaire #2

We are interested in your response to the following statements using the scale defined below:

|-----------------|----------------|----------------|-----------------|

1	2	3	4	5
strongly disagree	disagree	neutral	agree	strongly agree

Remember, there are no "right" or "wrong" answers in a questionnaire like this one; just give us your honest thoughts.

_____ 1. If I work on a team with others who have different skills and knowledge than I do, we will generally arrive at a better solution to most problems than a team composed of members with the same skills and knowledge.

_____ 2. Engineers and scientists need not be well-versed in fields such as humanities [e.g. literature, philosophy, history] or social sciences [e.g. anthropology, economics, political science] to be successful professionals.

_____ 3. Engineering, physical sciences, social sciences, and the humanities all have different but valid methods for generating knowledge and solving problems.

_____ 4. Engineers and scientists are only responsible for correct technical solutions to problems. Others are responsible for any non-technical (environmental, political, economic, cultural, ethical, etc.) ramifications of the technical solution.

_____ 5. To truly understand my chosen discipline of study, I must understand the historical and cultural contexts in which the discipline has evolved.

_____ 6. Studying about famous humanists, social scientists, engineers, and physical scientists will help me understand the subject matter of their disciplines.

_____ 7. Understanding some of the great accomplishments by engineers, physical sciences, social sciences, and humanists is an important aspect of my education, my profession, and my life.

_____ 8. I feel good about my educational experiences and about my decision to attend CSM.

_____ 9. I can see that my freshman year introductory courses are an important part of my CSM education.

10. Each of the following subject areas is <u>important</u> and <u>relevant</u> to my CSM education:

_____ humanities   _____ social sciences   _____ science   _____ engineering

Table C-1
Comparision of Perception and Attitude Questionnaire Responses
Between *Connections* Students and Their Non-*Connections* Peers

Question		*Connections* Students (1994-95 pilot group)		*Connections* Students (1995-96 pilot group)		Non-*Connections* Students (1994-95 freshman class)	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
1:	Strongly disagree	2.0	0.0	0.0	0.0	2.1	2.4
	Disagree	0.0	2.5	2.9	0.0	0.0	2.4
	Neutral	14.3	7.5	8.8	3.3	6.3	14.3
	Agree	63.3	65.0	61.8	60.0	58.3	54.7
	Strongly agree	20.4	25.0	26.5	36.7	33.3	26.2
2:	Strongly disagree	34.7	17.5	32.4	40.0	18.8	35.7
	Disagree	42.9	60.0	55.9	50.0	50.0	40.5
	Neutral	12.2	12.5	8.8	3.3	20.8	7.1
	Agree	6.1	10.0	2.9	6.7	6.2	11.9
	Strongly agree	4.1	0.0	0.0	0.0	4.2	4.8
3:	Strongly disagree	2.0	0.0	0.0	0.0	0.0	0.0
	Disagree	2.0	2.5	5.9	10.0	0.0	9.5
	Neutral	18.4	10.0	11.8	6.7	12.5	16.7
	Agree	65.3	60.0	64.7	50.0	58.3	38.1
	Strongly agree	12.3	27.5	17.6	33.3	29.2	35.7

Table C-1 (cont.)
Comparision of Perception and Attitude Questionnaire Responses
Between *Connections* Students and Their Non-*Connections* Peers

Question		*Connections* Students (1994-95 pilot group)		*Connections* Students (1995-96 pilot group)		Non-*Connections* Students (1994-95 freshman class)	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
4:	Strongly disagree	38.8	50.0	35.3	50.0	36.2	33.3
	Disagree	46.9	42.5	55.9	50.0	36.2	47.6
	Neutral	8.2	2.5	5.9	0.0	14.9	14.3
	Agree	4.1	5.0	0.0	0.0	8.5	2.4
	Strongly agree	2.0	0.0	2.9	0.0	4.2	2.4
5:	Strongly disagree	2.0	2.5	0.0	0.0	2.1	2.4
	Disagree	8.2	15.0	11.8	6.7	12.5	11.9
	Neutral	18.4	32.5	41.2	33.3	35.4	42.9
	Agree	55.1	37.5	38.2	56.7	41.7	30.9
	Strongly agree	16.3	12.5	8.8	3.3	8.3	11.9
6:	Strongly disagree	2.0	7.5	0.0	0.0	0.0	2.4
	Disagree	2.0	12.5	14.7	13.3	27.1	30.9
	Neutral	22.5	32.5	52.9	46.7	18.7	35.7
	Agree	57.2	40.0	26.5	36.7	52.1	28.6
	Strongly agree	16.3	7.5	5.9	3.3	2.1	2.4

Table C-1 (cont.)
Comparision of Perception and Attitude Questionnaire Responses
Between *Connections* Students and Their Non-*Connections* Peers

Question		*Connections* Students (1994-95 pilot group)		*Connections* Students (1995-96 pilot group)		Non-*Connections* Students (1994-95 freshman class)	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
7:	Strongly disagree	2.0	0.0	0.0	0.0	0.0	0.0
	Disagree	4.1	12.5	2.9	0.0	10.4	7.2
	Neutral	8.2	32.5	35.3	26.7	31.2	30.9
	Agree	73.5	52.5	50.0	63.3	52.1	52.4
	Strongly agree	12.2	2.5	11.8	10.0	6.3	9.5
8:	Strongly disagree	0.0	5.0	0.0	0.0	2.1	0.0
	Disagree	2.0	7.5	2.9	3.3	0.0	4.8
	Neutral	10.2	15.0	8.8	10.0	10.4	16.7
	Agree	49.0	52.5	26.5	36.7	58.3	45.2
	Strongly agree	38.8	20.0	61.8	50.0	29.2	33.3
9:	Strongly disagree	0.0	5.0	0.0	6.7	2.1	2.4
	Disagree	2.0	10.0	5.9	3.3	2.1	11.9
	Neutral	14.3	27.5	8.8	6.7	18.7	26.2
	Agree	57.2	47.5	50.0	53.3	47.9	45.2
	Strongly agree	26.5	10.0	35.3	30.0	29.2	14.3

Appendix D

Reports from External Evaluator

Connections

Colorado School of Mines

A Formative, Qualitative Assessment
May 17, 1996

Gloria Rogers, Ph.D.
Dean for Academic Services and Assessment
Rose-Hulman Institute of Technology

Objectives:

The purpose of this evaluation of the FIPSE-funded *Connections* project at the Colorado School of Mines (CSM) was to provide feedback to the Principle Investigators (PI) on the second year of the project. CSM is currently conducting a curriculum review focussed on the first two years experience. As this is the last year of external funding for the *Connections* project, this evaluation was designed to look specifically at the following:

- what has been accomplished to date
- what are the most significant changes
- what aspects of the revised second year were important to try to retain during the curriculum revision process
- what have been the lessons learned from this project

Evaluation Process:

Materials from the first year were sent in advance of the visit. This included results of student written evaluations, faculty summer workshop materials, and course materials. The site visit took place on April 4-5, 1996. Based on materials received and direction of the PI's, interview and focus group questions were developed. During the two-day visit, meetings were held with faculty teaching in *Connections*, principle investigator and a senior administrator, one group of students from the first year *Connections* class and two groups of students from the current *Connections* class.

Findings

Connections Faculty:

Changes from first year:

Students - Faculty who taught in *Connections* last year commented about the difference in the students' attitudes this year. Although there were fewer students in the second year (from 49 in the first year to 35) they seemed to be more social and have a closer relationship with faculty. The 35 students were assigned mentors from the 6 *Connections* faculty with the expectation that they would meet on a regular basis. The faculty also expressed the belief that, generally speaking, students who volunteered to be in *Connections* were more insecure and looking for a "safe environment." (This observation was validated by some of the *Connection* students' comments.) All faculty reported enjoying the close relationship with students. One faculty member commented that bonds were established with the students early on and that made the process of teaching easy. It was said, "No matter how well structured, if you don't make that bond with students, it doesn't work." The mentoring role of the faculty member was seen as the key element of the second year program.

Curriculum - Compared to the first year, the emphasis in the curriculum had shifted from trying to "force" students to make the connections among the disciplines to making connections between faculty and students. Students were described by faculty as being pragmatic and not particularly interested in the "big picture" and, based on the previous year's evaluations, the expectations for the students were reduced, the seminar was changed, and schedules were coordinated to accommodate testing. It should be noted that when compared with comments from the first year, faculty were much more comfortable with the changed format and student outcomes.

Goals - When asked if they thought the goals of the program had changed, faculty generally responded that they had not. As one respondent said, "The fundamental goals are the same, but a little less lofty." However, they agreed that the emphasis placed on connections among disciplines was reduced but the desired outcomes were the same. They felt that the effect of the program on the students could probably not be adequately measured until they were juniors or seniors.

Campus Impact - Faculty were asked if they thought *Connections* was having an impact on the campus, they generally responded positively. In the campus-wide curriculum reform, there are three new courses being created called "Systems." It is felt that some of the things that have been done in *Connections* will find their way into these courses--both content and process. Some pointed out that just having six faculty members "out there" talking about the experience has had an effect on the campus. Several of the faculty involved in *Connections* have been actively involved on the campus curriculum reform committee.

Faculty Interactions - Faculty were asked to compare faculty interactions of the first year to the current year. Generally, they found this year's experience to be more satisfying. One faculty member commented that the faculty interaction may be the most enduring piece of the program. Working on this program with faculty from other disciplines was seen as a very rewarding and energizing experience. Another conjectured that there was more trust in the second year. There was more happening at the social level and, through conversations, they began to see that there were common concerns. More was being shared about the classes as well as what was going on in their departments.

Future of *Connections* - When asked about the future of *Connections* after the external funding was over, faculty were hopeful and confident parts of it would survive in the new campus-wide curriculum but unsure of how it would play out. (Three of the seven faculty involved in *Connections* are on the campus curriculum revision committee.) They were in agreement that it would not survive at it is currently structured. Currently, the program was seen as too faculty intensive, however, it has shown that there is value in student contact with the professor. There was concern about the growing size of classes with many classes moving to sections of 100-150 students. This issue is still not resolved in the campus curriculum planning but *Connections* faculty feel that students should have at least one small class each semester in their freshman and sophomore years where faculty can get to know and mentor students on a personal basis. The other critical piece which faculty mentioned as needing to be preserved was the interaction among the faculty from different disciplines in curriculum delivery.

Administration:

The focus of the interviews with those in administration was to determine the effect of the program and plans for institutionalization. It was generally agreed by those interviewed that the program, in its current state, would not survive. However, there was optimism that the interdisciplinary nature of the program would be carried over through the proposed "Systems" courses in the proposed campus-wide curriculum. There is great concern on the part of the *Connections* administrators that the mentoring piece will be lost because of the large classes that are being proposed.

It was expressed that the greatest impact of the project has been on faculty. The interaction of faculty from different disciplines has been a positive outcome of this program. It has positively influenced the curriculum reform efforts currently taking place on the campus. Departments are beginning to discuss ways which they can work together in the proposed curriculum efforts.

After two years of the program, the program administrators report having learned the following:

- It is difficult to make curriculum changes
- It is difficult for faculty to make "integration" happen
- It is easier to make changes in courses which are not "content" specific than those which are (*e.g.* faculty in sciences tend to think that they have to cover "x" amount of material)

<u>Students:</u>

Connections students from current year:

The questions for these groups of students were designed to explore their understanding of the goals of *Connections,* the quality of their experience, what features of *Connections* they would like to see incorporated into new curriculum revisions being considered for first year students, and their general experiences at CSM..

Understanding of Connections: They generally described *Connections* in terms of their relationship with each other and faculty--classes with same students, close relationship with faculty, more feedback and interaction. They also saw their classes as being "special" and remarked that they made better grades than other freshman. They emphasized that faculty were trying to make connections between different subjects. Students reported that they had learned a lot in their seminars. The fact that they had an opportunity to express how they felt in their seminars was important to them--especially when faculty responded positively to their suggestions. They felt that faculty listened to them.

Students generally felt that *Connections* helped them with the transition from high school. They particularly liked having the same professor for lecture and recitation. This encouraged them to go talk to the faculty because they felt they knew them better.

Workload: They felt the workload in *Connections* was more than other classes but generally thought it was worthwhile. There were extra projects. However, they liked the "Revolutions" project. One student commented, "Yes, (*Connections*) is more work, but you can't get something for nothing."

Liked most:

Students reported that they liked the small classes and having "the best teachers." Generally, they felt they benefitted from having the same students in their classes indicating that their group work went better because they felt more comfortable sharing ideas. They reported liking the session on Revolutions--this was mentioned by both groups more than once. Not having to go through registration for classes like the rest students was reported by some students as a plus. Several students commented on the benefits of their calculus class. One stated, "I used to hate calculus; now I love it!"

First semester there was an extra help session before the tests and that was seen as helpful. The interviews with faculty were well-liked. They also liked having their mentor as one of their professors. It was unanimous that the small Crossroads classes were a real plus. "We got to discuss. . . . You can think your own ideas and think things through. The small discussions keeps you more focussed compared to other classes where no one pays attention and some even sleep." One student commented that, even though he rarely said anything in Crossroads, but he felt it was interesting and thought provoking. Group work was seen by students as being very helpful (even in large lectures where they did work in pairs).

Things that could be improved: Too much extra work compared to other freshmen. Students had varying opinions as to just how much extra work there was but they agreed that they were required to do more. However, as stated earlier, that was not always seen as negative. They thought some of the extra work was, "cool." Some students reported that having the same people in classes was good, but it would have been nice to see some new faces at times. They had to find other ways to get to know different students. The students indicated that they did not like the section on " Methods" and said it was a lot of work and they didn't think they benefitted from it. One student reported, " Methods was horrible. . . . It was tedious, but I could see the reason behind it." Others described it as too much theory with no examples. Some said that they thought the underlying idea was good, but it was not executed very well.

They also reported that first semester tests and major assignments were spread out, but this semester it didn't happen that way and it was more stressful.

Most beneficial academically: Again, they mentioned that they benefitted most by having the best faculty and the special attention of small classes. They said the *Connections* faculty were "cool" and they really want to know what students think. They also felt they benefitted from the smaller classes in Calculus. Having Dr. Pavelich for both lecture and recitation in Chemistry was also positive. "He knew what was important for us to know."

Relationship with faculty - Generally, students appreciated getting to know faculty and meeting with the professors in the Tuesday meeting. The said it was "kind of cool" to be in a lecture with 200 other kids and have the professor call you out by name. (One student commented that it certainly was better than being known as "You, in the yellow shirt!") Faculty were seen as caring about what's going on with students. "They really care."

What part(s) of *Connections* should be kept in the new curriculum: Students felt that, if possible, working with the same group of students and same teachers. They felt that consistency really helped them make the transition to CSM. " If you needed help you knew who was in your class. I know that when you are in college you are suppose to be on your own and self-sufficient but it still helps to have people you know that can help you." The small Crossroads classes that allow for small group discussion was also seen as important. Students were very sensitive to the fact that large lecture classes are just a fact of life and did not seem to think it was realistic that all of their classes be small.

Is Connections for everyone? Generally, students did not think *Connections* was for everyone. They saw themselves as volunteers. It was their feeling that some people would have been really mad about being forced to be in it. Students who were seen as more independent might not want to be in this program--too much like high school. They reported that other students accused them of being favorites. "No more different tests! It is really bad for student relations. We were given a different Calculus test and other students criticized us."

It was felt that some students would be bored in this program. Some students were seen to be at different levels and *Connections* would just hold them up. Some students don't want to be singled out and you can't "hide out" in Connections.

Why did they sign up for Connections? Students gave a number of reasons for signing up for *Connections*. The recurring theme was small classes and getting to know professors. They also reported: sounded similar to a high school course that they like, a new opportunity, and easier to get to know other students.

Did they think that being in *Connections* would be an advantage or disadvantage in their Sophomore year: Generally student felt that they had a good base this year and saw a smooth transition into the sophomore year. They felt that it was an advantage to get to know a lot more people well. They even reported that they had begun to talk about all registering for the same calculus class so they could be together. The only disadvantage they reported was that now they knew their faculty well and it will be harder to get to know their professors..

Recommend *Connections* to someone else? There was no hesitation in students response that they would recommend *Connections* to another incoming student. "Yes, very definitely!" "Yes, absolutely!"

Do it again? Again, students were very enthusiastic in their responses. "Yes, definitely!"

Suggestions: When asked for suggestions to improve *Connections,* they suggested eliminating Methods and limiting the writing assignments. They were pleased that the journals were dropped after the first semester. The idea of journals was okay, but it just wasn't worth it.

EPICS: For the work they had to do for the amount of credit, students didn't think it was worth it! " If you are going to do all that work you should get more credit." They also felt that if they got more credit, people would treat EPICS with more respect. However, the solar project in EPICS was fun. Some students felt it was not relevant to their options. They prefer the *Connections* Crossroads class to EPICS. Some were concerned that they couldn't transfer EPICS to another campus. Others reported that the projects part was "a waste of time." It was felt that it needed to be better organized and some faculty don't seem to know what is going on. "We've been wasting so much time. It doesn't seem like we do anything. We just sit there talking while they're trying to figure out what we're suppose to do. Most times they just give us time to meet with our groups." However, when asked, they report that the projects, for the most part, are okay.

General CSM experience: When asked about general impressions of their CSM experience students had several observations. Again, their relationship with faculty was reported to be the most significant positive effect on their self-confidence. They also felt that working with their peers in study groups had been very helpful. All students reported being involved in extra-curricular activities and/or work outside of class. They all valued their involvement in extra-curricular activities.

Students expressed concern about Physics. They felt they needed a recitation section. "Even with TA'S" it would be better and give them an opportunity to ask questions. Lots of people have dropped Physics and a lot of Connections kids have dropped it.

Sophomore Students (First Year Connection Students)

There were five former *Connections* students interviewed (all Chemical Engineering students)--three of the students participated in the focus groups that were conducted by the evaluator in the first year of the project. After two years of study, they all expressed satisfaction with their decision to attend CSM. In review, when interviewed last year, the cohorts from this group of *Connection* students were fairly negative about their experience in *Connections* and had a lot to say about what could be done for improvement.

Reflection on their experience in *Connections:* When asked to reflect on their experience last year in *Connections,* these students had a different viewpoint than expressed a year ago. One student commented, " I was negative at the end of the year (last year), but now I realize what I got out of it." This statement was the general sentiment of the group. They commented on the fact that they felt that they could still go and talk to the faculty they had in *Connections* if they had any problems and they were impressed with the fact that the faculty still talked with them informally.

How did *Connections* help in Sophomore year? Students reported that they thought *Connections* had provided a better background for the Sophomore year than their peers had. One student said, "Now I think more about different points of a problem." Another reported, "At the time I did not appreciate it (*Connections)*. Now I do." Students also felt that they knew more about people who were important to science and they saw that as a plus. Overall, students were unanimous in their opinion that they were not hindered as Sophomores by their participation in *Connections.*

What would they have done differently over last two years? The students interviewed all indicated that they would have studied more and tried harder. Most of them considered themselves to be good students in high school and now realize that they could not apply the same study habits that they did then. . .it's much harder and the competition is much greater. One student reported, "I would have tried to find out more about engineering." This student is not confident that this is the appropriate career path but feels it is too late to change because of the time and money invested.

What would they recommend be kept in the revised curriculum: The following comments reflect the general attitude of the students on what characteristics of *Connections* they would like to see in a new curriculum:

"Whole concept of trying to integrate our classes. It's really cool to see how what you are doing fits in with other things you are doing."

"You'll be in class and all of a sudden it will snap and you see how it fits in with other things. Even now I'll be sitting in Chemistry and they'll use an equation in another class and I'll think, 'Wow, they could use the other equation.'"

"I thought it was neat to learn about important people in science that we wouldn't have found out about otherwise."

"I liked having all those advisors. All eight of the profs were your advisors--even though we were assigned one, they would all help you equally."

They also had several comments regarding the advising system. They generally felt that advisors needed to focus more on students. "They shouldn't expect students to make the first step because (the students) are nervous and afraid to approach the advisor." It was reported that some students don't even know who their advisors are. They thought it was important that there was at least one faculty member students feel close to--especially in their major department. They were not positive about the Freshman Success Seminar and expressed that students did not feel it was achieving its goals.

Again, these students recognized the value of the close relationship with the faculty and other students and somehow felt that should be preserved in the new curriculum. However, they also recognized the difficulty in having the close student/faculty relationship that was offered in *Connections* on a large scale basis.

Suggestions about other areas of their experience at CSM: In asking this question, two topics generally come up with students: EPICS and Crossroads.

EPICS: The Sophomore students had the benefit of two years experience in EPICS and were not as critical as the first year students. As one student put it, "EPICS is a pain, but it is good because we do learn. I have learned about what we will face when we get out of here." Another student reported the value of experience gained in public speaking. "There's a lot of criticism but I think it is really awesome! We did a thing on waste-water treatment and when I had an interview for a summer job the interviewer was really impressed with what we had done--it really helped me out."

There was some feeling that by the time they had the class for the fourth time it was redundant. "We're doing the same writing assignments every time." Another student responded, "Yes, but I think it brings it all together." Students felt that their next chance for an experience like EPICS will not come until their senior year in their senior design class. They were unaware of the opportunity to participate in multi-disciplinary teams in senior design.

Crossroads: Generally, they liked the literature part. Although they claimed to have forgotten most of what they had learned in the class, they saw the importance of a course like Crossroads in order to be well-rounded. Some reported that their high school courses in literature and writing were more difficult than Crossroads.

Other: Very positive about helpfulness of professors. They didn't seem to mind the large sections in their core classes and felt that they could go and get help if they needed it. They were generally satisfied with their out-of-the-classroom experiences and had no suggestions about improvements.

Summary:

The modifications made in the curriculum had a very positive effect on the student attitudes as expressed in the focus groups. Compared to the first year's visit, the evaluator noted many positive changes in outcomes. However, it is important to note that the students from the first year's program also report more positive attitudes and perceptions of the program in retrospect.

Their comments should not be undervalued. Faculty had commented that *Connections* might not be effectively evaluated until students were in their third or fourth year at CSM. I would encourage the PI's to track these students into upper level courses. I would anticipate that their retention rates at CSM would be higher than a matched comparison group of students.

Both students and faculty viewed the close relationship between faculty and students as being one of the most positive aspects of the program. Each group wanted to see the new curriculum provide at least one small class where students could get to know each other and the faculty well but also for the class to have substance. Students are very intolerant of classes where they feel their time is being wasted. They also valued the coordination of work among the faculty.

The faculty were also more postive about their work with other faculty. The informal structure of the program has allowed them to make "connections" with each other on a personal as well as professional basis. This has created more trust and support among them. Opportunities for this to happen should also be fostered in the new curriculum.

The *Connections* faculty were very responsive to the recommendations made by students and others in the first year evaluation. The project has reflected growth and improvement is a short period of time. This reflects a commitment to student success and academic innovation. Although the program will not continue to exist in it's present form, the evaluator is confident that these efforts and "lessons learned" will provide significant resources for the development of the new first year curriculum.

Connections
Colorado School of Mines
A Formative Assessment
April 22, 1995

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Objective:

The purpose of this evaluation of the FIPSE-funded *Connections* project at the Colorado School of Mines (CSM) is to provide formative feedback about the project and to give an outsider's perspective on the project.

Evaluation Process:

Materials describing the *Connections* project were sent in advance of the site visit which took place on April 6-7, 1995. Based on the goals of the project and direction of the principal investigators, interview and focus group questions were developed to probe the experiences of the identified campus stakeholders in the project: Connections participants and CSM students, faculty, and administrators. During the visit to CSM, I interviewed the principal investigators, two faculty teaching in the *Connections* project, three non-*Connections* faculty, and three CSM academic administrators. I also conducted focus groups with two groups of students in the *Connections* project (total of eighteen), one group of non-*Connections* students (three), and the *Connections* faculty.

Findings:

Non-Connections Faculty:

For non-*Connections* faculty, the focus of the interview questions was to get a sense of what they perceived to be the goals of *Connections* and the extent to which they felt it was achieving those goals. They were also asked questions related to their attitude towards the project, their perceptions of CSM students, and what questions they thought the assessment of *Connections* should address.

The faculty were very positive about their experience at CSM as faculty members. Students were described as very bright and highly motivated. When asked about *Connections*, all of the faculty interviewed responded that they did not know very much about the project. However, two of them felt that they knew enough to indicate that they believed the philosophy behind the project was sound and they were complimentary about the faculty involved in the project. There was concern expressed on the part of one faculty member that the students finishing *Connections* might have some "holes" in their academic preparation which would put them behind in subsequent classes. This faculty member is hesitant to recommend students participate in the project until the assessment of the first year experience is complete.

Connections Faculty:

In both the interviews and focus group with the *Connections* faculty the responses to the program were mixed. They all agreed that working with other faculty was a very positive experience. They generally liked the teamwork approach to the curriculum. The year spent developing the curriculum was seen as very productive; however, the first year of implementation did not meet the faculty expectations. Some of this was credited to lack of clarity of goals and follow-through and some to lack of time on the part of faculty during the implementation year. It was reported that the faculty met regularly during the planning year--both in meetings and taking each other's classes. During the implementation year they did not meet as a group as regularly and even less as the year progressed. They agreed that the faculty had learned a lot and that expectations during the planning year far exceeded the implementation stage.

The faculty members perceived that faculty and student expectations of *Connections* were different. They felt that students were more interested in the "socio-emotional" benefits that a program like *Connections* would bring them than they were in the broader issues of the project. A majority of the faculty described the students in *Connections* as being "complainers". One faculty described the students as not interested in the "big picture" but wanting a "quick fix.". In some cases faculty described the students in the traditional first year courses as being more enthusiastic about the subject matter than the Connections students. Regardless of the source of the incongruity of expectations, it was agreed that the project goals should be more clearly articulated for students and that faculty needed to make changes which would provide a more consistent delivery of the stated goals. There was an expression by one faculty member that what *Connections* was trying to do was already being done through the Crossroads class and that the real value of the project for the students was the small seminars.

Administrators:

Three administrators were interviewed to get their perspective on the Connections curriculum. They were enthusiastic about what they perceived to be the goals of the program and were supportive of the faculty involved. There was general agreement that the direction of the CSM curriculum is toward a broader core with more connections and less specialization in specific areas. The issue of the demand for both depth and breadth requires greater efficiency which could be met in ways such as Connections. All the administrators interviewed were extremely complimentary of both the faculty involved and the established goals of the project. Although they did not claim an in-depth knowledge of the implementation of the project, their was optimism about the long-term prospect of institutionalization.

Students:

Non-Connections students: The focus group for the non-Connections students was designed to explore their attitudes about CSM and their academic experience. They were asked their perceptions of the Connections project.

The CSM Experience: These students were very positive about their decision to attend CSM. After a discussion of what it was like to be a student at CSM one student commented, "I didn't realize how much I liked it here." They particularly mentioned the small class size, getting to know professors, and having good professors. They commented that the course work was rigorous and demanding and that they felt there were too many hours required for graduation.

Perception of Connections: When asked about the Connections program, they had a reasonable concept of what it was about. Things they mentioned included: 1) they are with the same people all day, 2) "they (the faculty) try to get everything so you can understand how they are related." When asked why they thought students would volunteer for the program, they first identified the socio-emotional reasons. They responded that for some students it was a sense of security. They thought that being in Connections, these students wouldn't have to worry about going out and meeting new people.

The Connections Difference: These students viewed the workload as about the same as in the traditional curriculum except that Connections students had a different project in EPICS. Academically, they did not see any real difference between Connections and the traditional curriculum. When asked if they thought the students in Connections would have an advantage in upper level courses, they generally agreed that it would only be an advantage to Connections students over the non-Connections students who didn't already see the relationships among the classes. One student commented, "Maybe if you don't see it already then maybe you need to be taught it, but...I think most people can relate...because everything corresponds." When asked, they thought the course could be beneficial for everybody even though they might not need it.

Connections Students:

The questions for the Connections students centered on exploration of their expectations of the Connections program, whether or not their expectations were met, and what suggestions they might have in improving the program for the following year. Questions were also asked about how they think their experience differed from other students not in Connections and their general attitude towards CSM.

The CSM Experience: In general, the students were positive about CSM and their decision to attend. With the exception of a couple of students who seemed to be negative about all aspects of their experience, both groups of Connections students interviewed were generally enthusiastic about CSM. Like the non-Connections students, they felt that students coming to CSM needed to be willing to work hard and be self-disciplined.

What is Connections? When asked the question, "If I were new to campus and I asked you what Connections was, what would you tell me?" the responses were attitudinal rather than substantive. For example, they began to talk about the classes and what they liked and didn't like, not what the program was trying to accomplish. Later in the interview I asked them what made Connections different from the other classes, and they began to describe the program with more detail. Generally, they perceived the program as providing a sense of community where all the students in their classes were the same and they had the best professors on campus. They also recognized that the goal of the program was to help them to see how all of their classes related to each other. They identified other differences as having extra papers to do, a different EPICS project, and not having to take PA and 101.

Student Expectations: As a follow-up to the previous question students were asked if they thought the program was achieving its goals. Generally, they thought it was to a limited extent. Again, the question set into motion a discussion of how it did not meet their expectations. One student expressed the general attitude of the group in this way:

> "That's one thing, when we signed up I thought we would go into connections more. I thought we would go to our Connections class and talk about how things fit together and they would help us with our problems but we never did anything like that. We do something different....you could see the connections, and they would show them, and we would do reports....I thought it would be a time when the counselors would help us if we had problems in Calculus or whatever, but they never really said that or asked us if we had any questions or problems.

Other students responded with similar comments indicating that they thought they would get more tutoring and extra help to make the transition from high school to college easier. Some also indicated that they thought they would have all small classes and were disappointed to be in large lecture sections while other students saw the large lecture sections as being an opportunity to meet other students. The general impression was that they thought the "mentors" would take a personal interest in the students and provide them individual help when they needed it. This was highlighted when one student commented that s/he was failing in one of the courses and s/he was disappointed that not one of the "mentors" asked if s/he needed help or approached her/him about it.

Preparation for Upper-Level Courses: When asked about whether or not they thought they would be better prepared for their upper-level courses than non-Connections students they thought they had gained confidence in relating to faculty. They thought they would be able to ask others for help--both faculty and students--if they needed it.

Positives and Negatives of the Curriculum: When asked what they liked best about the curriculum, they were almost unanimous in their responses; they got to know several professors very well, they knew their mentors better than other students, they had the best professors, they got to know other students well. They also commented that during the second semester there seemed to be more discussion in their seminar classes. They all liked the class discussions. When asked what they liked least about the curriculum they agreed that they did not like the journals first semester. They indicated that they had not taken the assignment seriously and most students admitted to putting off writing until the last minute and backdating entries. They also did not like the extra paper assignments that other students did not have. They were divided as to which projects they liked and didn't like, however, most seemed to like the solar collector project, the session on revolutions, and the interview assignment. The global warming assignment was generally seen as irrelevant.

Suggestions for improvement: The following represents the suggestions Connections students had for improving the curriculum:

A. Faculty need to provide more individual help to students
B. No homework for the Connections seminar--101 has no homework and that is what it replaces
C. No journals
D. Two hour meetings are better than three--three is too long (they liked the second semester format better).
E. Give credit for each semester at the end of the semester instead of waiting until the end of the year.
F. Be more realistic in the material sent out before the year. "Not everything happened that they said it would....need to tone it down a little."
G. Need to make more connections.
H. Try to get more (student) diversity in the classes.
I. Have an activity in the beginning for students to get to know each other...a real activity, not just going around and giving names and hobbies.
J. Make Connections for only one semester.
K. Get corporate sponsors to come and set up internships and interviews.
L. Get corporate people to come in and talk during the seminars once in a while--maybe a debate.

General Observations: The interviewer got the impression that these students came prepared to express their concerns about the curriculum. Although they did not think Connections was for everyone, the more they talked, the more they reflected on the positive aspects of their experience. They seemed eager to share their experiences and many felt that they had, in general, gained from their participation. The students who indicated they were leaving CSM were generally dissatisfied with all aspects of their experience and had made the decision to leave engineering. Both groups indicated they enjoyed having the opportunity to talk with someone about their experience (evidenced by the afternoon group's willingness to come at 2:00 on a Friday afternoon). Their suggestions and comments seemed genuine and most expressed the belief that changes would be made in the following year and that the next Connections classes would be better for the students.

Recommendations:

Goal Clarification: Both faculty and students express uncertainty about the clarity of the goals of the Connections project. The initial enthusiasm of the faculty has been tempered by the reality of implementation. It is suggested that the faculty team revisit the goals of the project and reach a consensus about what student outcomes they desire and the preformance criteria which will be used to determine whether or not the goals were achieved. I encourage using teaming tools that incorporate processes utilizing the input of each of the team members. These tools are designed to maximize the likelihood of consensus and buy-in of team members. It might be advantageous to have someone with experience in teaming facilitate the initial meetings.

Student Input: It is my recommendation that student suggestions be seriously considered. If possible, I would encourage the team to involve students (at least one) in the initial discussions about project revisions. Their suggestions and observations will add an important dimension to the deliberations. The team must deal with the perceptions of students eventhough faculty may not view their perceptions as grounded in fact.

Project Assessment: Those involved in the project have been responsive to the need of getting student input and collecting data for the evaluation process. The use of student surveys and a number of other standardized instruments will provide important information to determine the efficacy of the project. However, I would suggest that the goal of the evaluation process should be not just to "prove" but to "improve." It is important to identify the campus stakeholders and be prepared to answer a number of questions which might not be related directly to student outcomes but critical to the long-term success of the project. As a part of the initial information gathering process, I asked those with whom I met on the site visit what kind of information they would need to make a decision about the "success" and institutionalization of Connections. The following are their responses:

Non-Connections Faculty:

How big are the holes--are they covering material so they can then go into the traditional classes and not be behind?

What is the level of confidence of these students?

Do the students have it in their ability to succeed even though they may not have covered the same material?

Connections Faculty:

What of value has been accomplished with this group of students compared to the traditional ones?

What is the cost of achieving value added--is it worth it?

Can we get the same value at a lower cost?

Can an instrument be developed to determine whether or not students are making connections?

Administrators:

How successful was the project in making the connections?
How has this project transformed the thinking of the faculty members involved?
Are there other approaches that can be used?
A comparison of Connections and non-Connections students in trying to articulate their understanding of the connections.
What is the overall benefit?
How does it improve what we are now doing?
How has this program allowed the students to become integrated?
How are resources going to be applied because of the amount of faculty time?
How does it effect student time?
What are the space needs?

I would suggest that other "stakeholders" critical to the curriculum development process be identified and be asked to provide input into the development of evaluation questions. Of course, time and resources do not permit one to tackle all of the questions that will be asked, but decisions must be made about which ones need to be addressed to improve the project and improve the likelihood of acceptance by the decision-makers.

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