Humanitarian Engineering at the Colorado School of Mines: An Example of Multidisciplinary Engineering

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Introduction:

With the support of a grant from the William and Flora Hewlett Foundation, we are developing a new program in Humanitarian Engineering at the Colorado School of Mines (CSM). The goal of this project is the nurturing of a new cadre of engineers, sensitive to social contexts, committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels and locations around the world. This goal is to be achieved through the development of a humanitarian component for the CSM engineering curriculum that will teach engineering students how to bring technical knowledge and skill, as well as cultural sensitivity, to bear on the real-world problems of the less materially advantaged.

Examples of this might be creating and maintaining the infrastructure of disaster relief, designing low-tech water supply and treatment systems in developing countries, assisting with the creation of inexpensive housing opportunities for the poor, constructing schools or health clinics, designing and implementing sustainable ways to meet basic human needs for food, shelter, energy, transportation, and communication. This new cadre of engineers may be employed by corporations, government agencies, or non-governmental organizations (NGOs). Their expertise will be balanced in terms of technical excellence, economic sagacity, ethical maturity, and cultural sensitivity. Humanitarian engineers will help corporations identify new ways to contribute to community development, promote more effective citizen service among government agencies, and assist NGOs in the creation of an transnational civil society.

Humanitarian Engineers will be recruited from the ranks of students enrolled in engineering programs at the CSM. In addition, we are developing new K-12 recruitment strategies aimed at attracting underrepresented groups into the Humanitarian Engineering program. We believe that the emphasis on humanitarian engineering will prove to be particularly effective in drawing women and minority students to engineering, and thereby promote campus diversity. We also expect it to be attractive to a broad spectrum of engineering students.

We will focus on our existing strengths – in energy systems, geotechnical and geoenvironmental engineering, remote sensing, signal processing, and image processing, and new technologies for "sustainable Engineering," and in emerging engineering disciplines including, bioengineering, information systems, and micro-nano systems.

These capabilities will be applied to the solution of problems for areas and people who can benefit from engineering expertise. This will be accomplished by developing a set of world-class of courses in humanitarian engineering, re-orienting laboratory and design elements of our curricula, and creating domestic and international internship opportunities for humanitarian engineering. This objective is particularly relevant to the CSM, school with a long tradition of leadership in resource and minerals fields and a strong commitment to stewardship of global resources.

We know of no federal funding source that specifically targets humanitarian or community service training for engineering students, and yet this aspect of engineering has great potential for attracting increased numbers of high caliber engineering students, while raising the image of the profession. The web sites http://careers.utah.edu/bennion/homePage.htm, http://www.reliefweb.int, http://www2.york.ac.uk/depts/poli/prdu/ , and http://www.reliefweb.int/w/contactDir.nsf/RelatedSites?OpenForm&Query=ACA provide information on several humanitarian programs in various universities, but apparently none of these focuses exclusively on engineering education. The University of Colorado at Boulder is developing a new certificate undergraduate program in Engineering for Developing Communities (http://ceae.colorado.edu/EDC/). The goal of the program is to educate globally responsible students who can offer sustainable and appropriate technology solutions to the endemic problems faced by developing communities worldwide. The program is designed to serve as a blueprint for the education of engineers of the 21st century who are called to play a critical role in contributing to peace and security in an increasingly challenged world.

The training that we will provide students will lead to a Bachelor of Science in Engineering, with a minor in Humanitarian Engineering. We anticipate that, even if graduates with these credentials do not spend their whole careers in humanitarian engineering endeavors, their multi-faceted expertise and international experience will be invaluable to their employers. Indeed, many of the major recruiters of CSM engineering graduates are international companies specifically searching for engineers with knowledge of international issues. Industrial partners who are interested in these issues will help us recruit students into the program.

Furthermore, this new model of integration between an existing engineering program and a humanitarian component serves as an exemplar on how to inject social and environmental responsibility to engineering education and the profession above and beyond of what is expected by professional codes of ethics and accreditation criteria.

The purpose of this paper is to describe the methods that will be used to create the new Humanitarian Engineering curriculum. First, we will describe the specific goals that we hope to achieve through the new program. Next, we will describe the unique features of CSM and the engineering department that make us an ideal setting for this project. This will be followed by a discussion of how the current curriculum will be re-designed to have a humanitarian emphasis. Finally, this paper concludes with a description of our methods for assessing our project goals.

Project Goals:
The specific goals of this project are to:

(1) *Create a culture of acceptance and value of community and international service activities at CSM.* We anticipate that the first result of this project will be an enhanced appreciation of the value and importance of the participation of engineers in community and international service, and expect that pre and post attitudes surveys of students and faculty will reveal a significantly meaningful change in their perceptions.

(2) *Increase the number of CSM engineering graduates that enter occupations that have a community or international service emphasis.* The measurement of this goal will involve a longitudinal study of student placement. Our goal is to increase students' entrance into these occupations by 25%.

(3) *Increase the recruitment of women and minority students to the engineering program at CSM.* As a result of new recruitment activities that emphasize service and our K-12 outreach activities, we anticipate an increase in applications from women and minority students. Our goal is an increase of 25%.

Further, when it comes to engineering's relevance to the world's most challenging problems, the public attitude toward engineering is not very encouraging (NSF, 2002). Leaders in engineering education and the profession have argued that the perception that engineering is irrelevant to humanity's present and future needs may be a key reason for the steady decline of engineering enrollment over the last decade, as well as the persistent under-representation of women and minorities in engineering. Engineering students are too often misperceived to be more concerned with their personal vocational interests and material goals and uncaring about society at large, particularly the plight of the developing world. (Brannan 1994; Wiggins 1995; Parsons 1996; Wall 1996; McIsaac and Morey 1998; McCuen 1999; Duffield and McCuen 2000; Lyons 2000; Bonasso 2001) This leads us to our fourth and most important goal, to:

(4) *Increase the number of engineering students that enter internships in community or international service.* As a result of the newly established agreements with sponsoring organizations such as the US Department of Health and Human Services, Engineers Without Borders, the Namlo Foundation, Golden Independent School, and the Federal University of Santa Maria in Brazil, we anticipate an increase in students participating in these endeavors. Furthermore, we plan to establish additional agreements with similar agencies during the course of the project. Our goal is an ambitious 30% increase in students participating in these internships by the end of the project.

Background:
The Engineering Division at CSM is an interdisciplinary program, offering a Bachelor of Science in Engineering degree with specialties in civil, electrical, environmental and mechanical engineering. In 2001, the program received a six year accreditation as a "non-traditional" engineering degree, and has been so accredited since its inception in ~

1975. In contrast to traditional programs, non-traditional programs are not required to conform to specific ABET Program Criteria for accreditation. This provides non-traditional programs with greater freedom for experimentation and flexibility than traditional degree programs. There are more than fifty ABET accredited non-traditional engineering programs in the USA, and the number appears to be growing. The American Society of Engineering Education (ASEE) recently established a Constituent Committee on Multidisciplinary Engineering that will serve as a home base for these non-traditional engineering programs.

Currently, about 915 students are enrolled in the undergraduate Engineering program at CSM. Approximately 440 of these are in mechanical engineering, 220 in civil engineering, 215 in electrical engineering, and 40 in environmental engineering. Thus, revisions to our curriculum are of direct benefit to over 900 CSM students and to the many students enrolled in the fifty non-traditional engineering programs at other institutions nationwide. Curriculum developed at CSM may also serve as a model for traditional disciplinary engineering programs nationwide.

Engineering design at CSM begins in the freshman year with the award-winning EPICS (Engineering Practices Introductory Course Sequence) and continues in the sophomore year in a second semester of EPICS. Included in the CSM core curriculum is a unique laboratory sequence, the Multi-disciplinary Engineering Laboratory (MEL I, II, and III). MEL has won several awards, including the prestigious award for *Academic Excellence and Cost Management* from the American Council on Education, a NSF CCLI grant, and grants from the Parsons Foundation, Chevron, and Kennecott Mining. During senior year engineering students in civil, electrical, environmental, and mechanical specialties participate in a two-semester seven-credit Senior Design class. As components of the CSM "writing-across-the-curriculum" program, EPICS, MEL, and Senior Design are all writing-intensive. These course sequences are also multi-disciplinary. Special effort is employed to find challenging projects that require students to work in teams and share their expertise. Senior Design also incorporates instruction in project management, ethics, social/environmental/ergonomic/ and manufacturability issues. The number of credit hours in Senior Design was recently increased from six to seven to better encompass multiple themes and objectives. In addition to the concepts listed above, students probe issues related to patent law, proposal preparation, scheduling, and professionalism.

A number of projects in both EPICS and in Senior Design already have focused on humanitarian service, environmental, or biomedical themes. Of the current list of fifty-two senior design projects (http://egweb.mines.edu/eggn491/), thirteen have international or community service as a theme, four are related to biomedical or bioengineering device design, and seven focus on energy conservation or energy efficiency. In several cases students have worked on projects in other countries, or with international impact. For example, a team of Senior Design students is currently continuing and expanding the efforts of a sophomore EPICS team to design a wastewater treatment facility in St. Kitts in the Caribbean. The sophomore team looked primarily at social, legal, and logistic factors associated with the project, while the senior team, consisting of three

environmental specialty and two civil specialty students, will perform the actual analysis and design of the structural and wastewater treatment facility. This is an excellent project for students, giving them the opportunity to do real-world engineering to solve critical community needs. Perhaps not surprisingly these projects are particularly attractive to female students who prefer projects that make a contribution to the betterment of society (Farrell, E., 2002).

The Engineering Division recently was awarded a grant from the NSF for reform of the engineering curriculum (https://www.fastlane.nsf.gov/servlet/showaward?award=0230699). One aspect of the planned reforms is the conversion of several three-credit courses into two plus one versions, in which fundamentals are taught in the two-credit module, with applications taught in the follow-on one-credit module. Students will be required to enroll in the fundamental two-credit course and then select one or more one-credit course as a follow-on. Applications courses are envisioned to involve collaborations with industry and government. The two plus one model, and particularly the one-credit applications courses, provide a convenient mechanism for introducing specific engineering topics relevant to humanitarian engineering. Thus, we can leverage the reforms under development through the NSF grant with new applications courses relevant to humanitarian engineering. This is discussed subsequently in more detail.

Details of the Humanitarian Engineering Program:

To implement the Humanitarian Engineering Program, we are modifying several existing courses and introducing new engineering courses that convey relevant knowledge and training for service missions. The curriculum consists of both technical and non-technical courses to develop the skills, expertise, understanding, and attitudes that support pro-active humanitarian service. New courses and course enhancements include: development of service missions within senior design, modifications to the MEL sequence, modifications to several courses, new one-credit technical "applications" courses, and a sequence of courses in the Division of Liberal Arts and International Studies to provide a Minor program in Humanitarian Engineering. We are also developing internships for participating students in appropriate organizations. This section describes each of these components.

Senior Design/Service Missions

Senior design is the linchpin of the program, through which students will engage in design projects with international and humanitarian emphases. In the past, senior design students at CSM have participated in various projects of this type; the proposed program will significantly increase the number, complexity and duration of these projects. With this expanded vision, we will designate those senior design projects that fulfill this framework as service missions. We have already developed relationships with a number of international liaisons and humanitarian organizations to promote service missions. These include Engineering Without Borders, the Namlo Foundation, Golden Independent School, U.S. Department of Health and Human Services and the U.S. Public Health Service. Our goal is to motivate and challenge engineering students to find innovative and creative solutions to technical problems afflicting underprivileged communities

worldwide. Students will acquire the appropriate skills to complete the revised senior design projects through the newly designed curriculum that is described in the sections that follow.

Multidisciplinary Engineering Laboratories
In our award winning Multi-disciplinary Engineering Laboratories (MEL) sequence, we will provide students with new skills in engineering disciplines that have particular relevance to service missions. MEL will introduce experiments related to distributed energy systems (fuel cells, solar cells, wind turbines), sensors for monitoring well water levels and quality, and sensors for contaminant transport and containment. This knowledge and the associated technical skills will enable CSM engineering students to help people in remote communities improve their access to energy and power.

For example, there are several solar appliances marketed for undeveloped regions like the Global Solar Refrigerator. We will use one of these units to modify an existing MEL experiment on refrigeration system modeling, analysis and redesign. Our present experiment powers the experimental refrigerators from building power. The experiment monitors power with a power-line analyzer and computes efficiency by the ratio of measured cooling power and measured line power. Students also develop a theoretical computer model of the refrigerator to compare theoretical cooling to measured cooling. We will continue this practice with the solar refrigerator, and we will add alternate small and inexpensive power sources like solar panels, wind turbines, and fuel cells.

Students will compare the alternative energy sources for the refrigeration experiment by measuring the power output and comparing cost, weight, reliability, maintainability and other factors important to developing region application. The experiment will be designed so students can compare various fuel cells, turbines, and solar cells for developing region applications. Students will become familiar with alternative energy sources and their application to developing regions. Here, as in the senior design component, students and faculty will study together new scholarship on the social dimensions of engineering design (Dym 2003) so they develop their designs under the precept that engineering design is an inherently social and political activity (Bucciarelli 1994).

Modifications to existing Engineering Courses
For soil mechanics laboratory, civil engineering students will be introduced to sensor technologies for identifying and quantifying soil contaminant species and concentration using an EPA superfund contaminated soil site next to CSM campus along Clear Creek. This knowledge will provide students with critical skills needed to assess pollution problems for communities and villages.

The Analog and Digital Communications Systems course will be modified to cover cellular and satellite communications systems particularly applicable to communications for remote and inaccessible communities. The Image and Multidimensional Signal Processing course will incorporate a new section on image processing for remote sensing, focusing on the utility of multi- and hyper-spectral sensor for agricultural and natural resource monitoring. The Introduction to Feedback Control Systems and the

Microcomputer Architecture and Interfacing courses will incorporate a new set of projects focused on the community service control applications such as power regulation in a windmill or a solar array, process control in a sewage treatment plant, or control of a pumping station for a community water supply.

New engineering and technical courses
We will develop a variety of one-credit "applications" courses, analogous to those under preparation to reform the engineering curriculum according to our new NSF Planning Grant. Topics will focus on technical issues related to humanitarian projects: small hydro; micro-turbine design; desalinization; photovoltaic systems; alternative energy; biomechanics for the disabled; groundwater and pollutant transport and remediation; low-cost medical imaging methods; small-scale communications systems; remote sensing as a tool in community planning, infrastructure planning, natural resource planning, environmental assessment, and disaster relief.

These topics differ from those supported by the NSF grant, which focuses on emerging areas and specifically, micro-nano, biotech, information technology, and computational methods. However, the NSF and the Hewlett applications courses are complementary, providing engineering students with valuable skills to bring to bear on critical problems for community and international service. For example, the most appropriate technology for providing remote areas with power may depend on advanced devices such as fuel cells and power electronics. Further, new computational techniques to monitor and predict groundwater transport may help to define strategies to alleviate pollutant contamination caused by industrial waste.

We will introduce a new senior civil elective course entitled *Expansive soils: causes, damages, and solutions*. This course will cover infrastructure damages due to geologic hazard of expansive soils locally, nationally, and internationally. The course will be taught in an integrated way: Website class modules, laboratory modules, and field work modules. The website modules will cover systematic learning materials encompassing types and breath of infrastructure damages, causes for such world-wide problems, and solution techniques to abate damages. Infrastructure damages due to expansive soils exceeds all other natural and geological hazards such as earthquake, flood, hurricanes, landslides, etc. It exceeds 3~5 billions dollars per year in the U.S. alone. The laboratory modules will consist of two experiments focusing on soil suction and volumetric measurement in order to understand the principal mechanisms that lead to damages to civil structures. We currently have an NSF funded project entitled "Introducing unsaturated soil phenomena into undergraduate civil engineering curriculum" that allows us to establish the necessary laboratory setups for the experiments characterizing expansive soils. The field work modules will consist of several identified expansive sites illustrating geologic information, residential house damages in Denver areas, and in-situ geotechnical experimental station. We will establish the field work capacity working with Colorado Geological Survey, and U.S. Geological Survey.

Humanitarian Engineering Minor

In addition to technical topics, students involved in humanitarian engineering also require knowledge of and skills in the ethical, cultural, and environmental dimensions of engineering practice related to the regional, national, and international setting where they will perform service work. We will collaborate with the Division of Liberal Arts and International Studies in the development of a minor and an area of special interest in Humanitarian Engineering. After being introduced to the Humanitarian Engineering component in the required freshman course, Nature and Human Values, students will chart an 18-credit Humanitarian Engineering Minor from the courses displayed below. Students in this minor may also select to take language courses such as Spanish, Arabic, German, Russian, Portuguese, Japanese and Korean.

Required courses (12 credits): this list contains proposed new courses
Engineering Cultures in the Developing World: Africa, Asia, Latin America
Engineering Ethics and Community service
Promises and Failures of Technology
Environment, Technology and Sustainability

Two courses (6 credits) from existing courses at CSM (Students will be encouraged to pick courses according to the geographic destination of their internship or geographic area of interest):

United States track
LIHU480 Urban Quality of Life
LISS 372 The American Political Experience
LISS 474 Constitutional Law and Politics
LISS 480 Environmental Politics and Policy
LISS 431 Global Environmental Issues

Latin America track
LISS 340 International Political Economy of Latin America
LISS 440 Latin American Development
LISS 441 Hemispheric Integration in the Americas
LISS 437 Corruption and Development
LISS 431 Global Environmental Issues

Asian track
LISS 342 International Political Economy of Asia
LISS 442 Asian Development
LISS 437 Corruption and Development
LISS 431 Global Environmental Issues

Africa and Middle East Track
LISS 344 International Political Economy of the Middle East
LISS 446 International Political Economy of Africa
LISS 437 Corruption and Development
LISS 431 Global Environmental Issues
Figure 1. Courses required for a Humanitarian Engineering Minor

Internships

Internships, both regional and international, will be a major component of the training for Humanitarian Engineering. In these internships, American students may experience their first exposure to extreme poverty and different cultural perspectives. We understand that it is critically important to provide interns and students on service missions with an awareness of and sensitivity to these differences. For example, through discussions with community leaders in St. Kitts, we have ascertained that a low-tech water treatment system is preferable to one with sophisticated electronic controls and other modern features. The simpler design is preferred for its ease of maintenance and repair. Therefore, the students are designing a system that meets the local preferences. Students will receive training regarding differences in cultural perspectives through the coursework associated with the Minor in Humanitarian Engineering. We will also follow the advice of our experienced host organizations on these matters. Additional information will be generated during the course of the project by direct contact with sponsoring agencies and local governments. This knowledge will be accumulated in the form of handbooks and guidelines. The sections that follow describe specific activities that are proposed with our regional and international partners. This is followed by a brief description of how the proposed internships will be maintained beyond the period of funding.

Internships with regional organizations. The U.S. Department of Health and Human Services and the U.S. Public Health Service very recently established a memorandum of understanding with CSM. Through this agreement students will participate in internships and summer projects related to health and human services, occupational safety and health, testing of medical and household devices, and in projects associated with the Indian Health Service, Center for Disease Control and Prevention, and the National Institute for Occupational Safety and Health. Host organizations, such as the Indian Health Service, will provide students with information on cultural perspectives. This information, coupled with the non-technical coursework in the Humanitarian Minor program, will help students to assimilate regional values and preferences.

Golden Independent School is also collaborating with us to identify Humanitarian projects and internships. Another agency of particular interest to us is the National Sports Center for the Disabled, a community organization in Colorado, with the goal of providing access to all forms of athletic activities to the disabled (http://www.nscd.org/). In the past, CSM students in senior design classes have participated in equipment design and development projects, but with limited resources have made only modest contributions to these efforts. The Hewlett grant will enable us to expand and improve our work in these fields.

Another venue for Humanitarian internships and service missions is the *Partnership for Public Service*, a federal organization dedicated to revitalizing civil service in the US, particularly by educating and facilitating the placement of college students in internships with local, state, and federal community organizations. The most significant of these

organizations is the *Corporation for National and Community Service*, which administers the *Americorps* and the *Learn and Serve America* programs. After 9/11 these federally funded programs have received a significant budget increase (+40%), have also become part of the USA Freedom Corps which will extend their service reach abroad, and have the incredible challenge to recruit an additional 25,000 members (+50%) for FY 2003. Hence, the demand for engineering interns and the financial resources will be available from an external source well beyond the life of this grant. Also, the availability of significant stipends and benefits will make these programs attractive to our engineering students who are usually offered well-paid summer jobs in the private sector.

Internships with international organizations. CSM has a long tradition of international participation. Exchange agreements exist with more than fifty universities in Australia, South America, Europe and Asia (http://www.iie.org/pgms/global-e3/). However, these are primarily for semesters abroad. We envision internships and service missions to be of shorter duration. During the course of the grant we will develop new agreements appropriate for service missions and internships. We have already established linkages with several organizations for this purpose. These organizations include the Federal University of Santa Maria (FUSM) in Brazil, Engineers Without Borders (EWB), and the Namlo Foundation (http://www.namlo.org) in Nepal to develop collaborative projects for senior design. Quoting the web page, "The mission of Engineers Without Borders …is to help disadvantaged communities improve their quality of life through implementation of environmentally and economically sustainable engineering projects, while developing internationally responsible engineering students." Both Engineers Without Borders (http://www.ewb-usa.org/home.htm) and the Namlo Foundation are non-profit 501©(3) tax exempt corporations created under the law of Colorado.

The health and safety of our students are paramount concerns in our plans. In a few instances, both senior design students and EPICS students have participated in projects in materially disadvantaged regions of the world. For example, we currently have one senior design team that is designing and building a water treatment plant in St. Kitts and for a second team designing a water pump for a village in Belize. In both cases, we have coordinated with the local government and sponsoring organizations to ensure that that our concerns for health and safety are met. In all service missions, we ascribe to a scrupulous regimen to ensure that the CSM students are not subjected to unwarranted risk for health or safety. Accordingly, our agreement with the *Namlo Foundation* calls for design and consultation only, since the site for these projects lies perilously close to the Tibetan border, and poses some risk at this time. Nevertheless, we have allocated a small fund in our travel budget for emergency evacuations. In addition, all CSM students are covered by health insurance. We will also insist that all faculty advisors traveling with students to remote areas take Red Cross courses in first aid, and strongly encourage students to do the same.

Continuation of Internships Beyond Funding. During the period of the Hewlett Foundation grant, we will focus on the development of four elements that will ensure the long-term continuation of international and regional internships in humanitarian

engineering. First, the creation of strong linkages with industry, government, and international and regional community service organizations will assure the continuation of the service mission of the program after completion of the grant. Second, the development of internship guidelines and handbooks will ensure that interns meet the learning and service objectives of the program, especially the objective that calls for continuously seeking and making explicit the relationship between engineering practice and community service. Students will be able to recognize this relationship, and hopefully act on it, later in their careers. Third, we will develop a training seminar and materials for internship advisors, who might come from CSM graduate students in International Political Economy and/or CSM faculty, to ensure that advisors provide students with high quality advising after the grant expires. Fourth, we will develop a handbook for host organizations to help them understand how to seek, recruit, and advise engineering interns beyond CSM. This will ensure that Humanitarian organizations build the capacity to host engineering interns beyond CSM and the life of the grant, thereby leveraging the effects of the Hewlett Foundation funding.

Evaluation

Recognizing that effective evaluation is crucial to the success of our program, we will complete both formative and summative assessments that employ both quantitative and qualitative research techniques. The purpose of the formative assessment will be to ensure the on-going improvement of the project plan as it is implemented. Our summative assessment techniques will directly examine the impact of the proposed project has on the intended outcomes.

Formative Evaluation
As was discussed earlier, the purpose of formative evaluation is to improve the project plan as it is being implemented. The following strategies are proposed for formative purposes.

- **Monthly meetings of project staff**: The investigators will meet on a monthly basis with the purpose of discussing the progress of the project and to suggest methods for improving the proposed project. During these meetings, the project evaluator will share with the investigators the results of assessment activities. This information will be used to continually improve the implementation of the proposed project.
- **Advisory Board:** An external advisory board that consists of community and business representatives will assemble at least once a year. The purpose of this group will be to review the progress of the service missions. Based on this information, this group will provide suggestions for further improving the project to better attain the stated project goals related to service missions.
- **Pilot of the Proposed Courses:** Each of the proposed courses will be piloted with a limited number of students prior to full implementation. Survey instruments and content tests will be used to evaluate the effectiveness of the piloted courses.

Information acquired through these instruments will be used to improve the course prior to full implementation.

- **Student Focus Groups:** Half-way through the pilot of a new or altered course, a focus group will be completed with the participating students. The purpose of these efforts will be to acquire direct feedback from the participating students that can be used to improve the given course. The confidentiality of the students will be strictly maintained.

The Advisory Board for service missions is already in place. The Board consists of our senior design clients and sponsoring organizations that meet each semester at a trade fair to provide us with objective reviews of the quality of the senior design projects. In 2002, more than 50 clients and invitees (such as alumni, recruiters, and representatives from regional engineering firms) reviewed and graded the senior design projects in the trade fair format. This semi-annual event is extremely popular in the CSM community. Indeed during the past few years, interest in the senior design trade fair has grown so quickly that the venue for the fair, Brown Hall, is no longer large enough to hold all the projects, students, clients and sponsors. We are therefore planning to hold the 2003 trade fair in the CSM Field House. Individuals attending the trade fair provide us with valuable evaluations of the quality and relevance of the senior design projects, as well as suggestions for improvements of the design process and engineering education. We use the trade fair feedback to continuously improve the program.

Summative Evaluation

The summative evaluation methods are designed to directly measure the extent to which the project goals are being reached. At the beginning of the project, we will collect baseline data in a number of areas. Comparison data will be collected at a later point in order to examine the extent to which the project has had the intended impact. The data will be collected and analyzed with respect to each of the goals is described below.

- **Goal 1:** An attitude survey will be administered to the entering freshman and the exiting seniors at CSM at the start of this program. This instrument will be specifically designed to address issues relevant to student acceptance of community and international service endeavors. This instrument will be administered again to graduating seniors in the fourth and fifth year of this project. Comparisons will be made between the changes in student's attitudes from their freshman to senior year and between the seniors that had not participated in this program to seniors that had participated in this program. An attitude survey will also be administered to the engineering faculty at CSM concerning their acceptance of community and international service endeavors. This instrument will be administered to the faculty a second time at the end of the proposed project. Comparisons will be made to determine changes in the faculty attitudes.
- **Goal 2:** Data will be attained from the career center at CSM concerning the number of students that graduated between the years of 1997-2002 that are currently employed in community or international service. This data will be compared to the number of students that participate in the proposed project and eventually pursue careers in these areas. Ten years after the implementation of this plan, a follow-up

study will be completed. Our goal is to witness a 25% increase in the number of students that pursue careers in these areas.

- **Goal 3:** CSM currently maintains detailed records through the registrar's office concerning the enrollment of female and minority students. This data will be carefully tracked to determine whether the inclusion of courses that address community or international service attracts more women and minorities to CSM. Our goal is to witness a 25% increase in this area.
- **Goal 4:** Data will be attained from the career center concerning the number of students that participated in internships in community or international service between the years of 1997-2002. This data will be compared to the number of students that participate in the proposed project and eventually attain internships in these areas. Our goal is to witness a 30% increase in this area.

Conclusion

The purpose of this paper is to describe the exciting new endeavor that is underway within the Engineering Department at CSM. Through the support of the Hewlett Foundation, we are developing an engineering program that has a humanitarian focus. This program has the potential of attracting more women and minorities to the field of engineering and of promoting engineering as a more caring field. We invite each of you to follow our efforts through the CSM's Engineering Division Web page at http://egweb.mines.edu/

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Biography of the authors

Dr. Joan Gosink has been a Professor and Director of the Engineering Division at CSM, the largest department or division in the School, since 1991. Under her direction, the Division received various accolades, including designation as a *Program of Excellence* from the Colorado Commission on Higher Education. During this period, student enrollment grew from about 500 students to over 900, and external research funding increased by 600%. The program also expanded to include Masters and Doctorate degrees and an undergraduate specialty in environmental engineering. Dr. Gosink twice served as a Program Director at NSF. Among other strengths, Dr. Gosink is an

experienced ABET evaluator, bringing unique insights on the ABET evaluation process to the project team.

Dr. Juan Lucena is Director of the McBride Honors Program in Public Affairs for Engineers and Associate Professor at the Liberal Arts and International Studies Division (LAIS) at the Colorado School of Mines. Juan obtained a Ph.D. in Science and Technology Studies (STS) from Virginia Tech and a MS in STS and BS in Mechanical and Aeronautical Engineering from Rensselaer. Currently, he is researching how images of globalization shape engineering education, hiring practices, and engineering practices and designs under a NSF CAREER Award titled *Global Engineers: An Ethnography of Globalization in the Education, Hiring Practices and Designs of Engineers in Europe, Latin America, and the U.S.* He is also a co-PI (with Dr. Moskal) on a NSF-funded project to develop, evaluate, and disseminate curricula on the cultural dimensions of engineering education and practice.

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