The MCEER Interface Between Research and Education

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Educational Objectives

MCEER conducts a program of education and educational outreach to encourage transfer of ideas and knowledge that emerge from its research. The effectiveness of these activities depends heavily on the Center’s ability to recognize the needs, expectations and capabilities of the learner/user. With this as a foundation, MCEER education and outreach activities work to build awareness of the earthquake hazard - particularly in those areas of lesser known exposure, to help others to understand and acknowledge the implications of seismic risk, and to encourage implementation of earthquake loss-reducing programs and engineering technologies. In parallel, and using earthquakes as a thematic concept, MCEER works with precollege students and educators to increase their understanding and appreciation of the role that science, technology, engineering and mathematics play in our society. This paper reviews MCEER’s ongoing activities and approaches for knowledge transfer, summarizes some obstacles which can inhibit the process, and assesses the potential influence of education and outreach on enhancement of earthquake resiliency.

In order for earthquake research to be effective, those who will put engineering strategies and knowledge into practice must utilize it. This knowledge may be implemented in the form of improved codes and standards, enhanced abilities to prepare, respond and recover from earthquakes, new design methodologies or advanced technological applications, even new educational curricula. How do research outcomes become useable and are there ways that the process of transfer can be improved? It is essential that there be a recognized interface between research and education that must be addressed to further knowledge transfer. This educational process is part of the strategic vision of MCEER. The program has several goals to help advance the Center’s mission to enhance community resiliency. Because end-users are derived from a broad variety of educational backgrounds, these goals are necessarily diverse. They include improving science and engineering education in the precollege environment, nurturing new generations of engineering doctorates, providing practicing professionals with substantive opportunities to enhance their techni-
This paper will highlight education work done by several MCEER faculty and professionals at their universities and at MCEER headquarters. The synthesis of these outcomes is intended to make the interface between research and education seamless.

Practice-Oriented Projects and Outreach to High School Students

The California State University at Los Angeles (CSLA) component was aimed at student development through a practice-oriented project. The project is to model and analyze a campus concrete multi-story building for seismic vulnerability with performance-based design concepts. In a parallel application, passive energy dissipation devices were studied as a seismic response modification methodology.

A group of five students, including three underrepresented minority students, worked on the project. The faculty mentor, two industrial representatives, and MCEER researchers guided them. This combination was very helpful in bringing a practice-oriented project cal proficiencies in earthquake engineering, and encouraging researchers to better incorporate end-user needs in their studies. It is also necessary to reach out to audiences who can benefit from the knowledge conveyed in a condensed and slightly less technical language, such as public officials, facility owners, the popular media and the public-at-large. To do so, we must acknowledge and appreciate the diversity of pedagogical environments within which we operate. Just as mitigative interventions remain singular accomplishments without an integrated systemic approach, so must education efforts address complex user needs in achieving their final mitigation objectives. MCEER builds its education and outreach activities as natural extensions of its research programs and tries to integrate the outcomes with end-user needs. By so doing, practicing engineers are better able to improve the effectiveness of their designs and communicate various risk scenarios with clients. Emergency managers are provided with better tools to develop pre- and post-event strategies; in both cases making more well-informed decisions about resource allocation.

The end users of MCEER education and educational outreach activities span a wide range of audiences, beginning with K-12 students, teachers and parents, university students, and extending to government officials, public and private business executives, practicing professionals, and researchers advancing the state of existing knowledge. In summary, the public-at-large can be considered to be MCEER's end user community.
with advanced technology applications to our urban commuting campus.

The project centered around modeling the campus building with a computer model with ETABS software. The lateral load resisting system for the building is a concrete shear wall system, shown in the computer model (Figure 1). The model was subjected to static, response spectra, and time history loading. A nonlinear static pushover analysis of the building is currently being performed.

In the high school outreach component of our activities, the faculty mentor helped the Alhambra High School MESA students prepare for the national Junior Engineering Teams (JETS) competition in Natural Hazard Mitigation related topics in 2002 and 2003. Through the Campus Structural Engineering Student Chapter, the MCEER students participated in field trips, seminars and the Los Angeles Tall Building Council Annual Conference (May 2002), where they presented a poster on the collapse of the World Trade Center. The MCEER group received several awards recognizing their contributions. The Los Angeles Tall Building Council honored a MCEER student with their student award (2001), and the Southern California Structural Engineers Association honored MCEER students in 2001 and 2003 with their student awards. A MCEER student was honored as the CSLA outstanding civil engineering student in 2003. The faculty mentor was honored with the CSLA Civil Engineering Professor of the Year Award (2003) given by the Engineering Computer Science and Technology Student Council.

Individual Study Programs for Underrepresented Students

The focus of the integrated research and educational initiative at the City College of New York (CUNY) is to involve undergraduate students, including minority and women, in research on smart structural control systems.

During spring 2002, four undergraduate minority students, including two women, were offered Individual Study in Earthquake Engineering. The students were taught basic concepts in structural dynamics and structural control through weekly study assignments, and interactive discussions and assignments with graduate students. The Quansar Instructional Shaking Table was purchased to introduce students to the experimental components of structural dynamics. One of the students, Ms. Susan
Romero, was selected to participate in the Research Experiences for Undergraduates program in Japan during the summer of 2002. Following her visit to Japan, Ms. Romero worked with graduate students to carry out some numerical analysis on semi-active control using friction dampers. As a result of this research activity, Ms. Romero has been motivated to join the Ph.D. track program in structural control in the fall of 2003.

During spring 2003, the team at CUNY is offering the individual study course to three undergraduate students, including one minority female student. The students learn basic concepts in structural dynamics and do shaking table experiments with the instructional Quansar Shaking Table. One of the students, Ms. Miriam Vargas, is applying for the Research Experience for Undergraduates program in Japan this year for research in structural control. Figure 2 shows the students using the instructional shake table.

A 5-ton, 5 ft x 5 ft shaking table system for research and education has been developed as part of this effort. The students involved are developing a 5-story building model for experimental research. The laboratory will be fully operational in the summer of 2003. At that time, both graduate and undergraduate students will be involved regularly in experimental research in structural dynamics and control.

As a further part of this effort, several practical issues in structural control are being investigated, such as the modeling of near-field ground pulses, effectiveness of passive damping systems for near-field ground motions, and development of hybrid control systems using passive and semi-active MR or friction dampers. With the development of the 5-ton shaking table, students have better opportunity to get involved in theoretical as well as experimental research.

WHEEL, the Instructional Shake Table and KiddieEngineer

At Florida A&M University, the Wind Hazard and Earthquake Engineering Laboratory (WHEEL) is structured around three interrelated components: research, education and outreach. The research goal of the lab is to improve structural performance of civil structures to natural hazards. The latest research project involved producing a detailed earthquake analysis of an existing high-rise structure in the southeast region of the United States. The structure was modeled using finite element methods and exposed to moderate and large-scale earthquakes. The probability
of structural and non-structural damage, caused by the building’s displacement, was approximated through the use of fragility curves. Repair costs were estimated based on the probability of exceeding each damage state. Passive control devices were used to improve the response of the building and reduce the extent of damage. The findings of this study have been published in the MCEER Student Research Accomplishments: 2001-2002. In addition, the results of the study have been presented at conferences in Orlando, Florida and Tokyo, Japan by the faculty and additional participation by graduate students involved in the program.

Florida A&M University/WHEEL has also contributed to the education of earthquake engineering students through the development of lab experiments and demonstrations using an instructional shake table (see Figure 3). The information was published as a part of the University Consortium for Instructional Shaking Tables (UCIST). In addition, these developments assist with the integration of structural dynamics into the Civil Engineering Mechanics course and the undergraduate curricula.

The final component, outreach, is a way of encouraging and involving K-12 students in the field of engineering. KiddieEngineer was a summer outreach program that engaged two elementary school teachers and a small group of 3rd and 4th grade students (see Figure 4). The teachers developed curricular elements that included teaching the students about natural hazards and their affects on buildings. The students also learned how engineers design structures to resist hazards. At the conclusion of the program, the students formed groups/companies where they constructed LEGO buildings, wrote reports on natural hazards, and tested their buildings on the instructional shake table. The summer program was a trial program to test the new curricular elements and to determine if they agreed with the interest of the students. The future goal of the program is to introduce the information to the local school system.
MCEER-Coordinated Education and Outreach Activities

The conventional university environment educates students through the completion of course work and theses. Since its earliest days as NCEER, MCEER researchers have also traditionally graduated several Ph.D. candidates each year. However, the system-integrated research environment created by MCEER helps to enhance the conventional university process. As MCEER researchers develop new knowledge, it is integrated into new and exciting courses at the undergraduate and graduate level. Several new courses and programs, such as the minor in Natural Hazards at Penn State University and the Master’s of Earthquake Engineering at the University at Buffalo serve as examples of educational programs which will expand the traditional university learning experience. Undergraduate and graduate students also actively participate in MCEER research as part of formal programs such as the Research Experiences for Undergraduates (see Figures 5 and 6) and the Student Leadership Council (SLC). Both programs are designed to provide a more enriched exposure to the team-based integrated research of the Center.

Opportunities to participate in multi-institutional seminars and earthquake related curricula increase the students’ appreciation of the systems approach to earthquake research and the relevance of research participation to emerging advances within the disciplines. Support through individual MCEER research projects and special fellowships help encourage gifted students to pursue careers in academia. This is especially important to increase the number of U.S. students pursuing advanced degrees in engineering. The students regularly publish their results in a special MCEER publication, Student Research Accomplishments.

An important new initiative is the Student Field mission, which is a collaborative effort of the three national earthquake centers. The
mission offers advanced graduate students an opportunity to visit centers of excellence in other countries, observe and be mentored, complimented by field excursions to sites of earthquake damage and rebuilding. It provides the students with a more global perspective on research, earthquake impact and recovery. The first mission was held in 2002 in Taiwan, and the participants are shown in Figure 7. The 2003 mission is scheduled to be held in Italy.

Interactions between SLC students and members of MCEER’s Industry partnership provide students and practitioners with opportunities to get better acquainted (see Figure 8). Increased involvement of industry partners in MCEER research activities further enhance the graduate experience. Lifeline studies at Cornell University involving Tokyo Gas and utilizing the experimental testing facilities of an MCEER industry partner, Taylor Devices, Inc., illustrate the value of graduate student participation. Current MCEER geotechnical work being carried out at Mactec, Inc. actively involves undergraduate engineers in the research effort. Experiences are especially designed to expose students to different career opportunities, whether in practice or academia, and to expand their professional capabilities.

However, each thrust area has its own unique contribution to advancing education of students, practicing professionals and other members of the community. Utility engineers at the Los Angeles Department of Water and Power (LADWP) are using the GIS-based tools developed as part of the Los Angeles lifeline project. The ability to spatially relate lifeline performance to potential seismic risk would not be available to them without the MCEER research effort. This will offer substantial improvement to LADWP’s ability to prepare and respond to the next Los Angeles area earthquake and to restore any loss of function more efficiently. Utility managers have seen an improved way to deal with the consequences of earthquake damages to the utility system. (see MCEER’s Research Progress and Accomplishments: 1999-2000).
As the MCEER hospital project progresses and seismic resistant strategies and technologies emerge which can address vulnerabilities in the systems and components of health care facilities, decision support tools are being developed in parallel, which will become educational methods to assist hospital administrators and engineers in making cost-effective decisions to strengthen the facility. Similarly, a database of information developed through the study will be a long-standing, valued educational resource to the hospital community, researchers, and engineering discipline.

An educational tangent from the MCEER program in Response and Recovery, the use of remote sensing and satellite imagery to develop damage recognition algorithms is helping to advance and broaden the use and application of the technology to other spatial phenomena. Several MCEER technical publications have been produced which can educate professionals in other hazard fields about the potential applications of the technology, such as MCEER monographs which are written as a concise guide on advanced technologies for a practicing professional. One publication on the use and application of remote sensing data, in particular, has been produced on CD-ROM so that greater amounts of data can be provided for the user (Tralli, 2000).

The MCEER networking effort is aimed at linking experimental facilities, improving the computational capabilities of Center researchers and increasing the availability and exchange of information and data. Several useful databases and software platforms, in particular, those developed by MCEER for inelastic analysis and design of structures, may be found at http://mceer.buffalo.edu/research/default.asp. In collaboration with the MCEER Education program, a series of monthly webcast seminars on topics of timely interest to the earthquake community has been offered for real-time or asynchronous viewing. Seminar topics have been multidisciplinary in nature, focusing on earthquake-related topics and are archived for permanent viewing. Viewers have been drawn in from around the world.

In addition to these educational outcomes, research in each of the Center’s thrust areas generates numerous publications in these study areas. MCEER publications and special reports have wide global readership. MCEER participates in and organizes several state-of-the-field conferences each year, with conference proceedings made broadly available. An important recent workshop brought together engineers, scientists, and emergency professionals to examine the potential interactions between earthquake and blast science as they might apply to engineering design, in the aftermath of the World Trade Center disaster. Abstracts of publications from similar events and other technical reports may be viewed online at http://mceervbuffalo.edu. In the future, online full document procurement is planned.

MCEER is also coordinating with earthquake engineers in the People’s Republic of China at the Institute of Engineering Mechanics and the China State Seismological Bureau on the co-production of a new journal on advances in earthquake engineering, Earthquake
The Information Service, headquartered at MCEER, assists thousands of information seekers throughout the world and maintains information exchange agreements with several organizations and universities. They acquire and maintain a collection of pertinent literature in related fields, provide extensive reference assistance, and maintain an MCEER-developed bibliographic database, Quakeline©, which includes earthquake references to materials in nontraditional, or fugitive, literature. The Information Service also produces a periodic newsletter with news of the profession and information on new publications. They also pioneered efforts to establish a national web-centric portal to acquire earthquake information from several nationally prominent, credible sources of earthquake information, such as USGS, FEMA, Red Cross and many others. EQNet can be accessed at: http://www.eqnet.org.

The Information Service has also assisted with MCEER’s K-12 activities, adding teaching materials and student reference materials to the MCEER web, and participating in teacher training and public outreach events.

Many of these materials have been useful to media, as well. Information has been used as background to popular science articles, news features, documentaries - even articles on New York City real estate - with a focus on the low hazard, high consequence Eastern North American event.

Java-Powered Simulation for Nonlinear Structures

One of the tangible outcomes of this educational project at University of Illinois at Urbana-Champaign (UIUC) is the development of virtual laboratory (VL) experiments to support earthquake engineering research and education. Educators must always strive to better prepare the next generation of structural engineers who can understand and effectively deal with the design of earthquake resistant structures to reduce the associated human and financial losses. One of the challenges of teaching students about the fundamentals of earthquake engineering is giving them an intuitive understanding of the dynamics of structures. Demonstrating the concepts of dynamics using static chalk boards or books is difficult. The best approach is through hands-on laboratories. Unfortunately, few instructors have the necessary facilities readily available to demonstrate structural dynamic concepts through experiments. The main goal of the VL experiments is to provide students and practitioners with a means to interactively develop a fundamental understanding and intuition regarding a wide range of topics in earthquake engineering via the World Wide Web. To allow for universal access, the VL experiments must be built using Sun’s Java Programming Language. Note that the Java platform provides for minimization of administrative overhead associated with maintenance of the VL. All of the VL experiments developed to date are accessible at http://cee.uiuc.edu/sstl/.
The focus of the most recently developed module is investigation of the nonlinear response of multi-degree-of-freedom (MDOF) structures subjected to earthquake loading. The VL module, “Java-Powered Simulation for Nonlinear Structures,” has been developed at UIUC and is available at [http://cee.uiuc.edu/sstl/java/twostory/animation.html](http://cee.uiuc.edu/sstl/java/twostory/animation.html). In this VL module, the user is allowed to select different nonlinear models to represent the behavior of the structure, to change the parameters of the structure, and to choose different earthquake ground motions to do analysis. This module is intended to be used to increase understanding and provide a conceptual “feel” for various parameter changes on the performance of nonlinear structures under different excitations.

The structure is modeled as a two story building, and can include four types of nonlinearity: (i) linear stiffness and linear viscous damping; (ii) linear stiffness and nonlinear power-law damping; (iii) hysteretic stiffness using the Bouc-Wen model and linear viscous damping; (iv) hysteretic bilinear stiffness and linear viscous damping. The same nonlinear behavior is assumed for both stories, while different parameters are allowed for each story. Figure 9 shows example nonlinear structural responses.

As shown in Figure 10, this simulator consists of one animation frame, one excitation frame, two response frames and the control panel. The animation frame shows the animation of the structure during the earthquake excitation. It is able to show absolute motion or relative motion of the structure with different designs. The excitation frame allows the user to select different excitations for the analysis and can display the excitation in terms of acceleration or displacement. Located at the lower part of this Java simulator are the two response frames. These two frames provide the user with the ability to look at the responses of the same story, e.g., one frame for displacement and the other for force, or to compare the same responses for different stories at the same time. This simulator also includes a control panel, which allows the user to define the structure’s characteristics. The help button links to the detailed help page for this VL experiment.

With approximately 500 visitors per month, the Java VL experiments provide an interactive means for students to gain a fundamental understanding and intuition regarding topics in earthquake engineering via the World Wide Web. The VL
modules are accessible to earthquake engineering students, researchers and practitioners throughout the world and have been fully documented with extensive online help pages. Efforts are ongoing to further expand the available modules.

**Conclusion**

The most advanced and sophisticated techniques to reduce seismic impact can remain unused if end-users are unable to understand or unwilling to acknowledge seismic risk or seismic mitigation; do not understand the relevance of a potential application; are reluctant to risk its use without imperatives or incentives; or are unwilling to assign earthquake improvements higher priority than other concerns.

These factors impact ability to take research results and implement them in the form of better educational tools, seismic rehabilitation methodologies, improved policies for preparedness, response and recovery. All must be better understood and incorporated into the education and technology transfer process. Educational products developed, as a consequence of research, will not independently achieve earthquake mitigation. Although many advances have been
made as a consequence of seismic standards and legislative action, such as the National Earthquake Hazards Reduction Program, regulations dictating seismic improvements cannot realize all goals (Adler and Pittle, 1984). In the event of a disaster, a window of opportunity is presented to advance, yet still all mitigation goals can be accomplished. This underscores the need for a well-coordinated, repetitive, interdisciplinary approach to most effectively deliver earthquake knowledge and technology (National Research Council, 2001). MCEER continues to work with its researchers and other partners throughout the world to use education and outreach to improve educational programs, assist the practice and advance the state of earthquake readiness throughout the world.

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