

**Selected NSF Projects of Interest to K-12 Engineering and
Technology Education**

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Selected NSF Projects of Interest to K-12 Engineering and Technology Education

Compiled by
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November 6, 2007

The National Science Foundation (NSF) portfolio addressing K-12 engineering and technology education includes initiatives supported by a number of programs. This list includes projects identified by searching lists of awards in the respective NSF programs as well as projects suggested for inclusion by researchers, practitioners, and program officers.

The list includes projects concerned with standards in technology education, teacher professional development, centers for learning and teaching, preparation of instructional materials, digital libraries, and technological activities in informal settings, as well as small numbers of projects in several other areas.

This compilation provides current information on projects of interest to educators, instructional designers, consultants, and researchers who are concerned with the development, delivery, and evaluation of instruction to develop technological literacy, particularly in K-12 engineering and technology education. Projects are grouped under headings for each program providing primary funding. Within each program, the award numbers determine the order of listing, with the most recent awards at the beginning of the list.

Each award entry includes the project title, NSF award number, funding program, amount of the award to date, starting and ending dates, the principal investigator (PI), the grantee institution, PI contact information, the url of the project Web site, a description of the project's activities and accomplishments, relevant previous awards to the PI, products developed by the project, and information on the availability of those products.

*An asterisk preceding an entry indicates that the PI had not yet provided 2007 updated information when the list was compiled. **A double asterisk indicates that an entry for a recent award had not sent to the PI for review before it was added to the list.

Researchers are encouraged to contact the principal investigators directly for more detailed information about the activities and outcomes of their projects. The complete electronic file is currently available from the compiler at d.householder@usu.edu and will soon be available from the Web site of the National Center for Engineering and Technology Education, <http://www.ncete.org>.

The compiler is solely responsible for selecting projects for inclusion in this list. The information included in this compilation does not represent the official position of the National Science Foundation. Updated information, corrections, and suggestions for improving the usefulness of the list are invited. They may be submitted to the compiler at d.householder@usu.edu.

Information on programs and projects may be accessed through the National Science Foundation Web site, <http://www.nsf.gov>. Awards may be searched by program, state, institution, or funding year at <http://www.nsf.gov/awardsearch/>. Current program solicitations, deadlines, and other pertinent information may be obtained through the NSF Web site.

Advanced Technological Education Program

Engineering is Elementary: Engineering and Technology Lessons for Children

NSF Award No. 0702853 (Advanced Technological Education)

\$740,649 July 1, 2007 – June 30, 2010

Christine Cunningham, Museum of Science (Updated 10/31/2007)

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<http://www.mos.org/EiE>

Advancing Technological Literacy and Skills (ATLAS) focuses on preservice instruction in technological literacy and the preparation of future elementary teachers to integrate technology and engineering concepts and activities into their elementary classrooms in accordance with the Massachusetts K-12 technology and engineering standards. The goals of the ATLAS project are to: (1) enrich community college elementary education courses with technology and engineering; (2) strengthen elementary educators' knowledge of and capabilities to teach technology, engineering, and science; (3) develop articulation pathways related to elementary technology/engineering between high schools, community colleges, and four-year institutions; (4) create a cadre of community college and four-year faculty that disseminate capabilities and curricular models to colleagues in the region and state; and (5) increase awareness among stakeholders about the importance of effective technology and engineering elementary education programs.

ATLAS partners include the Museum of Science, Boston; Northern Essex Community College; Holyoke Community College; Bristol Community College; Westfield State College; Fitchburg State College; the University of Massachusetts, Amherst; several high schools; two industry partners; the Massachusetts Executive Office of Community Colleges; and three Tech Prep consortia. Education faculty from the community colleges are participating in professional development institutes offered by engineering and technology faculty and Museum of Science staff to bolster their understanding of content and pedagogical techniques for teaching elementary technology and engineering and of career options and pathways in technical fields. In turn, the faculty work with ATLAS staff to develop and implement 1) elementary education course syllabi and sequences that include technology and engineering and 2) professional development workshops for their colleagues and other educators focused on technology and engineering elementary education. Industry externships are offered to community college faculty and preservice students to expand their understanding of the technological world. ATLAS is defining coursework for elementary teacher preparation pathways leading from high school through community college to four-year institution to include Standards for Technological Literacy and Massachusetts Science and Technology/Engineering Frameworks integrated into coursework at all three levels. The project is also working to raise awareness among stakeholders regarding the need to incorporate technology and engineering into elementary education.

SC ATE National Resource Center for Expanding Excellence in Technician Education

NSF Award No. 0602710 (Advanced Technological Education Program)

\$1,599,490 September 1, 2006 – August 31, 2010

Joshua Phiri, Florence-Darlington Technical College (Updated 11/2/2007)

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Through this project, the South Carolina Advanced Technological Education Center of Excellence (SC ATE) is expanding teaching excellence in technician education by (a) providing a central, Web-based clearinghouse to increase participation in professional development in the ATE program and assist project personnel who deliver professional development; (b) expanding the number of educators using SC ATE strategies to increase the number of students in the advanced technological educational pipeline; and, (c) stimulating high school and community/technical college use of ATE curriculum models and best practices that attract students, reduce dropout rates, and positively impact technician education.

Intellectual Merit: SC ATE models are based on educational research and focused on improving the success of pre-college and first-year college students in the educational pipeline leading to associate degrees in engineering technology and/or college transfer. The SC ATE curriculum model successfully integrates the study of physics, English/communications, mathematics and technology in technician education. SC ATE work has been the subject of research university studies on topics such as development of effective

curriculum, assessment of student learning, and exemplary teaching in undergraduate physics education. The SC ATE approach places emphasis on faculty development and content integration across disciplines. SC ATE innovations have proven effective in both high school and college programs where graduation rates, diversity, and employer satisfaction with graduates have all improved as a result of SC ATE-stimulated reform.

Broader Impacts: SC ATE curriculum models increase access to high-tech careers by improving success rates and retention as students finish high school and complete the first year of college study in engineering technology. SC ATE recruitment models increase participation and diversity in technician preparation programs. The Web site <http://www.teachingtechnicians.org/> alerts more educators to the professional development opportunities provided by ATE projects. Technician educators benefit from sharing best practices in delivering professional development and participation in industry-provided, Web-delivered seminars. Twelve geographically and demographically diverse outreach and implementation partners expand the impact. Collaboration with the National Dropout Prevention Center broadens SC ATE Center outreach to high school educators, increase national and international publishing of SC ATE outcomes and best practices, and increase interactions among K-12 and two-year college educators who serve the nation's most diverse and at-risk students.

Engineering Technology Competencies: Integrating Curriculum and Forging Pathways

NSF Award No. 0402616 (Advanced Technological Education Program)

\$374,440 August 1, 2004 - February 28, 2007

Tanna Kincaid, Bismarck Public School District #1 (Updated 11/1/2007)

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This project is developing curricula and an implementation model that will increase interest and the ability to pursue higher education in the field of engineering. The curricula and model will result in K-12 students applying critical math, science, and technology knowledge while they plan, design, test, revise, and implement engineering activities. Three main strategies were utilized to develop a distance delivery method which would contribute to the standards-based curriculum: 1) Online course delivery model; 2) Observation periods via a distance system; 3) Resources uploaded to a central online database. All of these components address the isolation in a rural state such as North Dakota. Components of the model include K-12 instructor training, curriculum alignment, collaborative interdisciplinary teams, and implementation of the curriculum with students, as well as recruitment of students into post-secondary engineering programs. Valley City State University faculty members facilitate the engineering courses for the 18 participating teachers.

The ETP project provides a model for distance delivery of a standards-based technology education curriculum. Professional development for a 'cohort' of instructors gains knowledge, theory, research and pedagogical methods. The standards-based technology education curriculum implements a proven researched-based model utilizing Understanding by Design. The development and posting of classroom ready materials within an online standards-based database is significant. Many secondary instructors throughout the nation are struggling with standards-based curriculum design, these courses and the deliverables are serving as a model for others. The ETP initiative is accelerating the process of moving technology education into the world of 'standards-based.'

This project has intellectual merit in need, design, and the qualifications of the team. The proposed activities address the challenge of preparing, motivating, and retaining students in the pursuit of engineering related opportunities. North Dakota has adopted the curricular framework recommended by the Center to Advance the Teaching of Technology and Science (CATTS). This project results in a model implementation of the CATTS framework by developing the units of instruction necessary to transfer the framework into a product that can be implemented in the classroom. A clear articulation pathway from elementary to middle school to high school and then to postsecondary engineering programs is identified and supported by the resulting implementation model.

The broader impacts of this project include: (1) an instructor training process that provides content knowledge in technology and engineering while helping teachers implement the content in ways that

require critical thinking and deep understanding on the part of students; (2) units of instruction that are standards-based, interdisciplinary, authentic, and engaging for dissemination via a web-based search engine; (3) an increase in the number of students with the foundational knowledge, skills, and the interest to continue into engineering- related postsecondary programs; (4) a support model that connects K-12 students and teachers, postsecondary students and teachers, and professionals in the areas of technology, engineering, science, and math.

Foundations of Technical Careers: An Advanced Technological Education Project Providing Access and Opportunity for Non-Traditional Students

NSF Award No. 0402581 (Advanced Technological Education Program)

\$599,956 July 1, 2004 - June 30, 2007

Anthony Ucci, Bristol Community College (Updated 10/22/2007)

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The Department of Engineering and Technology at Bristol Community College, several high schools in the region, industry, community organizations and governmental agencies worked collaboratively to identify, recruit, and prepare technicians for the new economy. Summer Institutes in Technology were offered for high school and college faculty. One-week workshops included discussion of teaching and learning styles which incorporated national and state standards as well as field trips to partnering industry work sites. Themes include remotely operated underwater vehicles (ROV) and LEGO ROBOLAB. Upon completion of the workshops, participants were given the materials and resources necessary to repeat the projects in their classrooms throughout the school year.

Foundations of Technical Careers is a four-course certificate program which includes: Introduction to Engineering and Technology, Computer Skills for Engineers & Technicians, Computer Aided Drafting and Technical Communication Skills. Two courses are designed specifically for students to become more informed about careers in Engineering and Technology before making a decision about their intended major. Assessments, course content, and personal advisement help direct students toward appropriate fields of study and technical careers. Courses are tuition-free, except for fees and texts of approximately \$300 which is a significant incentive for BCC's low-income students. Other implementation activities included outreach and recruitment, improvement of technology labs for project-based learning and discovery, and professional development.

Intellectual Merit: The program design and the content of the institutes and the certificate program address the regional educational needs at the secondary and postsecondary level. Activities included meaningful assessment of participants' progress, appropriate pedagogy and content for nontraditional students, and enhancement of labs for project-based learning.

Broader Impacts: A significant aspect of this project is the aim to close the skills gap in technical fields by creating a pathway between secondary and postsecondary levels. Efforts are grounded in a strong collaborative organization that brings all the players together to implement the project. Every aspect of the project is outcomes-oriented and designed to have a broad impact, including cultivating public awareness of engineering disciplines and their relationship to society and supporting career opportunities for a large region that is undergoing economic redevelopment. (Previous Award 0101421)

***San Juan County Initiative for the Enhancement of Pre-Service and In-Service Math/Science Teacher Education through Curriculum Development and Internship Experiences in Technology**

NSF Award No. 0402477 (Advanced Technological Education Program)

\$300,000 June 1, 2004 - May 31, 2006

Jana Wallace, San Juan College

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San Juan College is providing a 9-credit hour block of workshops designed to provide in-service and pre-service teachers with instruction in teaching math and science grades 5-8. The overall goals of this project are: (1) improved quality of math and science instruction based upon use of teaching pedagogy, curriculum

materials, and technology that address the standards, benchmarks, and competencies, (2) gains in children's knowledge of and interest in math and science as indicated by improved standardized test scores and increased enrollment in high school math and science classes, and (3) gains in recruitment and retention of math and science teachers.

The project is training pre-service teachers planning to endorse in math and/or science and in-service math and/or science teachers during summer weekdays and Saturdays during the fall. During the spring, each pre-service teacher works with his/her mentor teacher as a team teacher for 40 hours in the mentor teacher's classroom, presenting the lessons and activities learned in the workshops.

The intellectual merit of this project is evident in the variety of the topics and activities that do not comprise components of the standard teacher education math and science curriculum. The use of technology in the delivery of the workshop content and in the public school classroom as a tool to promote exploration, investigation and discovery learning, is a major and integral component of the project design.

The broader impacts resulting from this project include a systematic, directional, sustainable, and measurable improvement in a quality learning setting in San Juan County's math and science classrooms. Teachers more highly trained in the development and implementation of math and science classroom activities using technology are more knowledgeable, enthusiastic, and self-confident. These traits, in turn, produce students who are excited about math and science and who are critical, procedural, and analytical thinkers and problem solvers.

Getting Results: ATE Teaching in Community Colleges - Large Scale Materials Development for Professional Development

\$1,298,228 September 1, 2004 - August 31, 2008

NSF Award No. 0302832 (Advanced Technological Education Program)

Denise Blumenthal, WGBH Educational Foundation (Updated November 1, 2007)

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The WGBH Educational Foundation, in partnership with the League for Innovation in the Community College, has developed and field tested, and is now disseminating multimedia resources to foster the use of effective teaching and learning practices among Advanced Technology Education faculty members. The materials are based on the work of education researchers, John Bransford and Ruth Steihl, who are steeped in adult learning in community colleges. The online course features video segments illustrating exemplary practices, along with readings and interactive activities targeted to ATE disciplines. The primary audience of the course is adjunct faculty who are teaching in ATE programs. The course is also useful to new and experienced faculty throughout the community college system who are interested in revisiting their instructional strategies within the context of teaching for understanding.

These resources have been field tested in ATE centers and programs in community colleges across the country, revised to increase their effectiveness and ease of use, then further evaluated at a representative group of additional ATE programs across the country, and disseminated through a network of over 750 League for Innovation in the Community College member colleges and 112 corporate partners. In addition, the American Association of Community Colleges is assisting in the dissemination of the materials.

The intellectual merit of these resources was ensured by the active engagement of experts from industry as well as academia, including substantial representation from ATE programs and the community college system; and by the decades-long track record of WGBH in developing compelling teacher training resources that fully engage and inspire the viewer. The Community College Leadership Program at the University of Texas conducted formative and summative evaluation activities to ensure that the new materials are rigorously tested at each stage of development.

Power UP: Creating Leaders for Community College and High School Technology/Engineering

NSF Award No. 0402309 (Advanced Technology Education Program)

\$772,533 August 15, 2004 - July 31, 2008

Christine M. Cunningham, Museum of Science (Updated 10/31/2007)

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The Power UP: Creating Leaders for Community College & High School Technology/Engineering project is a professional development program for high school and community college educators. Intellectual Merit: The project meets five critical needs: (1) The need to engage college students just starting engineering/technology programs with creative and realistic problem-solving activities; (2) the need for instructional programs at the high school level that lead students to consider pursuing technical studies at college; and (3) the need for high school and college faculties to work together to smooth the transition from high school to college. In order to bring the benefits of the proposed program to a wider audience, (4) a cadre of teacher leaders is being developed and (5) the program is increasing awareness among high school guidance counselors, college faculty advisors, and parents about the importance of technology and engineering programs that are open and accessible to all students at the high school and college levels.

This project focuses on one area of engineering/technology education: energy and power technologies. At a national level, energy and power technologies are becoming increasingly important for society's continued development and growth. Engineers and technicians are needed to manage and maintain the current sources and grids while simultaneously alternative sources need to be explored for the future. Power Up! is a collaboration between the Museum of Science, Boston; three community colleges in Massachusetts: Bunker Hill Community College, North Shore Community College, and Quinsigamond Community College; three industry partners: Keyspan Energy, Northern Power, and The Engineering Center; eight school districts; and the Department of Education Tech Prep Network. Broader Impacts: The project is developing, pilot-testing, and refining a systemic model for collaboration between high schools, community colleges, and industry partners to develop new technology/engineering programs and pathways for students that can be disseminated nationwide. The project also fosters the creation of articulated pathways to enhance curriculum for sequences through high school, community colleges, and beyond in the field of engineering and technology. PowerUp! attends to deepening not only educators' but also guidance counselors' understandings of engineering. Finally the Power Up! Courses and instructional units for high school and community colleges revolve around energy, power, engineering and technology. The active, project-based learning materials and public workshops are available for use across the state and nation.

Integrating Low-Cost Virtual Reality into Design and Technical Graphics Curricula

NSF Award No. 0302832 (Advanced Technological Education Program)
\$860,450 September 1, 2003 - July 31, 2006
Shana S-F Smith, Iowa State University (Updated 10/6/2007)
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This project introduces low-cost virtual reality technology into design and technical graphics classrooms and laboratories, as well as developing instructional materials to enhance course delivery. Changing market needs and advances in technology, the focus of CAD technology education, and the shift from drafting to design, problem-solving, presentation, and communication point to the critical need to integrate virtual reality tools into the design and technical graphics curricula. The primary audiences for this project are students and faculty at all levels of design and technical graphics education and CAD technologists in industry. This project inspires the interests of high school students by providing outreach days and virtual reality experiences for students. The project, in collaboration with community college partners, promotes the advancement of their students and engages University students in enhanced learning opportunities that will better prepare them to contribute to the work force. The resulting instructional materials will be made available to graphics and design educators at other institutions through a project web site and by distributing a CD-ROM. Results will be disseminated through national conference presentations and publications. In addition, fifty community colleges will be selected and invited to use the instructional materials developed.

***New York State Professional Development Collaborative**

NSF Award No. 0302808 (Advanced Technological Education Program)
\$976,725 May 15, 2003 - April 30, 2006

Margaret D. Weeks, Hofstra University (Updated 3/16/05)
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Four New York State colleges (Dutchess Community College, Fulton-Montgomery Community College, Mohawk Valley Community College, and Oswego State University) in partnership with Hofstra University, are establishing a statewide professional development collaborative. The project is initially providing workshops in the areas of materials/manufacturing and information technologies to secondary school technology teachers through a program that brings together community college technical experts, high school teacher/leaders, and university pedagogical experts. The overarching goals are to provide contemporary professional development to technology educators using standards-based exemplary materials, to forge sustainable alliances between community colleges and the technology education community, and to create a professional development model that the colleges will sustain. Year I of the project is devoted to building the professional development leadership teams, comprised of faculty from the partnering colleges, and high school technology teachers who are leaders in their field. Year II is being spent conducting weeklong workshops for technology teachers at the colleges. Workshop content is based on curricular materials developed as part of the NSF ATE project, "New York State Curriculum for Advanced Technological Education," as well as other exemplary materials developed by ATE projects and centers. Standards-based materials are being chosen on the basis of a proven track record and relevance to technician education; and the pedagogical focus is on *informed design*, which emphasizes science inquiry and mathematical analysis in the context of design. Year III of the project is devoted to widespread dissemination through technology education conferences and mini-conferences at the colleges. These activities are ultimately establishing ATE professional development centers at the partnering colleges. By building the capacity of teacher/leaders to conduct enhancement workshops, the project is creating a replicable and transportable model of professional development and imparting a mechanism through which ongoing staff development can be sustained by the colleges.

Diversity in Engineering Technology

NSF Award 0302801 (Advanced Technological Education Program)
\$898,561 June 15, 2003 - June 30, 2006
Stephen J. Kuyath, University of North Carolina Charlotte (Updated 11/1/2007)
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This project addresses the issue of increasing the pool of qualified technicians, technologists, and scientists in the region by increasing the interest of secondary school students from historically underrepresented groups in science, technology, engineering, and mathematics (STEM) fields. To reach out to students in public schools, technology clubs are established at public schools, summer technology camps are sponsored, and engineering and technology competitions are sponsored. Technology club coordinators selected from underrepresented groups serve as strong role models, and college and university student chapters of professional societies provide mentors for secondary school students. This project includes an awareness program to effect a new appreciation in the community for the career and educational opportunities that exist in STEM. Secondary school mathematics and science teachers and counselors attend workshops that address issues related to encouraging underrepresented students interested in mathematics and science. Parents receive information about STEM careers and methods to encourage their children in mathematics and science and a project web site includes information for students, teachers, counselors and parents.

At the collegiate level, project leaders collaborate to improve the alignment of technology curricula between the community colleges and UNC Charlotte to articulate the preparation of students for the B.S. degree. College students mentor and advise high school students; both groups are encouraged to consider careers in academic fields. Internships, technical classes, and shadowing experiences for high school teachers improve math, science, and technology content in the high school and college programs. The project assesses student participation in technology clubs and high school science and mathematics courses in the high schools as well as student performance in courses and on college entrance exams to assess knowledge of STEM fundamentals.

The intellectual merit of this project lies in its unique approach to increasing the pool of qualified technicians, technologists, and scientists in the region by recruiting secondary school students underrepresented in STEM fields, and by providing strong role models and effective mentoring programs. The broader impacts of this project are its innovative approaches to advance learning and awareness of STEM principles and career opportunities while promoting learning and teaching in secondary schools, community colleges, and the university. The concentration on creation and enhancement of technology clubs in inner city and rural areas and the careful selection of effective role models broaden participation of individuals from targeted groups in STEM. The collaborative efforts enhance the infrastructure of education and encourage further participation from the community.

Fast Track to Engineering Technology

NSF Award No. 0302713 (Advanced Technological Education Program)

\$797,525 September 1, 2003 – August 31, 2007

Kamil Zakhour, Florence-Darlington Technical College (Entered 11/2/2007)

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This project addresses four major challenges facing technician education: recruitment, under-prepared students, retention, and on-time degree completion. The primary goal of the project is to meet industry's current and future needs for engineering technicians by stepping up efforts to prepare high school students for college ET programs, reducing the number of credit hours required for associate degrees in ET, and specifically addressing the learning and financial needs of minority, female, and working students. Improved student learning of science, technology, engineering, and mathematics (STEM) is realized by (1) an expanded and continued use of an integrated, problem-based curricula developed by a previous ATE project, and (2) a new focus on relevant, smart, teaching that extends best practices to second-year ET students and reduces overall credit hours required for graduation. An image and marketing campaign is enhancing the status of ET careers and publicizing corporate sponsorship of ATE ET students. The project is also demonstrating academic value to the students and economic value to the employers of paid internships as early as the freshman and sophomore years. The outcomes of this project, supported by detailed evaluation research, are being widely disseminated through workshops, publications, presentations, and a web site in collaboration with the National Center for Engineering Technology Education.

***Development and Implementation of a Laboratory Project to Promote Pre-engineering and Marine Robotics Technology in Regional High Schools**

NSF Award No. 0302674 (Advanced Technological Education Program)

\$249,848 June 1, 2003 - May 31, 2005

Ike L. Coffman, Alvin Community College

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The demand for technologically literate workers is increasing. However, many students are not being adequately prepared for technical careers. A program is needed that will take technical training into high schools, significantly raise the interest level among students and teachers for technology education, and then encourage more students to enroll in these programs at the college level. This project is accomplishing this mission by delivering an underwater robotics program to regional high schools. Alvin Community College recently received approval to offer both a one-year certificate and a two-year Associate in Applied Science degree program in Marine Robotics Technology. The Texas Higher Education Coordinating Board recognized the need for this program to help supply a properly trained workforce for a demand occupation. The College is now expanding the delivery of this marine technology education into area high schools. This project is creating a marine robotics lab, complete with equipment and educational support, and delivering these materials to selected high school classes in 10 regional high schools. Teacher training is provided during the initial presentation and through follow-up visits in order to facilitate the integration of technology into the normal curriculum. High school Counselors and Career and Technology Education Directors are selecting appropriate sophomore and junior level high school classes to receive this training. We are specifically targeting under-represented groups as part of this educational experience, particularly minority and female students. The project is striving to implement innovative and highly technical instruction into regional high schools with the subsequent goal of producing highly skilled individuals to enter the marine robotics field.

PHOTON2: Web-based Collaborative Learning for Teachers

NSF Award No. 0302528 (Advanced Technological Education Program

\$833,197 September 1, 2003 - August 31, 2007

Fenna Hanes, New England Board of Higher Education (Updated 11/1/2007)

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PHOTON2: Web-based Collaborative Learning for Teachers is an adaptation and implementation project built on Project PHOTON (DUE/ATE #0053284), a program of the New England Board of Higher Education. This project is: 1) adapting the successful PHOTON instructional materials, laboratory equipment kit and "alliance" model to a web-based distance-learning environment, 2) disseminating PHOTON instructional materials, laboratory equipment kit and "alliance" model, (the inclusion of teachers/faculty and career counselors from consortia of secondary and postsecondary institutions) to a national audience, and 3) evaluating the effectiveness of a web-based distance-learning program that methodically applies adult collaborative learning principles for future replication.

PHOTON2 is utilizing 21st century web-based technology to deliver a one- semester web-based professional development course "Introduction to Photonics," the content of which has been implemented and field tested by teachers and faculty in middle, secondary and postsecondary institutions in New England. In spite of a slowdown in the technology sector, the applications of photonics technology are growing rapidly in fields as diverse as national security, medicine, manufacturing, aerospace, the environment, transportation and more. Demand for these technicians continues to grow. Distance learning has proven to be a very useful tool in bringing education to more learners in a time-efficient manner. Research has shown that although there are many positive aspects to distance learning, there are challenging pedagogical aspects to achieving successful learning experience. PHOTON2 addresses these challenges by applying collaborative and adult learning principles in the design and development of the new web-course. Collaborations established with photonics companies and industry associations (OSA and SPIE) in Project PHOTON are being continued and expanded from a New England to a national focus. Outreach is being initiated with other NSF photonics programs.

The growing demand for photonics technicians requires that new ways be tested to train technicians nationwide. This project is not only adapting the tested technician-level "Introduction to Photonics" instructional materials, it is testing a pedagogically designed distance-learning model. Evaluation strategies are designed throughout the project and results are informing what support components are the most critical in achieving effective transfer of knowledge and program implementation.

Two cohorts of educators from 38 institutions in twelve states from across the US located in Alabama, Arizona, California, Hawaii, Pennsylvania, Texas, and five of the six New England states (Connecticut, Maine, Massachusetts, New Hampshire and Vermont) were selected to participate in the PHOTON2 professional development project. These schools formed eight secondary and postsecondary geographically proximate "alliances."

Project activities included an introductory two-day workshop, a one-semester web-based "Introduction to Optics and Photonics" course, a two-week summer internship with a local photonics company, extensive hands-on experiential learning, and ongoing technical support with curriculum development and implementation from the project principal investigators and a capstone showcase workshop.

Each institution was provided with a 15-chapter text, *Introduction to Photonics and Optics*, that contained the optics and photonics course content, a \$4000 custom optics lab kit that includes a field-tested lab manual with over 30 experiments ranging from simple demonstrations of refraction and diffraction to building and aligning a Michelson interferometer, and two CD-ROM videos in which PHOTON2 instructors provide step-by-step instructions for performing each experiment. In addition to the PHOTON2 lab kit, a supplemental lab kit was developed toward the end of the project to allow for greater student access to the lab exercises. .

During the “no cost” extension year, a third cohort of educators was recruited for an additional section of the “Introduction to Photonics” online course that was offered in the spring of 2007. The PHOTON2 project provided scholarships to the educators who applied for the course and met the application criteria. Twenty-two educators from 11 different states, (Alabama, Connecticut, Iowa, Illinois, Massachusetts, Michigan, North Carolina, New York, Ohio and South Carolina) and one from Romania participated in the online course.

The PHOTON2 project also provided educators with internship experiences in photonics companies and in college/university laboratories. In summer 2005, 24 PHOTON2 teachers/faculty and counselors completed one-to two-week paid internships. Eighteen employers, including photonics companies as well as universities that conduct research in optics/photonics provided internship sites for the PHOTON2 educators. In 2006, nine instructors and one counselor also did a one-to two-week internship with either the same or a new internship host during summer.

In terms of sustainability, the PHOTON2 project has developed a complete set of instructional materials and established a national network of educators that spans across the U.S. and also includes an educator from Romania who was a participant in the online “Introduction to Photonics” course offered in the spring of 2007. These educators along with industry mentors are all members of the PHOTON2 listserv. This listserv has over 100 members and has continued to be in operation after PHOTON2 has ended. It was further expanded to include the participants from NEBHE’s newly funded, PHOTON Problem Based Learning (PBL) NSF ATE project.

The “Introduction to Photonics” distance learning course will be offered again in spring 2008 since the International Society for Optical Engineering (SPIE) awarded the New England Board of Higher Education a \$3000 Education Grant to partially subsidize this new cohort of high school and college science and technology instructors to take the web-based PHOTON2 “Introduction to Photonics” course. Project PIs continue to give presentation about PHOTON2 at conference across the country and abroad.

***Plastics Resources Educators Program (PREP)**

NSF Award No. 0302527 (Advanced Technological Education Program)

\$492,091 July 15, 2003 - June 30, 2006

Timothy E. Weston, Pennsylvania College of Technology

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The Plastics Resources for Educators Program (PREP) has developed a broad range of multimedia instructional reassures on synthesis, structure, properties, applications and processing of plastics. The interactive programs and virtual instruments create an exploratory learning environment that allows students to explore complex multivariable problems. This project is to develop a sustainable dissemination effort that includes workshops for faculty and the construction of workbooks and CDROMs that customize the use of various modules to address educational needs of different audiences. Dissemination is done through a commercial publisher, but marketing is done through faculty contacts, industrial partners, a special interest group associated with the Society of Plastics Engineers and presentations at professional meetings. A PREP Web site is a communications and distribution hub. Formative and summative evaluation of all components is done by a third party evaluator. The interactive electronic materials provide faculty with new ways of teaching. (Previous Award 9950072).

South Carolina Advanced Technological Education Center of Excellence

NSF Award No. 0242550 (Advanced Technological Education Program)

\$425,000 September 1, 2002 - August 31, 2004

Elaine L. Craft, Florence-Darlington Technical College (Updated 11/2/2007)

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The South Carolina Advanced Technological Education (SC ATE) Center of Excellence began as a statewide systemic initiative designed to increase the quantity, quality, and diversity of engineering technology graduates throughout the state’s 16 technical colleges. The effort has now extended beyond South Carolina. An integrated, problem-based curriculum, collaborative teaching strategies, and extensive

active learning techniques together with faculty and student teamwork form the cornerstone of the SC ATE's strategy to recruit, retain, and graduate more students in engineering technology programs. Additional information may be obtained at www.scate.org.

SC ATE has achieved critical milestones on the road to designing and implementing a model of faculty development, program improvement, and curriculum reform, and partners in Texas, Kentucky, and North Carolina are now using the SC ATE model to improved engineering technician education. The key to SC ATE success continues to be reform-ready faculty acting as change agents for development and delivery of innovative engineering technology curriculum and promoting program improvement. SC ATE's critical lesson learned is the proven effectiveness of exemplary faculty leading grassroots reform and the necessity of administrative support to create an environment that supports faculty as change agents.

The Center has identified four critical success factors (essential accomplishments) that guide its work: (a) continuing development and implementation of learner-centered pre-engineering technology and first-year engineering technology curricula; (b) faculty development that supports the most effective teaching methodologies and creates learning environments that model the workplace; (c) recruitment and retention of students, particularly women and minorities; (d) engagement of industry partners in the recruitment, retention, and education process; and (d) development of an effective and seamless pipeline for educational opportunities for students to become well-qualified engineering technology graduates.

21st Century Urban Technical Education Project - Phase II

NSF Award No. 0202399 (Advanced Technological Education Program)

\$900,001 September 1, 2002 - August 31, 2005

William K. Hodgkinson, Milwaukee Area Technical College (Updated 10/5/2007)

www.matc.edu/21CUTEPE

In Milwaukee and the State of Wisconsin too few high school graduates transition into technical careers. A gap exists between the existing supply of graduates and the high wage technical jobs available. The 21st Century Urban Technical Education Project, funded in 1999 by the National Science Foundation, has responded to this problem by creating a new approach to technology education. Focusing initially on the construction trades during Phase I, the current initiative focuses on the application of this technology education model/design to Energy and Power and Transportation. Phase II begins to diffuse this technology education model at three district high schools in the Milwaukee Public Schools in an effort to bring about systemic change in the future. The project continues to prepare technical high school students for technical career opportunities through an articulated 2+2+2 approach and the development of an integrated and connected education model.

This project refines and assesses the template for standards-based educational reform designed and developed in Phase I as part of the construction technology cluster. Phase II addresses the areas of curriculum reform, faculty development, diversity, marketing and recruitment, partnerships, and the integration of applied technology in education. The major partners in Phase II include the Milwaukee Public Schools, the Milwaukee Area Technical College, the University of Wisconsin-Stout, Wisconsin Energy Corporation, the U.S. Department of Transportation, the Association of General Contractors of Greater Milwaukee, and various business, industry, and labor organizations.

Phase II curriculum for grades 11-14 in Energy and Power and Transportation is being aligned to state and national standards. A coordinated secondary and post-secondary teacher training initiative, which is based on the successful NSF/WASDI (Wisconsin Academy for Staff Development Initiatives) project, is being established in collaboration with business and industry for ongoing faculty development. A committee of partners, using a shared decision-making model, is guiding and overseeing technical education initiatives and providing technical training opportunities for staff and students. A career development model and a marketing plan are also being developed and implemented. In addition, research and implementation strategies are breaking down barriers for women and minorities in non-traditional technical careers and supporting and increasing involvement by underrepresented populations. (Previous award 9950046)

Project ProBase

NSF Award No. 0202375 (Advanced Technological Education Program)

\$757,024 July 1, 2002 - June 30, 2005

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Project ProBase (problem-based technology units) developed a standards-based, engineering-related series of instructional units designed for upper-level high school students. The ProBase units are being published and disseminated by the International Technology Education Association (ITEA) as part of its Engineering by Design series. Four of the units are in the Advanced Technological Applications section and four are in the Advanced Design Applications section. The project also developed the ProBase Professional Development Guide, which is also being published by the ITEA. The ProBase series was designed to address the need for advanced-level high school instruction by offering problem-based, constructivist activities and materials. The series consists of eight separate learning units, each with both student and instructor guides. The learning units deliver standards-based concepts through hands-on technical problem-solving activities related to the following areas: information and communication technology; agriculture and related biotechnologies; manufacturing technology; energy and power technology; medical technology; construction technology; transportation technology; and entertainment and recreation technology. The goal of Project ProBase is to provide an engineering and technical base for high school students who plan to continue their education in technical or engineering programs at the community college or university level.

The ProBase units were developed using the "backward design" process advocated by Wiggins and McTighe in *Understanding by Design* (1998). First, enduring understandings were derived from the core concepts identified in *Standards for Technological Literacy: Content for the Study of Technology*. Essential questions were then derived from the enduring understandings to focus each of the learning units. In addition, research-based core bridge competencies were established to deliver the technical base needed by students entering college-level technical and engineering programs. The ProBase units were developed by a panel of experts from across the United States. The units underwent a series of pilot- and field-tests at diverse secondary school sites in a range of geographic areas from Florida to Oregon. The field tests were conducted in real classrooms and laboratories across a broad spectrum of programs and serving students of widely varying ability levels. Regular instructor debriefing sessions, on-site visits, student debriefings, and surveys, guided the refinement of the materials.

The eight student guides and eight instructor guides are available as a package or as individual units. Each nine-week learning unit begins with a robust design problem that is further supported in subsequent learning cycles. The learning units are comprised of four-phase learning cycles that include exploration, reflection, engagement, and expansion activities and materials. The units are designed to use a constructivist approach, allowing students to focus on and design solutions to problems, with minimal constraints. Group work is encouraged to develop collaborative skills in brainstorming and designing solutions to the problems. While the student guide provides the student with problem-based learning experiences, the instructor guide provides the instructor with teaching techniques, laboratory set-up procedures, material lists, planning calendars, assessment guides and rubrics as well as a host of other materials. For a complete description of each unit, contact ITEA at <http://www.iteaconnect.org>.

***RoboEducators Project**

NSF Award No. 0202328 (Advanced Technological Education Program)

\$600,000 July 1, 2002 - June 30, 2005

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The RoboEducators' ATE project was initiated by the faculty in the Engineering Technology Center at American River College in conjunction with staff at the Jet Propulsion Laboratory to create an engaging pathway for student to enter the world of science, technology, engineering, and mathematics (STEM) via robotics competition. The work is a collaborative effort between three regional engineering and technology consortia in California. Through their efforts they have been able to join the Silicon Valley Engineering/Technology Consortia (SVE/TC) and the Sacramento Regional Engineering and Technology Consortia

(SETRC) together with California State University-Northridge (CSUN) to establish the Los Angeles Engineering and Technology Consortia and create/deliver/support a world-class K-12 robotics curriculum. The project has two structural and three functional components. The structural elements are to organize the Los Angeles consortium and expand the interrelationships of the regional consortia in the state to create a pathway for K-16 students engaged in manufacturing and technology careers. Functionally the project builds a standards-based K-12 robotics curriculum to attract and engage students in manufacturing and technology and provide extensive professional development in support of robotics curricula and competitions.

The project is also engaging non-traditional students and teachers in technology careers through robotics courses. Teachers are contracted to develop the curriculum and training materials as well as deliver workshops specific to the needs of a range of teachers from entry through advanced levels. Strong industry support is expected for these training activities that range from conference presentations up to two-week workshops. During the second and third years, a Statewide Robotics Conference is held in the Los Angeles area. Efforts have been directed toward creating an infrastructure to engage middle and high school students along with an audience of K-16. Teachers are delivering and receiving robotics-related professional development through the three regional consortia and their industry partners. The ultimate goal is to continually excite students and engage them in order to encourage them toward careers in STEM. The project is doing this by engaging students in regional and national competitions including Lego League, Bot Ball, Red Rover and Robotics FIRST.

SC ATE Center of Excellence Focal Point for Expanding Excellence in Engineering Technology Education

NSF Award No. 0202272 (Advanced Technological Education Program)
\$900,000 September 1, 2002 – August 31, 2007
Elaine Craft, Florence-Darlington Technical College (Entered 11/2/2007)
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Florence-Darlington Technical College and Piedmont Technical College are collaboratively serving as a national Resource Center for dissemination of educational materials, curricula, pedagogical practice, and recruitment strategies resulting from the highly successful South Carolina Advanced Technological Education Center of Excellence (SC ATE). As a national Resource Center for Excellence in engineering technology education, this partnership serves as a highly visible resource for ideas, materials, contacts, and mentoring focused on recruiting, nurturing, and teaching students at the beginning of the engineering technology educational pipeline where most attrition occurs. The institutions involved were an integral part of the SC ATE Center of Excellence work for the past six years, and the envisioned systemic reform has "taken root." They have the largest number of SC ATE-prepared, reform-ready faculty and the most experience in implementing the SC ATE curricula and fostering numerous other improvements in the teaching/learning environment. These two colleges are carrying this significant statewide work from a base of experience and success in South Carolina to the next level to benefit the greater two-year technical and community college engineering technology (ET) community. The vision of the project is to serve as a national model and clearinghouse to increase the quantity, quality and diversity of engineering technology graduates from two-year ET degree programs.

The goals of the project are to:

- (a) Serve as a national focal point for improvement in ET education;
- (b) Refine and share successful SC ATE recruitment strategies (e.g., ATE Scholars) and share new recruitment strategies;
- (c) Refine and share the SC ATE Technology Gateway (pre-engineering technology) curriculum (three courses) and the SC ATE Engineering Technology Core curriculum, "ET Core";
- (d) Develop multiple course and curriculum scheduling options to increase use of the SC ATE curricula;
- (e) Introduce a pilot electronic version of Technology Gateway to facilitate greater access to ET programs for students for whom a full-time or an uninterrupted course of study is not possible;
- (f) Share insights into organizational change issues that can support or hinder lasting improvement in the teaching/learning environment for engineering technology students;
- (g) Deliver a pilot version of ATE Teaching Team Training via an interactive web-based workshop;

- (h) Leverage the experience of SC ATE's principal investigators, college administrators, and faculty by providing mentoring for others as they adapt and implement SC ATE models or otherwise address the special needs of beginning engineering technology students; and,
- (i) Demonstrate how the processes of project evaluation, program evaluation, and accreditation can be linked to implement total quality improvement in the preparation of students for successful careers in engineering technology and beyond.

A National Focal Point for Education in Nondestructive Testing/Nondestructive Evaluation

NSF Award No. 0101709 (Advanced Technological Education Program)

\$899,990 May 15, 2001 - April 30, 2004

Lester W. Schmerr, Iowa State University (Updated 10/31/2007)

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The Center for Nondestructive Evaluation and six community colleges form a dissemination focal point to enhance the education of technical workers in the fields of nondestructive testing/nondestructive evaluation (NDT/NDE). The project builds upon previous projects that developed a variety of computer-based educational materials. Education for NDT/NDE is fragmented, taking place in various technological studies. The focal point provides an Internet site that informs high school and community college faculty and students about the knowledge and skills required for jobs in NDT/NDE. This web site brings standards, skills, curricula, and job information together in one place. The site also provides a variety of on-line and downloadable educational materials that students and instructors are using to supplement their courses. The materials are being used in related technology programs such as manufacturing, welding, airframe, power plant and chemical processing. The Internet site, which can be found at www.ndt-ed.org, is receiving over 135,000 visits and over 2.5 million hits each month. The project also provides opportunities for faculty development and has provided over 670 copies of instructional materials to NDT instructors. (Previous Award 9602370.)

***Strategic Alliance to Advance Technological Education in Rockford, Illinois Public Schools, Grades 7-12**

NSF Award No. 0053276 (Advanced Technological Education Program)

\$1,500,000 July 1, 2000 - September 30, 2004

Jule D. Scarborough, Northern Illinois University (Updated 3/18/05)

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<http://strategicalliance.niu.edu/>

The primary goal of this project was to improve student achievement in secondary mathematics, sciences, technology, and English (MSTE) education, especially for non-majority students and young women, in Rockford through an alliance between the Rockford Public School District, Rock Valley College (community college), Northern Illinois University, and 300 business, industry, and community organizations. The following objectives provided the operational framework through which to accomplish the goals. The purpose was to motivate and prepare students for technical careers requiring a solid foundation in MSTE.

Objectives:

1. To provide inservice education, training, and technical assistance to secondary teachers. (Refer to program section for description and program content.)
2. To provide inservice education to district school administrators and counselors on change, reform leadership and strategic planning as well as briefer exposure to the teacher development program.
3. To partner with local business, industry, and community organizations to provide teachers (and ultimately students) with exposure to the real world of MSTE problems and applications, authentic contexts, careers requiring MSTE foundations, and information about the higher educational pathways and MSTE requirements to realize access to career clusters.
4. To externally evaluate all project activities, monitor project progress, and to determine the ultimate merit and broader impact of the initiative by a third party evaluator.

5. To produce a systemic reform model for improving MSTE education at the secondary level through business, industry, educational, and community partnerships.
6. To develop teacher knowledge and skills in the use of computer technology for teaching and learning.
7. To develop teacher and counselor knowledge and skills in strategies to assist students to develop post-secondary educational and career plans.
8. To develop a systemic long-term sustainability and continuous improvement plan.

Population: All middle and high school teachers in the Rockford Public Schools who teach mathematics, the sciences, technology or related, and English education.

Outcomes and Products: All outcomes are described, explained, and reported on the project Web site as well as on the CD listed below. Information on the integrated curriculum modules is available through the Rockford Public Schools Web site. Specific outcomes are:

- Professional staff development model and program
- New standards-based integrated interdisciplinary curriculum modules
- Implementation of new teaching models and learning processes
- New performance based or authentic student assessment procedures
- The implementation of computer technology for teaching and learning
- Use of collaborative software to share curriculum across the teacher and school network
- District Web site publishing all curriculum
- New partnerships to enhance the teaching and learning of MSTE
- External evaluation of project, program, and products
- Quasi-experimental data on student achievement during curriculum pilots
- Qualitative data on teacher attitudes and evaluation of activities
- Identification and discussion of major concerns, issues, or problems
- Trends or patterns across projects leading to this initiative
- Recommendations for replication

(Previous Award 895336)

Product:

Scarborough, J. D. (2004). *Strategic alliance to advance technological education through mathematics, science, technology, and English education at the secondary level*. (CD). Washington, DC: American Association for Higher Education.

New York State Curriculum for Advanced Technological Education Project (NYSCATE)

NSF Award No. 0053269 (Advanced Technological Education Program)

\$1,529,984 April 1, 2000 - April 30, 2004

M. David Burghardt, Hofstra University

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www.hofstra.edu/nyscate

This project, under the leadership of Hofstra University, is conducted by a consortium of two-year and four-year institutions, including Finger Lakes Community College, Fulton Montgomery Community College, and New York City Technical College, with cooperation from the New York State Education Department. The NYSCATE project developed and field tested, 13 articulated curriculum modules for grades 9-14 in three overarching areas of technology: bio/chemical technology, information technology, and physical technology (materials and manufacturing). NYSCATE engaged community college, university, and high school faculty, industrialists, state-level policy makers, and NSF ATE Centers of Excellence as collaborators in developing exemplary materials and in unifying secondary and postsecondary segments of the New York State ATE delivery system. The project field-tested its products in New York and three other states to bring a standards-driven, academically integrative, pedagogically contemporary perspective to ATE curriculum and instruction. (Previous Award 9353514)

Bridges to Engineering Education (BEE) Projects

Engineering Contexts and Concepts for Developing and Promoting Students' Higher Level Learning

NSF Award No. 0342028 (Engineering Education)

\$99,997 January 1, 2004 - December 31, 2004

Heidi A. Diefes-Dux, Purdue University (Updated 11/1/2007)

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This Bridges for Engineering Education planning grant project consists of collaboration between the faculty in the Schools of Engineering and Education at Purdue University along with middle and high school (6-12 grade level) teachers with the goal of using engineering contexts and concepts to develop instructional settings (tasks and pedagogy) to promote higher level learning (e.g., abilities to problem solve, reason, create models, and perform critical analysis) for undergraduate students and middle and high school students. The goal is to strengthen and extend existing informal collaborations between Engineering, Education, and K-12 schools to develop a coherent, focused, and integrated research and development program for the purpose of improving the teaching of undergraduate engineering and to use engineering contexts and concepts to enhance mathematics and science education in 6-12 education. This project will involve: (1) Setting the stage for a novel coherent and integrated education program; (2) Development of prototypical model-eliciting activities using engineering contexts and concepts for undergraduate engineering students; (3) Development of innovative pedagogical environments for undergraduate engineering students - small group and class discussions; (4) Development of prototypical model-eliciting activities using engineering contexts and concepts for middle and high school students; and (5) Realization of a framework for a novel coherent and integrated education program.

***Bridges for Engineering Education: Virginia Tech (BEEVT)**

NSF Award No. 0342000 (Engineering Education)

\$100,000 September 1, 2003 - August 31, 2004

Vinod K. Lohani, Virginia Polytechnic Institute & State University (Entered 9/24/03)

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This project seeks to initiate collaborative relationships among engineering and educational faculty at Virginia Tech. The goals are to develop a new degree program in education to enable engineering graduates to earn a master's degree while also qualifying for licensure as technology teachers in the Commonwealth of Virginia, to strengthen pedagogy in freshman engineering courses, and to initiate a collaborative aligning the university's activities with those of corporate stakeholders, K-12 educators, and policy makers to strengthen the infusion of engineering content in K-12 programs in Virginia schools.

WMU Design Center for K-12 Math & Science Learning

NSF Award No. 0315695 (Engineering Education)

\$421,000 July 15, 2003 - June 30, 2007

Andrew Kline, Western Michigan University (Updated 11/02/07)

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The College of Engineering and Applied Sciences (CEAS) and the College of Education (COE), Western Michigan University (WMU), were awarded a planning grant from the NSF Bridges for Engineering Education program in August 2002 to build collaboration between the two colleges. This current project leveraged this partnership to create a Design Center for K-12 Mathematics and Science Learning for CEAS and COE students to continue collaboration throughout the four years of undergraduate learning. Students will experience professional practice in design, teamwork, communication, and leadership skills, and will produce exemplary instructional "hardware" and "software" to support the needs and specifications of K-12 mathematics and science teachers. Student projects developed for this project and other Center materials may be viewed at: <http://www.wmich.edu/engineer/ceee/edcsl/>

The Center provides a structure and an environment for engineering and technology students to develop and grow through design courses. The collaborative activities between students and faculty from CEAS and

COE will result in a Center that supports K-12 teachers and WMU pre-service education students to bring the excitement of engineering and technology into teaching mathematics and science. By exposing engineering and technology students early in the first year to the joys of creation through design and hands-on experimentation in ENGR 101, and a summer design institute for high-school juniors, they can be recruited and retained in the programs. The community service nature of the Center will motivate students, particularly females and ethnic minorities, to remain in engineering and technology. About 51% of Kalamazoo Public Schools students are ethnic minorities, who are traditionally underrepresented in the study of college-level mathematics, science, and engineering disciplines. Two of the project service sites are the Boys and Girls Club and Millwood Middle School, an urban district middle school serving primarily students from low-income families. About 400 WMU students per year participate in volunteer activities through the Student Volunteers Office, with 50% coming from the COE. The Center can add value to the services of these education student volunteers by partnering them with engineering students to develop and implement after-school activities at these two sites to stimulate interest in mathematics and sciences. This project will also initiate new collaborations between WMU faculty, students, and the local community. (Previous award 0230654)

***"How Things Work" - A Model for Introducing Engineering Concepts to Primary Students**

NSF Award No. 0230705 (Engineering Education)

\$99,995 September 1, 2002 - August 31, 2004

Steve Watkins, Robert Mitchill, Kristine Swenson, EvaLee Lasater, University of Missouri Rolla (Updated 9/10/03)

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This project will create educational resources for primary school teachers dealing with technical literacy and to develop significant interactions between engineering programs and K-12 schools. Unfortunately, many K-12 students lose interest and motivation for science, mathematics, and technology early in their school years. Consequently, technical programs and resources dealing with high school students and, to some extent, middle school students are too late in the educational process. Primary school instruction needs a strong technical component that captures the imagination and stimulates interest of students. Too little work is currently being done to develop the technical abilities of primary teachers and to provide level-appropriate resources for our youngest scholars.

The project will build a foundation that connects engineering faculty, programs, and resources to elementary teachers, schools, and students. In particular, a comprehensive, multi-course program in science, mathematics, and engineering for primary teachers is a long-term aim. The specific goals for this planning proposal are to facilitate the collaboration among university faculty in education, engineering, and arts and sciences; to increase pre-college student interest and motivation in engineering concepts by developing an innovative prototype course; and to enhance the synergy among university programs, K-12 curriculum, and Missouri teachers. A fundamental aspect of the plan is to involve university faculty, university students, in-service teachers, and parents as partners in the developments.

The Virginia Middle School Engineering Education Initiative: Teaching Engineering in the Middle Schools

NSF Award No. 0230609 (Engineering Education)

\$100,000 January 1, 2003 - December 31, 2003

Larry G. Richards, University of Virginia

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The award will develop engineering teaching materials which emphasize design for teachers in middle schools. This builds upon the first stage of a long-term multidisciplinary project: the Virginia Middle Schools Engineering Education Initiative (VMSEEI). This will infuse selected engineering concepts and procedures into the context of preexisting science and mathematics classes.

Engineering schools need to develop ways to attract and retain students. Middle school is when we start to lose potential students. In these grades, they make choices that either open or close the doors to advanced

science and mathematics. If we start in middle schools, we can make students aware of engineering, and motivate them to pursue the science and mathematics they need to succeed in engineering programs. The interdisciplinary faculty team is in place, as are engineering students, education graduate students and exceptional local science teachers. Additional middle school teachers are being recruited from local (Charlottesville\Albemarle) and regional (Central Virginia) schools, and teachers-in-training at the Curry School of Education at UVa will participate in this project.

Bridges to Engineering Education

NSF Award No. 0229441 (Engineering Education)

\$100,000 September 15, 2002 - August 31, 2004

Robert C. Wicklein, University of Georgia (Updated 11/2/2007)

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The primary focus of this one-year project is to design and develop a summer engineering education institute focusing on integration of engineering content with mathematics, science, and technology education that could motivate academically qualified high school seniors to seriously consider engineering majors in college. In addition, the institute will seek to build model teams of educators at various levels - teacher educators from mathematics, science and technology education; engineering educators; in-service teachers; pre-service teachers; undergraduate engineering students; and secondary students - to stimulate the inclusion of significant engineering related instructional content within the public school curriculum.

On June 2-13, 2003 the Summer Engineering Institute took place on the campus of the University of Georgia. A total 46 students and faculty participated in the institute (19 secondary students, 13 college students, 6 in-service teachers, 2 teacher educators, and 6 UGA project staff). The high school students and in-service teachers represented two public schools in Georgia. The in-service teachers and the pre-service teachers represented the mathematics, science, and technology education curriculum areas. The students and educators participated in a variety of classroom and laboratory-based experiences along with field trips that focused on engineering concepts to illustrate real-world applications of mathematics, science, and technology. The institute culminated in the presentation and testing of student designed projects to solve an engineering related problem. In addition, in-service teachers presented plans on how they would integrate engineering related content within their class curricula. Project staff will continue to examine the efforts of the students and in-service teachers during the Fall and Spring semesters of the 2003-2004 school year.

Broadening Participation in Computing, Workforce Program

BPC-DP: Collaborative Computing Experiences to Broaden Participation in Computer Science

NSF Award 0540564 (Broadening Participation in Computing, Workforce Program)

\$457,376 March 1, 2006 – February 28, 2009

Holly Yanco, University of Massachusetts Lowell (Updated 11/5/2007)

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Artbotics is a collaboration between the University of Massachusetts Lowell and the Revolving Museum, both located in Lowell, Massachusetts. The program has been designed to allow students to explore the intersection between Art and Computer Science, especially Robotics, through project-based learning, public exhibitions and service-learning experience. Students learn founding principles in both the fields of Art and Computer Science, and put them into practice by creating interactive, tangible exhibits that are displayed in public settings. Programs have been designed for undergraduate students and high school students.

The goals of the program are to increase the participation of women and minorities in computing through the use of innovative and interactive technologies, to broaden student understanding of the field of computing, to introduce computing to the public through art exhibitions of the projects, and to build community with mentoring opportunities for students. A summer workshop on Artbotics for educators will be held in the summer of 2008.

Centers for Learning and Teaching Program

National Center for Engineering and Technology Education

NSF Award No. 0426421 (Centers for Learning and Teaching Program)

\$1,999,914 September 15, 2004 - August 31, 2005

Christine Hailey, Utah State University (Updated 10/26/2007)

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The National Center for Engineering and Technology Education (NCETE) is a collaborative network of scholars with backgrounds in technology education, engineering and related fields with a mission to build capacity in technology education and to improve the understanding of the learning and teaching of high school students and teachers as they apply engineering design processes to technological problems. The Center includes partners with strengths in engineering and in technology education, including four land-grant university doctoral-degree granting partners (Utah State University, the University of Minnesota, the University of Illinois and the University of Georgia), five technology teacher education partners (Brigham Young University, California State University at Los Angeles, University of Wisconsin - Stout, Illinois State University and North Carolina A&T State University) and regional high school district partners.

NCETE is building a community of informed and able researchers and leaders to improve the national capability to conduct research to define the current status of engineering design experiences in engineering and technology education in grades 9-12; to define an NCETE model for professional development by examining the design and delivery of effective professional development with a focus on selected engineering design concepts for high school technology education; and to identify guidelines for the development, implementation, and evaluation of engineering design in technology education.

In the fall of 2005, NCETE selected 12 doctoral students to form the first cohort of fellows in the Center. NCETE has retained 10 of the fellows, all of whom are making good progress toward the completion of their doctorates. In the fall of 2007, NCETE selected nine doctoral students to form the second cohort of fellows in the Center. The collaborative network of scholars in NCETE continues to mature, in part, through the development of a series of four doctoral-level courses taken by the doctoral fellows. The courses focus on cognitive science in engineering and technology education, theoretical foundations of engineering design, and applications of engineering design. This two-year sequence of course represents an important contribution in providing researchers and teacher educators with a foundation in engineering design.

The Center seeks to improve the understanding of the learning and teaching of high school students and teachers as they apply engineering design processes to technological problems. The Center continues to strengthen the research climate across institutional settings. An internal research program has been successful in providing relatively non-threatening experiences in proposal preparation, review, and negotiation, as well as the conduct of small research projects. Eleven projects have been funded and the research findings from these projects are beginning to appear in the literature. Personnel affiliated with the Center have published seven refereed journal articles and presented papers at nearly 40 professional conference sessions, including the International Technology Education Association and the American Society for Engineering Education (ASEE). Scott Johnson presented an invited paper at the Fifth Annual ASEE Global Colloquium on Engineering Education on behalf of NCETE. Also, the editors and many of the authors of chapters in the 2008 Yearbook of the Council on Technology Teacher Education (in press) are Center faculty members.

During the first two years, NCETE conducted tested five site-specific professional development (PD) programs. Each of the sites developed and delivered over 100 hours of PD to technology teachers as well as science and mathematics teachers. The goal of PD has now shifted from the pattern of delivery teacher enhance programs at each of the five sites to the development and pilot testing of an exemplar of professional development for teams of high school science, technology and mathematics teachers. The current development and implementation of a year-long PD program is guided by the earlier collective

experiences of the five sites and by the existing literature. The professional development program is being piloted at multiple sites within the Center with support from internal and external evaluators to improve the understanding of the effectiveness of the program. The current approach provides an opportunity for researchers to study the design and delivery of professional development with a focus on selected engineering design concepts for high school engineering and technology education.

A Center to Develop Nanoscale Science and Engineering Educators with Leadership Capabilities

NSF Award No. 0426328 (Centers for Learning and Teaching Program -- co-funded by other programs)

R. P. H. Chang, Northwestern University (Updated 11/1/2007)

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The National Center for Learning and Teaching (NCLT) in Nanoscale Science and Engineering Education (NSEE) focuses on the learning research and development of nano-science instructional resources for grades 7-16, related professional development opportunities for 7-12 teachers and faculty, as well as building capacity among the NSEE community through an online NSE resource repository. The Center would bring together educators and scientists from several areas of nano-science and engineering research to collaborate with science teachers and doctoral candidates in education on both the development of the resources and research on their efficacy. The PI has prior experience as director of the Materials World Modules project, an NSF-funded curriculum currently in use in several secondary schools across the country. Lead partners in the Center are Northwestern University, Purdue University, University of Michigan, University of Illinois at Chicago and University of Illinois at Urbana-Champaign. Additional partners include Argonne National Laboratory, Alabama A & M University, Fisk University, Hampton University, Morehouse College and University of Texas at El Paso. These additional partners widen the geographic range of the project, expanding opportunities to reach a diverse and currently underrepresented population of graduate students, teachers and ultimately students.

NCLT has a mission to build national capacity in Nanoscale Science and Engineering Education (NSEE) by reaching over 1 million students. This mission calls for the development of a globally competitive national nano workforce and national cadre of leaders in NSEE. STEM and education faculty along with nanoscience researchers from the partner institutions participate in interdisciplinary teams to address the Center's mission and goals. These synergistic efforts are developing NSE curricula and nanoconcepts that are currently being field-tested in 7-16 classrooms as well as with Professional Development programs across the country for 7-12 science teachers and college faculty. NCLT continues to advance its network and resource base within the NSEE community through academia, government labs, and industry. The Center has developed an online educational resource repository for the NSEE community, the NanoEd Resource Portal at www.nclt.us.

Center for the Advancement of Engineering Education

NSF Award No. 0227558 (Centers for Learning and Teaching)

\$12,142,788 January 1, 2003 - December 31, 2007

Cynthia J. Atman, University of Washington (Updated 10/19/07)

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<http://www.engr.washington.edu/caee/>

The Center for the Advancement of Engineering Education (CAEE) is advancing the scholarship of engineering learning and teaching through a partnership of the Colorado School of Mines, Howard University, Stanford University, the University of Minnesota, and the University of Washington (lead). CAEE is a multifaceted Higher Education Center for Learning and Teaching clustered around three core elements: Scholarship on Learning Engineering, the Scholarship on Teaching Engineering, and the Institute for Scholarship on Engineering Education.

The Center's Scholarship on Learning Engineering element includes a cross-institutional longitudinal research study of the undergraduate engineering student learning experience and separate targeted studies of core competencies and concepts central to engineering.

The Center's Scholarship on Teaching Engineering element has created an engineering teaching portfolio program for graduate students that will serve as a model for thinking about teaching decisions in the early stages of the engineering teaching experience and is also studying the teaching decision making of engineering faculty using multiple methodologies.

The Institute for Scholarship on Engineering Education has held three year-long Institutes for engineering faculty and graduate students (47 participants) to build and sustain the community of engineering education scholars. The Institutes are advancing the engineering education research infrastructure by increasing the number of people able to conduct rigorous research and to become leaders in engineering education research and change agents in engineering education.

Control, Networks, & Computer Integration

***RET: Nanofabrication Training and Research Experience for Virginia Teachers**

NSF Award No. 0321851 (Control, Networks, & Computer Integration)

\$30,000 June 1, 2003 - May 31, 2006

Stephen J. Fonash, Pennsylvania State University - University Park (Entered 9/26/03)

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To meet the expanding need for nanotechnology workers, new nanotechnology education programs, courses, and course modules must be developed and delivered to students at all levels. There is a particular need for secondary science teachers to receive hands-on nanotechnology training and research experience so that they are equipped to incorporate nanotechnology principles and concepts into science curriculum. This proposed Research Experience for Teachers (RET) project will provide a three-day hands-on nanotechnology training and research experience to 20 high school science teachers from Virginia at the Penn State Nanofabrication Facility during late March or early April 2003. This project will build upon prior investments by the state of Pennsylvania and the NSF in nanotechnology education in Pennsylvania. The Pennsylvania NMT (Nanofabrication Manufacturing Technology) Partnership was initiated in 1998 by the state of Pennsylvania. It involves more than 30 colleges and universities, secondary schools including vocational-technical schools, and private industry. The NMT Partnership leverages the \$26 million Penn State Nanofabrication Facility, part of the NSF National Nanofabrication Users Network (NNUN), to provide semester-long, hands-on nanofabrication education to students enrolled in associate degree programs in nanofabrication at community colleges and other institutions across Pennsylvania. The NMT Partnership also provides professional development workshops for educators and industry personnel, and summer inano camps in secondary school students. The NMT Partnership is also a NSF Advanced Technology Education Center. The NMT Partnership first began offering professional development workshops for educators at the Penn State Nanofabrication Facility in 1999. To date, 169 educators and industry personnel have attended these workshops. This proposed project builds upon and expands the components of the Pennsylvania NMT Partnership associated with professional development of educators, and will take the NMT Partnership beyond the boundaries of Pennsylvania through an alliance with the Initiative for Nanotechnology in Virginia (INanoVA). INanoVA is a statewide initiative involving higher education, national laboratories, state and local education and economic development organization, and private industry. INanoVA aims to promote collaborative nanotechnology research, commercialization, and workforce education. The University of Virginia provides leadership for INanoVA. The University of Virginia will coordinate recruitment of 20 secondary science teachers from Virginia for the proposed RET workshop, ensuring balanced geographic representation across the state. Penn State will deliver the three-day nanotechnology training and research experience at the Penn State Nanofabrication Facility. The project will be managed by Penn State. The project has clear intellectual merit, as evidenced by the role of the PI in leading the Penn State site of the NSF NNUN, the NSF Center for Nanofabrication Manufacturing Education, the September 11-12, 2002 NSF Workshop on Nanotechnology Undergraduate Education (NUE), and other nanotechnology research and education activities. The project is expected to have broad impact on the science and engineering workforce of Pennsylvania, Virginia, and the nation.

Course, Curriculum and Laboratory Improvement Program

Collaborative Research: Improving Engineering Students' Learning Strategies Through Models and Modeling

NSF Award No. 0717508 (Course, Curriculum, and Laboratory Improvement Program – Phase 3)

\$264,448 September 1, 2007 – August 31, 2011

Heidi Diefes-Dux, Purdue University (Entered 10/17/2007)

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This is a collaborative project involving California Polytechnic State University, Colorado School of Mines, Purdue University, United States Air Force Academy, University of Pittsburgh, and the University of Minnesota-Twin Cities. It is building upon and extending model-eliciting activities (MEAs), a proven methodology developed in mathematics education research and recently introduced to engineering education. MEAs use open-ended case studies to simulate authentic, real-world problems that small teams of students address. MEAs were developed to observe the development of student problem-solving competencies and the growth of mathematical cognition. However, it has been increasingly documented as a methodology to help students become better problem solvers, as well as a tool to help both instructors and researchers better design situations to engage learners in productive mathematical thinking. The investigators are taking the theoretical framework from mathematics education and research results from a series of NSF funded studies and creating a strategic, scalable approach for addressing crucial goals in engineering education. These goals include developing effective, transferable competencies in problem-solving and creativity; more effectively learning and retaining important concepts; and more effectively identifying misconceptions and nurturing positive ethical frameworks. They also are investigating and extending a suite of assessment approaches that have been developed and tested in recent MEA research. Their specific objectives are: (1) to expand the MEA methodology and application, (2) to study students' problem solving strategies and extend the use of MEAs to specific aspects of undergraduate reasoning and problem-solving, (3) to determine solution paths first-year engineering students use in solving MEAs, (4) to execute a comprehensive dissemination and infusion effort, and (5) to develop a comprehensive research agenda for models and modeling in undergraduate education. In particular, they are deepening the implementation of MEAs and related student and faculty assessment in undergraduate curriculum across the six partner institutions; broadening the libraries of usable MEAs to different engineering disciplines; and extending the MEA approach to misconceptions, innovation, and ethical decision-making in engineering. They are disseminating their material and results through papers at conferences and in achieved journals, through CD and web formats with links to the NSDL, through a number of workshops for both engineering educators and K-12 teachers, and through special programs for pre-service teachers at several participating institutions. The evaluation effort, which is led by an outside independent evaluator, is monitoring progress on all five objectives. Broader impacts include the dissemination of the materials and results, the workshops for other faculty, the K-12 teacher outreach, and the positive effects of this engaging approach on students from underrepresented populations.

The Development of a Remotely Accessible Rapid Prototyping Laboratory

NSF Award No. 0536509 (Course, Curriculum, and Laboratory Improvement Program)

\$125,000 June 1, 2006 – May 31, 2009

Ismail Fidan, Tennessee Technological University (Updated 10/5/2007)

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This CCLI Phase 1, Exploratory Project is promoting an awareness of rapid prototyping technology through the development of a remotely accessible rapid prototyping laboratory. This project is: a) introducing cutting edge rapid prototyping technology to 2-year and 4-year engineering technology students, b) increasing overall student diversity in technology education, c) enhancing student learning in advanced manufacturing technologies, d) modernizing laboratory facilities for a wide regional area, e) encouraging undergraduate student research projects, f) creating new opportunities for faculty development, and g) developing educational innovations by contributing a novel 3D printing rapid prototyping knowledge base for Science, Technology, Engineering, and Mathematics (STEM) education. The evaluation plan is focusing on student learning and is also comparing the relative advantages of remote and traditional laboratories. Through this project, many more users are benefiting from state-of-the-art

rapid prototyping technology, thereby better justifying the cost of purchasing and maintaining the overall facility. Furthermore, the project is providing new insights into the strengths and weaknesses of remote access environments for both the design/manufacturing technology and distance education communities. (Previous Award 0311586)

***Technology Literacy Workshop**

NSF Award No. 0444677 (CCLI-Adaptation and Implementation Program)

\$49,988 September 15, 2004 - August 31, 2005

David Ollis, North Carolina State University (Entered 3/16/05)

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A workshop is being conducted to help define the major issues in the effort to address technological literacy at the undergraduate level. Topics of discussion include: identification of successful implementations, obstacles to courses on technology, learning objectives and student outcomes, relevant assessment tools and techniques, strategies for developing a scholarly community in the area, potential means of stimulating growth of interest in the topic, implementation in different types of institutions including community colleges, perspectives and issues concerning women, underrepresented minorities, and considerations regarding inclusion of persons with disabilities. The intellectual merit of this work stems from furthering an understanding of the how to promote technological literacy among undergraduate students. Broader impacts to society will result by the workshop having a direct influence on the ability of undergraduate education to contribute to the development of a technically literate citizenry. A report summarizing the findings of the workshop is being prepared and will be disseminated widely.

***Enhancing Learning in Electronics Engineering Technology**

NSF Award No. 0411022 (CCLI - Adaptation and Implementation Program)

\$75,000 August 15, 2004 - July 31, 2006

William Morales, Valencia Community College

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Valencia Community College is developing coursework for a new Robotics and Simulation specialization within its Electronics Engineering Technology Associate Degree program. The new specialization is incorporating best practices in curriculum and instruction from other institutional models while addressing local industry needs. Site visits are providing information about textbooks and laboratory manuals to be used in the specialization courses, course syllabi, equipment and equipment maintenance, facility modifications to house equipment, lab safety practices, assessment practices, expected competencies, enrollment, faculty training resources, and course scheduling. An independent evaluator and representatives from the program's business advisory committee are providing continuous feedback to achieve maximum effectiveness of the project. The PI and Co-PIs are integrating research on measuring learning outcomes and diversity of learning styles with examples of best curriculum practices to enhance learning among Valencia's underrepresented significantly-minority and economically disadvantaged student population. Project activities include (1) identification of specific assessment practices that are designed to help students develop the skills, dispositions, and knowledge needed to be actively engaged in their academic work; (2) set and maintain realistically high expectations and goals; (3) seek and find connections to and real-world applications of what they're learning; (4) understand and value the criteria, standards, and methods by which they are assessed and evaluated; and (5) work regularly and productively with academic staff and students to help students attain a high quality academic performance.

***Implementation and Enhancement of Internet Based Robotics, Automation, and CAD/CAM/CNC in a New Manufacturing Engineering Technology Curriculum**

NSF Award No. 0410719 (CCLI-Adaptation and Implementation Program)

\$155,648 August 15, 2004 - July 31, 2006

Richard Chiou, Drexel University

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The project is enhancing Drexel's new Manufacturing Engineering Technology (MET) curriculum through the incorporation of state-of-the-art Internet based robotics, automation, and CAD/CAM/CNC technology.

The project is using information and communication technologies to develop real-time control of production processes, which is a key element in creating and deploying global manufacturing enterprises. The project is adapting Internet based technologies that other schools of engineering have developed in robotics, CAD, communication, and information management. Adaptation includes Internet programming, design and production, E-commerce, and advanced manufacturing systems from Industrial Engineering at the University of Iowa; sensor-based intelligent process control, tele-robotics, and machine vision systems and motion control in Mechanical Engineering at Drexel University; E-transactions, and Internet supply-chain and network integration from Industrial Engineering at Arizona State University; Internet based reverse engineering and advanced manufacturing, and artificial intelligence in manufacturing and process optimization from Industrial and Manufacturing at Bradley University; and E-manufacturing, precision, sensor-based manufacturing and automation, and Internet based collaboration and product design from Manufacturing Sciences at Western Kentucky University. Courses are being restructured and new courses developed to support a new Mechatronics laboratory. This is providing students with contemporary practices and hands-on skills for an expanding e-manufacturing sector. The project is integrating Internet based technologies with those at other universities and community colleges in the Greater Philadelphia Region to provide students access to the curriculum that is being developed at Drexel. Distant delivery is enabling students of diverse educational backgrounds to develop technical skills needed to enter the workforce in this emerging technology. The project is targeting women and minority students.

A LEGO™ MindStorms Based Laboratory for Teaching Robotics

NSF Award No. 0410705 (CCLI-Adaptation and Implementation Program)

\$84,998 September 1, 2004 - August 31, 2006

Alexander Leonessa, University of Central Florida (Updated 10/25/2007)

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Interdisciplinary faculty in a Mechanical, Materials Science, and Aerospace Engineering Department are incorporating the use of Lego™ MindStorms robotics kits into several courses to support a new robotics curriculum strand. Principles of multidisciplinary design, feedback control systems, and mechatronics that have typically been treated in a disconnected fashion are being unified under this robotics theme. Modules developed for teaching robotics at Drexel University and Case Western Reserve University are being adapted for this new curriculum; and the approach is enhancing the learning of interrelated concepts from mechanical, electrical and computational systems. Moreover, students receive important tangible feedback from physically experiencing the products of their own work. Finally, the impact of this project is being extended to teachers and students from neighboring secondary schools in the form of a workshop on implementing robotics concepts in their classrooms.

***Practice-Based Manufacturing Education -- Adapting a Learning Factory Approach**

NSF Award No. 0410683 (CCLI-Adaptation and Implementation Program)

\$95,526 October 1, 2004 - September 30, 2006

Constance Ziemian, Bucknell University (Entered 4/16/05)

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The project is adapting and implementing The Learning Factory model developed at Pennsylvania State University, the University of Washington, and the University of Puerto Rico-Mayaguez by creating an on-demand fabrication laboratory to integrate design, manufacturing, and business curriculum. The project is integrating manufacturing topics and equipment within existing core curriculum courses in fluid mechanics and dynamics, solid mechanics, materials sciences, manufacturing processes, fracture mechanics, and computer aided manufacturing, rather than creating new courses. The project is providing appropriate hands-on experiences and practical applications related to important course topics. Syllabi are being coordinated between core classes in order to provide common laboratory experiences for students when they are concurrently enrolled in two or more core courses. Assessment of the project is being coordinated through an independent evaluator who has been part of the original Learning Factory team at Pennsylvania State College. A Haas CNC Machining Center and an EDM Die-sink Machine is being purchased with matching funds provided by the Department of Mechanical Engineering and the College of Engineering. The equipment is the foundation for expanding the laboratory infrastructure, which is providing the opportunity for complementary coverage of fundamental fabrication principles; providing senior design

experiences that simulate real life-product development processes including manufacturing planning, fabrication, assembly and testing of functional products; providing the resource to integrate industry-based projects within undergraduate research; expanding the opportunity to offer programs to industry through the institute's Small Business Development Center; providing accessibility for the Society of Women Engineers to engage fifth graders in annual engineering workshops; and developing outreach programs and activities for K-12 STEM students.

***Development of Educational Materials and Acquisition of Equipment for a Nanoscale to Microscale Engineering Laboratory**

NSF Award No. 0410540 (CCLI-Adaptation and Implementation Program)

\$150,000 September 1, 2004 - August 31, 2005

Luz Martinez-Miranda, University of Maryland College Park

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This project is developing a laboratory curriculum and laboratory based on the concept and facilities of the Materials Testing Instructional Laboratory at the University of Illinois, Urbana-Champaign. The laboratory is providing undergraduate students in the Departments of Aerospace (AERO), Materials Science (MSE), and Mechanical Engineering (MECH) at the University of Maryland (UMD) with an integrated lab experience that connects the nanoscale structure of materials to the macroscopic physical properties. Two experimental systems are being developed, which will facilitate the changes in the curriculum through the use of miniature test specimens: 1) a pair of micro-tensile testers, one for conventional uniaxial testing and one with state-of-the-art biaxial testing capability, and 2) an integrated nanoindentation/AFM testing system. The laboratory curriculum and facilities are being shared across (at least) three Departments at UMD through the use of a common college-wide undergraduate laboratory for the testing and characterization of materials. This sharing of joint undergraduate laboratory facilities across Departments and fields represents a new interdisciplinary view of the undergraduate curriculum that emphasizes micro- and nano-technology, and connection of nanometer and micron scale characterization to macroscopic properties. The curriculum being developed and associated laboratory facilities integrates recent research in materials characterization and testing into the undergraduate curriculum. The research covers the use of atomic force microscopy and nanomechanical testing of materials along with fabrication and testing of micromechanical systems. These techniques and concepts have not been covered in the undergraduate curriculum and represent the transference of current topics and developments into the educational system. The lab modules being developed will expose students to this rapidly developing field and provide training with direct application in modern manufacturing in the areas of microelectronics, packaging, and MEMs. The lab modules and procedures developed in this revised laboratory curriculum will be provided on the web with metadata for indexing in the National Science Digital Library to allow other institutions to either adopt or modify the materials for their own use. This laboratory will benefit close to 400 students a semester, of which approximately 20% are women and 15% are minorities. This laboratory will also aid the extensive outreach activities for high school students already in place at UMD.

***STEM Learning Modules and Technologies Development**

NSF Award No. 0341564 (CCLI- Adaptation and Implementation; Educational Materials Development)

\$350,492 March 1, 2004 - February 28, 2006

D. Millard, Rensselaer Polytechnic Institute

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The project is developing, deploying, evaluating, and disseminating interactive learning modules (ILMs) and web-based educational technologies to help student learn the fundamentals of electrical engineering. Investigators from three other universities, representing a minority institution, a four-year school, and an urban university, are participating in the project. The ILMs, which build on a prior prototype development project, support the "key concepts" of electrical engineering (i.e., areas associated with the PE and FE exams). These ILMs provide illustrative supporting materials for engineering students that can be further used to stimulate interest in K-12 students to consider STEM careers. Deployment also involves a faculty exchange program, allowing faculty partners to "swap" classrooms for a particular topic, and experience diverse teaching/learning environments. Evaluation experts at a separate university will organize and carry

out the evaluation. The materials will be available on the Internet and on CDs and a major publisher has indicated interest in the product. The project team plans a series of workshops.

***A WWW Based Autonomous Robotics Practicum for Engineering Undergraduates and STEM Educators**

NSF Award No. 0341150 (CCLI- Adaptation and Implementation Program)
\$68,214 July 1, 2004 - June 30, 2007
Richard Drushel, Case Western Reserve University
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This project is based on a recently completed CCLI proof-of-concept project that developed an undergraduate autonomous robotics class that was offered via the World Wide Web. In this project a full-development effort producing versions of the class for both (1) engineering and science undergraduates and (2) STEM educators and those studying for careers in STEM education is the focus. In addition to delivering these classes, tools and techniques that may be used to enable the offering of other types of science practica online are produced. Although all responsibilities are shared, primary responsibility for robots and software tools for the courses rest with Wright State University in Dayton, OH and primary responsibility for pedagogy and evaluation rest with Case Western Reserve University, Cleveland, OH. This project directly addresses several of the NSF CCLI merit criteria and impact areas listed in the call for proposals. The work directly serves the educational needs of both science and engineering undergraduates and STEM educators. It also studies how project based courses can be offered online. Because many accrediting boards require project content, knowing how to manage project courses online is a necessary part of moving many degree programs online. This project contributes significantly both to a body of educational material and to the base of knowledge about how to develop effective online materials. The project significantly improves the content and pedagogical preparation of STEM educators. Further, the project is appropriate for and amenable to national distribution and adoption at a wide assortment of educational institutions.

Beyond LEGOs: Hardware, Software and Curriculum for the Next Generation Robot Laboratory

NSF Award No. 0231363 (CCLI-Educational Materials Development)
\$400,194 January 1, 2003 - December 31, 2005
Holly A. Yanco, University of Massachusetts Lowell (Updated 11/5/2007)
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This project provides the tools and assistance that faculty need to create the next generation robotics laboratory at their own institutions: (1) a well-supported research-level hardware platform; (2) an open source software system, Pyro, that abstracts from the details of any particular robot and allows users to explore complex control methods at a high level; and (3) a project-based curriculum integrated with the hardware and software. Course materials are available at <http://www.pyrorobotics.org>. Pyro was awarded the NEEDS Premiere Award for Courseware in 2005.

***Technology Literacy for Non-Technical Majors**

NSF Award No. 0126876 (CCLI-Adaptation and Implementation)
\$84,989 May 1, 2002 - April 30, 2005
David F. Ollis, North Carolina State University (Updated 9/10/03)
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This A&I project seeks to create a technology literacy lecture course and a hands-on laboratory for non-technical undergraduate majors in the College of Humanities and Social Sciences (CHASS), the College of Education, and the College of Management at North Carolina State University (NCSU). The course structure is based on key elements from a successful education venture developed and offered since 1995 at Hope College, Michigan, by Professor John Krupczak. Krupczak's course materials including: (1) lectures on modern technology; (2) a device laboratory; and (3) writing assignments on the impact that a technological device has on social, economic, and cultural aspects of United States society. The project is to adapt Krupczak's Hope College model to an earlier first year engineering laboratory created by the PI. The laboratory contains familiar modern day devices, including bar code scanners, CD-players and

“burners,” FAX machines, the Internet as a virtual device, electric guitars, photocopiers, optical fiber communications, videocameras and VCRs, satellite TV, internal combustion engines, water purifiers and bicycles. The course includes Krupczak’s lecture-demonstration style, integrated with TA-led lab demonstrations and student hands-on exercises. Evaluations include pre/post student attitude surveys, a standard NCSU student course evaluation, and a new course assessment developed by the College of Engineering staff. Student outcomes are measured using Nan Byar’s definition of technology literacy.

Animation and Visualization in Engineering

NSF Award No. 0126874 (CCLI-Adaptation and Implementation)

\$75,081 April 1, 2002 - March 31, 2005

Howard Turner, California State Polytechnic University, Pomona (Updated 11/6/2007)

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Engineering - Civil (54) Visualization and animation are areas of increasing importance in civil engineering practice. The goal of this project is to adapt concepts developed in the Graphics, Visualization and Usability Center at Georgia Institute of Technology, and to implement a modification of these concepts into the civil engineering curriculum at Cal Poly Pomona. The first objective is to introduce static visualization into lower division courses. A second concurrent objective is to introduce real-time 3-D visualization and animation into upper division courses.

Rhinoceros, a 3-D NURBS solid modeling and static visualization tool, is being utilized to accomplish the first objective. Static visualization concepts are being introduced into CE 127 CAD Engine Concepts, a freshman computer graphics class. More advanced concepts and basic animation are being addressed in CE 134 Elementary Surveying, CE 220 Advanced Surveying, and CE 222 Highway Design. Objective two is being accomplished by acquiring 20 graphics accelerated SCSI workstation with static and dynamic visualization software. This equipment is going to be used to modify the spatial positioning systems, photogrammetry and GIS classes. Data are being collected in these classes by global positioning systems and softcopy photogrammetry. These data are going to be used to build computer models with visualization and animation software currently applied in industry. Concurrently, this equipment is being used in senior projects and the comprehensive civil engineering design classes. Students are developing terrain fly-throughs, building walk throughs, earthquake simulations and civil engineering equipment simulations. The visualization and animation techniques are being integrated throughout the curriculum. Students are incorporating these techniques into most senior projects. These senior projects are presented to faculty, students, and industry on College Symposium Day. The impact of visualization and animation techniques on these audiences will assure their inclusion.

The project is expected to reach 3,700 enrolled engineering students. This project addresses both upper and lower division student audiences and integrates new technology into the curriculum of the Department of Civil Engineering enabling student learning and understanding of three-dimensional space. In addition, based on current enrollment statistics approximately 33% or 175 students who are underrepresented minorities are going to be impacted by this project. Finally, the College of Engineering works with a consortium of high schools, and Metropolitan Transit Authority Foundation transportation academies. Through these avenues, the project promises to reach several hundred high school students.

***The Use of Virtual Reality Simulated Accidents to Improve Laboratory Safety through Increased Safety Awareness**

NSF Award No. 9972302 (CCLI-Educational Materials Development)

\$194,541 September 1, 1999 - August 31, 2004

H. Scott Fogler, University of Michigan

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Tens of millions of dollars are lost each year due to accidents in chemical and other laboratories, not to mention the accompanying pain and suffering. University laboratories are worse than industrial laboratories, both because the rate of accidents is much higher and because this is the training ground at which generations of future scientists learn their unsafe laboratory skills.

These accidents continue to occur in spite of extensive safety training programs already in place. One contributing factor is that people only have a limited memory and respect for written rules, and over time tend to either forget their safety training or become complacent about safety rules.

Experience has a much greater impact on the human memory than written text, and therefore people who have experienced laboratory accidents are more likely to remember those experiences, and follow safe laboratory practices as a result, than those who have not. Obviously, however, the idea of deliberately causing accidents in order to improve safety is not an acceptable solution.

Virtual Reality, VR, is a computer interface designed to deliver highly realistic "experiences" that are (ideally) indistinguishable from the real thing. Although this ideal has not yet been achieved, (and probably never will be), many high-end VR simulations are extremely believable, and even low-end systems produce experiences having a much greater impact on the user than written text.

This project is developing a series of VR-based laboratory accidents that give users valuable experience in the safety of their homes, offices, and computing laboratories. These modules graphically illustrate the consequences of disregarding safety rules, using the high impact medium of virtual reality. A World Wide Web framework provides for on-line VRML simulations, extensive support materials, and fast distribution of more rigorous executable programs. Formative and summative evaluations and site testing will determine the optimal effectiveness of virtual accidents for laboratory safety, in order to guide their development and eventual implementation. The modules in the form of CD-ROMs will be distributed to a variety of schools at the end of the project.

Discovery Research K-12 Program

Exploring Content Standards for Engineering Education in K-12

NSF Award No. 0733584 (Discovery Research K-12 Program)

\$300,000 October 1, 2007 - March 31, 2009

Greg Pearson, National Academy of Engineering (Posted 10/11/2007)

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The National Academy of Sciences exploratory proposal aims at assessing the potential value and feasibility of developing and implementing K-12 content standards for engineering education. The specific objectives of this exploratory project, to be carried out by the National Academy of Engineering (NAE), are (1) to review existing efforts to define what K-12 students should know, (2) to identify elements of existing standards documents for K-12 science, mathematics, and technology that could link to engineering, (3) to consider how the various possible purposes for K-12 engineering education might affect the content and implementation of standards, and (4) to suggest what changes to educational policies, programs, and practices at the national and state levels might be needed to develop and implement K-12 engineering standards.

To accomplish these objectives, the project will conduct literature reviews, two commissioned background papers, three meetings of the project committee, and a two-day workshop to solicit expert views on the subject. The principal product of the project will be a peer-reviewed workshop summary report, which will be distributed to key stakeholders and presented in various professional meetings. This report is expected to set the stage for discussions and future actions related to the establishment of engineering standards.

****Learning Progressions for Scientific Inquiry: A Model Implementation in the Context of Energy**

NSF Award No. 0732233 (DR K-12 Applied Research; REESE Programs)

\$2,012,208 January 1, 2008 - December 31, 2009

Fred Goldberg, San Diego State University (Posted 10/11/2007)

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The project's goals are to (1) devise learning progressions for students and teachers in scientific inquiry and its facilitation, with respect to energy, and (2) develop model materials and strategies for grades 4-5 curriculum and teacher professional development.

The research questions are:

1. What constitutes a learning progression in inquiry that builds toward a conceptual understanding of energy? And how can instruction help?
2. What constitutes teachers' progression in their abilities to facilitate scientific inquiry? What scaffolding, instructional activities, and professional development activities support teachers' movement along this progression?

The work is conducted by research teams from San Diego State University and the University of Maryland. Energy will be treated through concepts in the physical sciences in grade 4, the life sciences in grade 5 and earth science in grade 6.

The research will focus on coding students' reasoning about energy concepts by identifying levels of sophistication in argumentation and on their progress in conceptual understanding of energy. The project studies teacher learning through analysis of video data from the professional development sessions, and the degree to which teachers modify instructional practice along with their assessment practices.

****SPIRIT 2.0: Silicon Prairie Initiative for Robotics in Information Technology 2.0**

NSF Award No. 0733228 (Discovery Research K-12 Program)
\$1,067,160 January 1, 2008 - December 31, 2009
Bing Chen, University of Nebraska-Lincoln (Entered 11/2/2007)
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Building on previous ITEST funding, the PI is designing and developing a set of curriculum materials centering on a revised version of the NSF funded TekBot robotics platform developed by Oregon State University. Having added to the TekBot, a new robot, called NUBot is being developed by the Technology Development Corporation of the Peter Keitit Institute of the University of Nebraska. These robots are substantially less expensive than most major commercial kits and use off the shelf parts from local electronics suppliers.

The leadership team creates materials for grades 5-8 that address and assess STEM concepts through a robotics curriculum. The curriculum addresses STEM standards through such documents as the NCTM Focal Points and the Atlas of Science Literacy. There are three problem based ways in which students can use the TekBot: building, moving, and programming. The intent is to scale up to a cyberinfrastructure that supports the national distribution and implementation of the curriculum. The cyberinfrastructure provides for summer workshops, distance education, a means of permitting teachers to identify lesson plans based upon their educational objectives, and an internet on-call technician as means of teacher professional development.

Physical Science Comes Alive: Exploring Things that Go

NSF Award No. 0733209 (Discovery Research K-12 Program)
\$2,406,457 September 1, 2007 – August 31, 2012
Gary Benenson, CUNY City College (Updated 10/5/2007)
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The project seeks to develop four half-year curriculum units that use design of toys and game strategies as starting points for learning concepts of force, motion and energy in grade bands K-2 and 3-5. Classroom implementation, professional development and dissemination planning will be tightly coupled with the development of this curriculum. Because research is lacking in engineering design in the elementary grades, a research team led by Richard Lehrer of Vanderbilt will undertake microgenetic and sociogenetic studies to explore learning trajectories and outcomes, and build a knowledge base that can inform curriculum and professional development. The curriculum is being published online at the City Technology Web site and in print form by Science Source. The materials are very simple, mostly available in typical

schools. Additional products include supply kits, concept inventories for the units, assessments, and materials for the professional development of teachers. Pilot and field tests are planned in 17 elementary schools in Nashville, New York, Los Angeles, Washington DC, and Las Vegas. Teachers carrying out these tests receive 40 hours of professional development.

****STEM Fusion**

NSF Award No. 0733198 (Discovery Research K-12 Program)

\$300,000 August 15, 2007 - July 31, 2010

Kristine Chadwick, Appalachia Educational Laboratory, Inc. (Posted 10/11/2007)

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This project revises and tests integrated STEM modules and an accompanying professional development component that promote differentiated instruction in order to facilitate high school teachers' instruction of 21st Century skills and integrated STEM content. STEM Fusion is a multi-tiered project focusing on the refinement of draft professional resources and the development of teacher skills related to differentiated instruction within integrated STEM instruction.

Project goals include: refining, testing, and finalizing draft curriculum modules in science, mathematics, and engineering; developing, refining, and testing a professional development process that promotes the effective curricular integration of science, technology, engineering and math content into real-world applications; and the use of pedagogical strategies that promote differentiated instruction and standards-based curriculum; and disseminating widely models of effective STEM integration utilizing differentiated instruction in the classrooms through the NSDL database, WVDE communication channels, and a STEM Fusion Web portal.

High school teachers will participate in revising draft modules and testing an implementation model that increases the focus on content and pedagogical knowledge. The STEM Fusion modules will utilize differentiated instruction to assist teachers in diagnosing the differences in readiness, interests and learning styles of all students in the class, using a variety of performance indicators and formative assessments. Participating teachers will apply critical math, science, and technology knowledge while they test and revise tiered lessons during summer learning experiences and in their classrooms. The curriculum, aligned with current West Virginia and national science, technology, engineering, mathematics standards, as well as with 21st Century skills, will be refined, pilot tested, further refined, and field tested. An integral part of the professional development component and the STEM Fusion curriculum will be effective strategies for teaching special needs, ESL, and advanced students. Teachers will be supported by content-expert facilitators, who will guide the module revision and implementation process and group reflection.

Distinguished Teaching Scholars Program

***Teaching and Designing Technology for Diversity**

NSF Award No. 0428935 Distinguished Teaching Scholar Program

\$304,994 July 1, 2004 - June 30, 2008

Alice Agonino, University of California - Berkeley

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A freshman/sophomore service learning class on human-centered design and a senior/graduate level course on engineering education are being developed. The classes incorporate cutting edge research with teaching scholarship as well as highlighting the social context of the engineering profession. In the first course, students are given the option to develop pre-college design activities and serve as student role models in support of initiatives of UC Berkeley outreach programs and San Francisco Bay Area Science Museums that strive to increase the diversity of engineering students (e.g., "Communicating Engineering" in collaboration with the Lawrence Hall of Science, the "TechBridge" program at the Chabot Space & Science Museum and the Pre-Engineering program in Berkeley's College of Engineering).

A minor in Studies in Engineering, Science and Mathematics Education (SESAME) is being developed for all STEM disciplines. The senior/graduate course will serve as the core practice course for the SESAME minor in engineering disciplines. On-line resources in STEM education digital libraries are being cataloged, evaluated and annotated as part of the senior/graduate class in engineering education.

Dissemination is being achieved through contributions to the NEEDS and SMETE.ORG digital libraries and through the SMETE Open Federation's newsletter and discussion groups. Project outcomes are being assessed through several levels of including pre-/post-questionnaires, formative and summative team and peer assessments, professional judgment of process and process, and student satisfaction surveys.

Energy and the Environment: Educating K-16 Students to Improve Energy-Related Technological and Environmental Literacy

NSF Award No. 0428127 (Distinguished Teaching Scholars Program)

\$305,000 July 1, 2004 - June 30, 2008

Susan Powers, Clarkson University (Updated 10/5/2007)

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This project is identifying the knowledge and skills necessary to increase our technical and environmental awareness of energy issues and to improve the implementation of project-based energy and environment curricula in K-16 classrooms, particularly in New York State. There are two primary components of the project: (1) interdisciplinary PhD research that is defining the intersection between technical and environmental literacy related to energy issues and the means of improving the integration of the latest research findings into communication materials to improve our literacy; and (2) the use of this research work for a range of activities that result in the preparation, assessment and dissemination of project-based educational materials for K-16 classrooms.

The research has led to the identification of benchmarks for energy literacy and the development of a middle-high school level survey for its assessment. The survey will be implemented at schools across the country to quantify our current understanding, attitudes and behaviors about energy and to correlate this literacy level to the depth of and pedagogical approaches used in energy related classroom activities.

An energy choices board game has been developed to help students evaluate how the choices they will make in their personal lives will impact the availability of fossil fuel energy and their energy expenditures. This game and other energy related curricular materials are available by contacting the PI.

Teacher workshops have been conducted to disseminate the curricular materials. Workshops are also being conducted for college faculty to expand their interest and capabilities in providing effective K-12 outreach in a manner that is valued by academic institutions.

***Cross-college Collaboration of Engineering with Languages, Education, and Design**

NSF Award No. 0427904, Distinguished Teaching Scholar Program

\$304,999 August 1, 2004 - July 31, 2008

David Ollis, North Carolina State University

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Eight different courses involving seven non-engineering faculty, an education consultant, and the engineering Principal Investigator are being taught based on the READ-USE-ASSEMBLE-CALCULATE-TEACH process related to relevant technological devices. The student-driven sequence incorporates student-faculty contact, cooperation among students, and active learning; gives prompt feedback; emphasizes time-on-task; communicates high expectations; and respects diverse talents and ways of learning. By matching appropriate devices to non-engineering courses with appreciable technical content, cross-college faculty collaborations are being used for co-teaching of or supplementation to existing courses in the College of Humanities and Social Sciences (CHASS), the College of Education (CED), and the College of Design (COD). The efficacy of this cross college collaboration is being demonstrated by serving a diversity of students including (1) engineering and science students in foreign language courses,

(2) pre-service technology education students seeking teaching degrees, (3) in-service, practicing teachers of technology education in grades 6-12, and (4) industrial design majors.

Evaluation of these collaborative instruction efforts includes student questionnaires, independent laboratory observers, and interviews of participating faculty and a sample of students. Dissemination is being accomplished through publications and presentations at professional society meetings of language instructors, technology education teachers, industrial design professionals, and engineers. The final project product will be a compact disc (CD) containing all lab device chapters, as well as all publications and evaluations of this effort. The product CD distribution is being distributed to US engineering deans and engineering faculty involved in undergraduate laboratory instruction.

***Teaching the Grand Tradition of Modern Engineering through Introductory Courses for Engineering Students and for All Other Students in Higher Education**

NSF Award No. 0308549 (Distinguished Teaching Scholar Program)

\$305,000 July 1, 2003 - June 30, 2007

David P. Billington, Princeton University (entered 12/24/03)

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Over a quarter century of research and teaching, the PI and his colleagues have developed an approach to engineering education at the introductory level that reconnects engineering to the liberal arts and attracts new groups of students to engineering. The core of the approach is the idea that efficiency, economy, and ethical and aesthetic choice are all intrinsic to engineering design, not separate considerations superimposed from without. Students come to understand that engineering is not mere technical work but is a creative activity that combines discipline, imagination, and responsible choice. While other approaches that try to link engineering and the humanities have engineering students take more liberal arts courses, the approach that the PI and his colleagues have developed brings out the humanistic potential in engineering itself. Teaching in introductory courses is reinforced through visual understanding, numerical work, and expository writing.

The aim of this project is to disseminate this work nationally through scholarly publication, a structured series of symposia, public lectures, and traveling exhibitions. The NSF award, along with other grants, is enabling the completion of the basic scholarly foundation of the courses. A textbook is being written that completes a three-volume series on the historical development of major American engineering innovations from 1776 to the present. An important article-length work on the transfer of foreign technology to the United States in the twentieth century is also being written, as is the second of two books on the great public works of the twentieth century United States.

The NSF award is also supporting an annual symposium and exhibition that will bring about thirty faculty from other colleges and universities to Princeton each spring. During this project, the PI plans to lecture at schools and in professional gatherings, such as the annual meeting of the American Society for Engineering Education, as a plenary speaker.

The broad goal of the project is to help other schools attract non-traditional students to the engineering profession and to improve the engineering education of all students by teaching its modern tradition of outstanding works.

Teaching through Touching: Using Research to Motivate Education

NSF Award No. 0307656 (Distinguished Teaching Scholars Program)

\$304,888 June 1, 2003 - May 31, 2007

Chris Rogers, Tufts University (Updated 10/23/2007)

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The aim of this project is to make engineering education attractive to students of all backgrounds, races, and gender by including the excitement of open-ended research, i.e. neither student nor teacher knows the right answer. The project utilizes the ROBOLAB toolset, developed by the PI over the past 5 years, which is a combination of LEGO hardware and LabVIEW software and allows students to predict, investigate,

test, and understand math, science, and engineering. ROBOLAB, designed for students of all ages, provides the tools and gives students self-confidence to satisfy their curiosity and to understand math and science. The project combines new directions in both research and education by integrating the virtual world with the real world of ROBOLAB, and tests new informal education efforts, that include integrating math, science, and engineering education with movie cinemas and the Internet. The goals of the project are to investigate how the kindergartner and the university students learn engineering, to enhance the robotics toolset by combining it with the chemical-mechanical planarization (surface polishing process in semiconductor manufacturing) research, and to increase the collaboration of all institutions (K-12 and university) dedicated toward bringing open-ended research problems into the classroom as a teaching method. The project includes education and engineering graduate student teams, a faculty team, some in engineering, some in education, and partners with industry, government institutions, and international science centers, which provide support and dissemination structures for these efforts.

Instructional Materials for Nanoscale Science and Technology

NSF Award No. 0123904 (Distinguished Teaching Scholar Program)

\$305,000 September 15, 2001 - August 31, 2005

Wendy C. Crone, University of Wisconsin Madison (Updated 9/10/03)

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This project aims to create and disseminate instructional materials on nanoscale science and technology for use in undergraduate science and engineering curricula. A text, demonstrations, and laboratory experiments are being developed around the themes of nanoparticles, nanoporous materials, and nanoarchitectures. Examples of nanoparticles include colloidal metals, ferrofluids, semiconductor quantum dots, and artificial atoms. Nanoporous materials include aerogels, dendrimers, micelles, and zeolites. Nanoarchitectures focuses on nanotubes, amorphous metals and quasicrystals, giant magnetoresistance (GMR) structures, LEDs/diode lasers, self-assembly, and surface reconstruction. Collectively, these products illustrate the importance of surface effects, the limitations of scaling laws, and the onset of quantum effects as nanoscale dimensions are approached. They also demonstrate the tools and techniques required for nanoscale studies, including scanning probe microscopes, lithographic and contact printing techniques, and mechanical, electrical, optical, and magnetic characterization of materials and devices. The project is being conducted with assistance from experts from academia, industry, and national laboratories, and with resources from the University of Wisconsin-Madison NSF-supported Materials Research Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces. The inherently interdisciplinary themes of nanoscale science and technology will be adapted for use in a variety of science, mathematics, engineering and technology (SMET) classes through a pair of workshops. A collection of web-based learning objects has been created from the instructional materials that are readily accessible, adaptable, and affordable. Field testing is an integral part of the project and includes volunteers from the full spectrum of post-secondary institutions. Evaluation of the project is being conducted using a variety of tools and techniques. Project participants include undergraduates, graduate students, and postdoctorals, who have the opportunity to contribute to this integration of cutting-edge research and education. The project aims to enhance science literacy and to help attract a diverse group of talented undergraduates to technical careers and to teaching careers.

A key outcome of this project is a set of experiments that have been collected and developed for a *Laboratory Manual for Nanoscale Science and Technology* unique for both its content topic area and the video-based presentation format utilized. The experiments presented are broken into steps with short text descriptions and a video of the procedure or manipulation. The *Laboratory Manual* is available on the Internet at <http://www.mrsec.wisc.edu/edetc/nanolab/index.html> and currently contains 10 experiments with additional experiments in the development and testing phase. These experiments have been used in both high school and college level laboratories and as virtual experiments when laboratory equipment was not available or a student's disability prevented a hands-on laboratory experience. *Science* featured the MRSEC Interdisciplinary Education Group Web site in the August 30, 2002 installation of NetWatch. In particular it drew attention to the video lab manual and noted its applicability to teachers looking to incorporate nanoscale science and engineering into the laboratory and/or classroom. Additionally, the Spring 2003 edition of The American Chemical Society's *Chemistry* included the MRSEC Education and

Outreach Web site in its 'Quick Hits' section. This 'Quick Hit' pointed out the variety of resources available on the Web site, specifically citing the video lab manual.

The *Laboratory Manual for Nanoscale Science and Technology* and other products of this grant and the Interdisciplinary Education Group of the MRSEC have been presented over the past year in forums such as:

- an invited talk and poster at the Joint EC-NSF Workshop on Nanotechnology: Revolutionary Opportunities and Societal Implications in Lecce, Italy
- an invited talk for educators and scientists attending the Nature of Science Symposium at Fermi National Lab.

Gender Diversity in STEM Education

***TECH TEAM: A Project Based Technology Sequence for Middle School Girls**

NSF Award No. 0217199 (Gender Diversity in STEM Education)

\$755,257 October 1, 2002 - September 30, 2005

Betsy Newman, ETV Endowment of South Carolina, Inc. (Updated 9/10/03)

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<http://www.knowitall.org/techteam>

The Educational Television Endowment of South Carolina, in collaboration with the South Carolina Educational Television Network (SCETV), will carry out a program to increase middle school girls' enthusiasm for and understanding of technology and introduce them to women who work in science and technology fields. The project is a three-year pilot program called TECH TEAM that consists of afterschool technology clubs, workshops in computer applications at SCETV and Summer Technology Camps. Partners include the Girl Scouts of the Congaree Area, Inc., the Girl Scout Council of the Pee Dee Area, and the College of Education of the University of South Carolina. In addition to the girls themselves, TECH TEAM will train the club facilitators - teachers and Girl Scout leaders - in video and computer-based technologies, project based curriculum development and techniques for gender equitable education in an annual series of Saturday workshops.

The TECH TEAM project will take place in three South Carolina school districts - the School District of Fairfield County, Richland District One and Marion District One - all of which are considered critical needs districts. Fairfield is a rural county in which 40.8% of the adults have less than a high school education and unemployment is at the second highest level in the state. Marion District One is in a poor, rural area in which 76% of the students qualify for free or reduced lunch, over 50% come from single parent homes and 75% are minority. Richland District One is an urban district. 80% of students are minority and 58% qualify for free or reduced lunch.

TECH TEAM is designed to increase girls' technological fluency through a progressive sequence of technology applications in a hands-on, project based setting. In the first year, 2002-2003, the girls will videotape interviews with local women who work in the fields of science, math, technology and engineering. To locate their interviewees, they will learn and use research skills, including both informal and Internet-based techniques. The girls will edit their videos using a computer-based editing program, and broadcast them to schools across South Carolina via SCETV's Instructional Television Fixed Service (ITFS). They will host two-way call-in shows on the ITFS, allowing students anywhere in the state to respond and ask the girls questions. In the second year of the project, 2003-2004, the girls will create a Web site about TECH TEAM that will be integrated into www.knowitall.org, SCETV's Web portal for teachers and students. The girls will design the layout of their site and publish writing, post videos and contribute to a threaded discussion that will be developed for the site. In addition, each team will design a science service-learning project for their school. Preliminary plans for these projects include the creation of a health and nutrition program based on data the girls will gather from their fellow students, and a school garden consisting of native plants. The teams will report on the progress of their projects on the Web sites. In TECH TEAM's third year, 2004-2005, the girls will create a searchable database of their videos for inclusion on the site, adding dynamic elements that require the use of computer codes, so that they extend their fluency in the use of computer technology. They will learn about SQL (Structured Query Language), and they will develop CFML (Cold Fusion Markup Language) to make their databases Web accessible. In

addition to the afterschool clubs, they will attend a series of Saturday workshops taught by SCETV programmers.

During each summer of the project the TECH TEAM girls will attend a Summer Technology Camps at SCETV's Telecommunications Center in Columbia. The camps will allow all the participants to meet each other, work in SCETV's computer labs, and present their work to an invited audience. Throughout each year a video crew will document the progress of TECH TEAM on videotape and interview the participants. This material will form the basis of a CD-ROM to be produced for teachers' professional development. The CD will be mailed free of charge to every middle school in South Carolina and will be made available nationwide through SCETV's marketing division. Evaluation and assessment of TECH TEAM will be conducted by Dr. Kenneth Stevenson of the College of Education of the University of South Carolina. The impact of TECH TEAM goes beyond gender equity considerations to universal issues of technology education, teacher training, adolescent development, the design of afterschool programs, and partnerships between schools and informal education providers; TECH TEAM will advance understanding of these areas as they apply not only to girls but to all students and teachers.

TECH TEAM has been selected for inclusion in a CLOSER LOOK: MEDIA ARTS 2003, a publication of the National Alliance for Media Arts and Culture. This is an anthology of organizational case studies of media arts organizations that are responding creatively and strategically to change.

The TECH TEAM Web site can be accessed at www.knowitall.org/techteam. Visitors are encouraged to read the girls' journals, join the bulletin board discussion, play science and math games, and gather information about starting a TECH TEAM of their own.

Program for Gender Equity in Science, Mathematics, Engineering and Technology (PGE): (DEM) Bringing Up Girls in Science

NSF Award No. 0114917 (Research on Gender in Science and Engineering)

\$900,001 August 1, 2001 - July 31, 2005

Tandra L. Tyler-Wood, University of North Texas (Updated 11/2/2007)

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Bringing Up Girls in Science (BUGS) is a demonstration project in the Department of Technology and Cognition at the University of North Texas (UNT) College of Education. The goal of this project is to provide educational experiences for girls in grades four and five that will increase girls' interest, participation, self-concept, knowledge, and achievement in the environmental sciences.

During year one, 30 girls in grades 4 and 5 (BUGS participants) will participate in an after school outdoor science lab at Sam Houston Elementary in the Denton Independent School District in Denton, TX. Additional activities will be held at the Elm Fork Education Center, the public education branch of UNT's Environmental Program. Participants for the project will be recruited from across the Denton School district. Female high school students who are enrolled in the Texas Academy for Mathematics and Science (TAMS) serve as mentors for BUGS participants. TAMS provides an opportunity for talented students in mathematics and science to complete the first two years of college while earning a high school diploma. Each TAMS student will be matched with a BUGS participant. TAMS students will also serve as instructional aides for the science lab. The TAMS students will assist the BUGS participants in developing a science project and a hands-on demonstration of a concept in the lab that will be presented to parents and faculty at UNT. An adult mentor from the University of North Texas will serve as a mentor for both the TAMS students and BUGS participant. The adult mentor will provide information on career and educational opportunities in science. A two-week summer experience at the Environmental Education Center of Elm Fork will be provided for the academic year participants.

During the second and third year of the project, BUGS participants and mentors will be joined by girls in special populations at distant sites. Special populations joining the project will include: (1) students with emotional and behavior problems attending Rose Street Day Program and Therapeutic School in Wichita Falls, TX; (2) a school district which serves large numbers of Hispanic and Native Americans students in Bernalillo, New Mexico; and (3) students from a rural school district in Decatur, Texas. The third year of

the project extends implementing change for the future with an additional group, pre-service teachers at the university level. During teacher certification, a required three-hour on teaching diverse students, pre-service teachers will receive instruction on effective instructional strategies for including girls into science. Pre-service teachers will have the opportunity to observe and participate in the science activities.

Family involvement will be ongoing throughout the project. The Denton Public Library will provide career awareness and educational opportunities materials for the parents of BUGS participants. Parent meetings will be held each semester to showcase student work and provide educational and career information.

Through collection and analysis of the project data, the effectiveness of mentoring combined with environmental education grounded in effective teaching practices for gender equity will be determined. National dissemination of learning materials developed by the project will provide electronic field trips in environmental sciences for diverse and/or special needs populations. The results of this project will be incorporated into the pre-service teacher education program at UNT.

Graduate Teaching Fellows in K-12 Education (GK-12)

Teaching through Outreach: The Institutionalized GK-12 Model

NSF Award No. 0538556 (Graduate Teaching Fellows in K-12 Program)

\$475,208 May 1, 2006 – April 30, 2008

Chris Rogers, Tufts University (Entered 10/23/2007)

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This project is an Accomplished Based Renewal of the Tufts' Engineering: the Next Steps (TENS) GK-12 project entitled "Teaching through Outreach: The Institutionalized GK-12 Model" (NSF Award No. 0230840). This project would continue the work begun in the summer of 2003 on Track 2 funding from NSF. The long-term goal is to increase pre-college engineering education on a national scale and see the GK-12 model as one successful way of accomplishing this. Funding for this project will more research to be done on the impact of the GK-12 program on the attitudes and engineering skills of participating fellows. In addition, the project team will gather and disseminate the best practices developed at GK-12 (and GK-12-like) programs across the nation in an effort to increase communication between these groups. This project will continue its partnership with the Malden, MA school system.

Inspiring and Building Tomorrow's Workforce: A Grades 3-12 Engineering Continuum

NSF Award No. 0338326 (Graduate Teaching Fellows in K-12 Education)

\$ 2019785 January 1, 2004 - December 31, 2008

Jacquelyn Sullivan, University of Colorado at Boulder (Updated 10/24/2007)

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This Track 2, GK-12 project builds upon existing relationships and infrastructure developed in a previous GK-12 project with two school districts serving diverse students traditionally underrepresented in engineering and the College of Engineering and Applied Science at CU-Boulder.

The broader impact of the project is very high. Fellows, in partnership with cooperating teachers, are improving STEM literacy in high-needs schools through a grades 3-12 pre-engineering program and are learning to be effective service learning mentors for undergraduate students engaged in K-12 classrooms. Students are from seven high needs, suburban and urban schools, with large minority enrollments.

Part of the intellectual merit of the proposal is that the Fellows will use engineering as a vehicle to integrate math and science learning by K-12 students in the seven participating schools. The Fellows will become "engineering ambassadors," who deliver hands-on engineering curriculum — developed for and available from www.teachengineering.org — that addresses state educational STEM standards and serve as role models for grades 3-12 students to link the study of math and science to future careers in engineering and technology.

Tufts Engineering the Next Steps (TENS) GK12 Project

NSF Award No. 0230840 (Graduate Teaching Fellows in K-12 Education)

\$1,499,795 June 1, 2003 - April 30, 2006

Chris Rogers, Tufts University (Updated 10/23/2007)

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Tufts University is partnering with four schools in the Malden school district in Massachusetts on the Tufts Engineering the Next Steps (TENS) project that focuses on engineering. The primary goals of TENS are: 1) to raise teachers' knowledge of, comfort with, and capability to teach engineering and algorithm design, 2) to increase all students' engineering knowledge and skills, 3) to increase fellows' appreciation for and knowledge about K-12 formal education, teaching, and outreach, and 4) to develop a grade 5-12 community in four schools that is supportive of innovations that integrate engineering and algorithm design. The TENS project focuses on engineering and builds upon an existing GK12 project that worked with a suburban district to explore whether and how teachers might integrate engineering into their classes. The broader impacts of this project include expansion of this successful project into a more diverse setting; good dissemination plans; good university-K-12 collaboration; and an adequate training program. The fellows and teachers work as partners that recognize, capitalize upon, learn about and slowly develop some of the expertise that the other party possesses.

Informal Science Education Program

***How People Make Things -- A Traveling Exhibition**

NSF Award No. 0407355 (Informal Science Education Program)

\$184,645 (July 1, 2004 - June 30, 2005)

Jane Werner, The Pittsburgh Children's Museum

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The Pittsburgh Children's Museum (PCM) is developing a 2,700 sq ft traveling exhibition, "How People Make Things," in collaboration with Family Communications, the producers of "Mister Rogers' Neighborhood." The exhibition will use the factory visit segments from this popular television program, the longest running on PBS, as a jumping off point for engaging children in the processes by which familiar objects are manufactured. PCM is building on its prior success with "Design It!," an after-school program funded by a prior NSF grant. This project extends that work to expose children to the hidden science and technology that form the basis for manufacturing. The exhibition will include the Neighborhood Factory orientation area and sections on Making Things: Designing Things, Forming Things (Additive, Subtractive, Deformational), and Assembling Things. Project collaborators include members of the Carnegie Mellon University Industrial and Engineering Design program and the University of Pittsburgh Learning Research and Development Center UPCLOSE. Broader Impact: The exhibition is projected to reach at least 750,000 visitors in nine museum venues through its nationwide tour; the target audience is families with children ages 3 to 10. Promotion and dissemination will be enhanced by the connection with PBS, which continues to air the "Mister Roger's Neighborhood" program. Partnerships with the AFL-CIO, Catalyst Communications, and Society of Manufacturing Engineers will extend the outreach effort. Special efforts will be made to target girls and underserved audiences.

***Traveling Exhibit on Technology, Imagination and the Future Using the Fantasy Technologies in the Star Wars Movies as Examples**

NSF Award No. 0307875 (Informal Science Education Program)

\$705,953 September 1, 2003 - August 31, 2005

Lawrence Bell, Museum of Science

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Over a three year period, the Museum of Science, Boston will develop a national traveling exhibition and associated programs that will support the goals and standards for technological literacy that were recently articulated in reports by the National Academy of Engineering and the International Technology Education Association. Intellectual Merit. The exhibit will take advantage of the widely known characters and images of future technology from the Star Wars movies to attract visitors and to engage them in learning about

potential technologies that may impact our lives. It incorporates new and adapted interactive devices that will involve visitors in inquiry-based learning about technologies related to frictionless land vehicles, robotic mobility mechanisms, and habitats for living underwater and in space. Broader Impact. The exhibition will reach a large national audience by traveling to the members of the Science Museum Exhibit Collaborative as well as other institutions. Use of popular culture, science fiction and futuristic technology will help attract those who may not be traditional science center visitors. Educational impact will be extended through programming for the public and school groups, including materials for institutions that do not host the exhibition, along with a Web site.

The Franklin Air Show

NSF Award No. 0229721 (Informal Science Education Program)

\$1,221,177 May 1, 2003 - April 30, 2004

Philip Hammer, Franklin Institute Science Museum (Updated 11/5/2007)

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The Franklin Institute Science Museum will develop, install and evaluate "The Franklin Air Show," a 5,000-sq. ft. interactive, permanent exhibition that explores the science and technology of aviation and aeronautics. Taking advantage of nationwide interest in the 100th anniversary of powered flight occurring in 2003, and the institute's collection of Wright Brothers Aeronautical Collection (including a restored 1911 Model B Flyer), "The Franklin Air Show" presents aviation and aeronautical technology as a vehicle for demonstrating basic science principles and the practical application of scientific and technical knowledge through invention, innovation and design. To extend the reach of "The Franklin Air Show," the Institute will disseminate parent and teacher curriculum guides through partnerships with the American Association of Physics Teachers and the Federal Aviation Administration. The exhibit is supported by innovative World Wide Web programming on The Franklin Institute Online, including "Flights of Inspiration" and digitized artifacts from the Wright collection.

***Connections: An Interactive Exhibition on Networking**

NSF Award No. 0229268 (Informal Science Education Program)

\$1,392,319 February 15, 2003 - December 31, 2005

Alan J. Friedman, New York Hall of Science (Updated 3/30/05)

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The New York Hall of Science has completed "Connections," a 3,500-sq. ft. interactive exhibition and related learning resources that introduce visitors to the fundamental technology of networks. "Connections" offers diverse audiences opportunities to explore networks, both natural and human-designed. The exhibition highlights the fundamental characteristics of networks such as their structure, function and adaptability. The project also produces supporting educational resources for families, after-school programs, community groups, students and teachers. Audio-tours are being produced for general visitors and for visitors with visual impairments. The Connections Discovery Lab, a 750-sq. ft. enclosed space adjacent to the exhibition, offers scheduled workshops and drop-in programs.

Technoquest

NSF Award No. 0206403 (Informal Science Education Program)

\$1,821,569 September 1, 2002–August 31, 2005

Raymond J. Vandiver, Oregon Museum of Science and Industry (Updated 11/7/2007)

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On November 11, 2004, the Oregon Museum of Science and Industry (OMSI) presented to the public a transformed Turbine Hall, named for the energy producing machinery used when the building was operated by Portland General Electric and still currently on display. This transformation was made possible through the support of founding donors—the National Science Foundation, the Lemelson Foundation, Intel Corporation, and Vernier Software & Technology—and resulted in over 40 new exhibits, 18 new lab activities, 12 computer stations, and an educator demonstration area, all promoting engineering and technology education.

A key element in the Turbine Hall transformation is a 6,000-square-foot exhibition named *Innovation Station* and funded as part of the “Technoquest” project. *Innovation Station* is a suite of highly interactive, exciting and engaging, hands-on educational exhibits, computer simulations, audio and video components, text, graphics, and artifacts for families, underrepresented groups, school groups, and OMSI’s general audience. The exhibition focuses on how people use technology to change their world and aligns with state and national science standards. It also addresses educational principles established by the International Technology Education Association (ITEA) that emphasize the processes common to all forms of technology. Thematic areas include: The Nature of Technology, Technology and Society, and Design. Ancillary educational materials are disseminated to the general public and to educators via print, the exhibition website, teacher workshops, and professional development workshops for informal science educators.

One of the most popular components of *Innovation Station* is the *Inventors Ball Room*, a 900-square-foot interactive space where children and adults engage in activities that inspire creativity and exercise problem-solving skills. Visitors tinker, explore, build, and invent with different construction materials and hundreds of foam balls. By connecting, manipulating, and controlling self-designed systems, visitors move balls in all directions and deliver them to several enticing targets. Visitors in this area have been building creative systems and using parts and pieces in innovative ways, sometimes in ways unanticipated even by staff—a true indication of inventive minds. The adjacent 750-square-foot Vernier Technology Lab features activities that convey a deeper understanding of the general principles of technology as outlined by the ITEA. Please see the *Innovation Station* website for more information, including images of the exhibition and the summative evaluation report: <http://www.oms.edu/visit/tech/exhibits.cfm>.

***Build Your Internet: An Exhibition to Foster Public Understanding and Participation**

NSF Award No. 0206399 (Informal Science Education Program)

\$981,928 June 15, 2002 - November 30, 2004

Rachel Hellenga, Tech Museum of Innovation

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The Tech Museum of Innovation is producing a 3,000 square-foot permanent exhibition, complementary online activities, and a Design Challenge curriculum to engage visitors in the exploration of Internet technologies. The goals of the project are to enhance the technological literacy of middle school students, provide the general public with tools, experience, and confidence to participate in shaping the future of the internet, and advance the informal science education community through applied research in networked exhibit technology. Two distinct features of the exhibit are: 1) The Smart Museum, a computer network linking gallery and online experiences, and 2) "dynamic content," a set of strategies for rapid exhibit updates that will mirror the changing Internet for the life of the exhibition. The Design Challenge curriculum will be used at the museum, in outreach to classrooms and community centers, and in training sessions for science educators. The summative research will be shared with the science education community via The Tech’s web site as well as professional seminars, publications and conferences.

Skyscraper: Achievement and Impact -- A Permanent Exhibition

NSF Award No. 0206350 (Informal Science Education Program)

\$1,674,618 September 1, 2002 - August 31, 2005

Wayne LaBar, Liberty Science Center (Updated 11/1/2007)

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The Liberty Science Center (LSC), located across the Hudson River from the former World Trade Center, opened in July 2007 a 13,000 square foot exhibition, 30’ tall, about the architectural design and engineering, physics, and urban-related environmental science of skyscrapers. At this size it is the largest and tallest exhibition on skyscrapers in the world. The exhibition is organized around three basic theme areas and is balanced between the advantages and disadvantages of skyscrapers. Visitors enter the exhibit through SKYSCRAPER WORLD, an advance organizer that sets the stage for the exhibit and looks at significant tall buildings around the world. DESIGNS AND PLANS addresses principles in the design and engineering of skyscrapers. THE CONSTRUCTION SITE looks at the science, technology and project management of constructing these structures, while THE BUILDING describes patterns of adaptation in

the ecosystems created by skyscrapers and the green building effort. The exhibit is supported by mediated public programs in LSC and by experiences for school audiences, both at LSC and in local schools. Although "Skyscraper" is primarily an informal learning experience, it has significant linkages to formal in-school programs.

***Elementary, Secondary, and Informal Education: "Invention at Play"**

NSF Award No. 0125417 (Informal Science Education Program)

\$1,513,181 June 1, 2002 - May 31, 2005

Gretchen Jennings, National Museum of American History, Smithsonian Institution (Updated 9/10/03)

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Exhibition Web site: www.inventionatplay.org.

The Lemelson Center for the Study of Invention and Innovation at the Smithsonian's National Museum of American History in collaboration with the Science Museum and the PIE Network has developed an exhibition entitled *Invention at Play*. This is a traveling exhibition in two sizes (3,500 sq. ft. & 1,500 sq. ft.) exploring the value of play and its critical role in the development of creative human beings. Audiences can (1) learn how play fosters creative talents among children as well as adults; (2) experience their own playful and inventive abilities; and (3) understand how children's play parallels processes used by innovators in science and technology. The exhibition is divided into three sections: (1) the "Invention Playhouse" where visitors are offered a variety of creative play activities to help them understand how playing builds creative and inventive skills; (2) "Inventors' Stories" where visitors learn about the playful habits of a diverse group of historic and living inventors—men and women, young and old, famous and less well-known; and (3) "Issues in Invention and Play" where visitors learn about ideas and debates among theorists who have linked inventive processes to children's play. This exhibition is based on documentation collected by the Lemelson Center since 1995 from and about inventors of the past and present, and symposia they have organized to examine the characteristics of innovative processes. This research has led to new insights into remarkable parallels between children's play and the way inventors approach their work.

Complementary educational activities and programs have been developed and documented in an Educational Manual. These programs are aimed at diverse audiences including families, parents, teachers, and other groups in science and children's museums nationwide, and help extend the impact of the exhibit theme beyond the exhibit itself. Programs for teachers can be arranged for each venue. There is also a teachers' manual offering a variety of activities on the themes of inventive play, creative models of problem solving, and exemplary tales of playful events and habits in the lives of interesting American inventors. Randi Korn and Associates (RK&A) have worked with SMM to do formative and summative evaluations for the project. Both the larger and smaller exhibitions will travel to approximately nine museums each between 2003 and 2006. The Association of Science-Technology Centers (ASTC) will manage the exhibition tours.

The Worcester Pipeline Collaborative ASCEND Initiative

NSF Award No 0104710 (Informal Science Education Program)

\$313,732 August 21-2001 - July 31, 2004

Deborah Harmon Hines, University of Massachusetts Medical School Worcester (Updated 11/5/2007)

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The Worcester Pipeline Collaborative (WPC) ASCEND Initiative

The long-term project goal was to enhance scientific literacy in Central Massachusetts by preparing students and teachers interested in science with the necessary skills to be academically successful. This is equally as important to bring about change in an urban community, where biomedical research and health care industries positions are replacing traditional manufacturing jobs.

The ASCEND Initiative offered participants the opportunity to be involved in long-term, academic research projects, summer research projects for high school students and self-directed research projects for middle and high school students competing in local and state science fairs. This initiative also provided support to

continue the WPC Summer Science Camps and After School Science Clubs for middle school and high school students.

***Cyborgs: A Natural History of Machines and Humans**

NSF Award No. 0104691 (Informal Science Education Program)

\$1,881,283 September 15, 2001 - August 31, 2005

Donald K. Pohlman, Science Museum of Minnesota (Updated 9/10/03)

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The Science Museum of Minnesota (SMM) will develop "Cyborgs: A Natural History of Machines and Humans." The Project will result in a national traveling exhibit entitled "Robots and Us", a web site, and a complement of related educational programs focused on the boundaries between humans and their machines and on recent scientific efforts to understand the human body and mind. The 5-6,000-square-foot exhibit will open in February 2004 at the SMM before traveling to the six large museums in the Science Museum Exhibit Collaborative (SMEC), and then will be available for lease by other museums.

***The PIE Network: Promoting Science Inquiry and Engineering through Playful Invention and Exploration with New Digital Technologies**

NSF Award No. 0087813 (Informal Science Education)

\$2,078,635 March 1, 2001 - February 29, 2004

Mitchel Resnick, Massachusetts Institute of Technology (Updated 9/26/03)

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<http://www.smm.org/pie/>

The MIT Media Laboratory, in collaboration with six museums, will develop the "Playful Invention and Exploration (PIE) Network," with the goal of engaging a broader audience in science inquiry and engineering by enabling more people to create, invent and explore with new digital technologies. PIE museums will integrate the latest MIT technologies and educational research into their ongoing public programs. The museums will organize MindFest events, modeled after a two-day event at MIT in 1999, at which youth, educators, artists, engineers, hobbyists and researchers came together to collaborate on invention projects. The PIE Network will disseminate PIE ideas and activities to educators and families nationally.

***What Floats Your Boat? Boat Building, Art and Science**

NSF Award No. 0003630 (Informal Science Education Program)

\$575,093 September 1, 2001 - August 31, 2005

David Beard, Independence Seaport Museum (Updated 3/28/05)

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The Independence Seaport Museum will create "What Floats Your Boat? Boat Building, Art and Science," a 3,000-square foot permanent exhibit that is designed to educate visitors about the science of boat building and design. Concepts such as buoyancy, water displacement, turbulence and drag will be explored through interactives, maritime artifacts, models and oral histories of tradesmen. By using the principles identified by the Family Science Learning Research Project of the Philadelphia/Camden Informal Science Education Collaborative (PISEC), the exhibit will be user-friendly for families with young children. Visitor workstation topics may include boat building, floating, buoyancy, sails, wind and boat shape. Visitors will use science processes while learning through open-ended play and exploration. Creative programs for families and school groups, as well as curriculum materials will support the exhibit. A Web site and technical training manual will also be produced. Four phases of evaluation are planned, and include front-end analysis which will incorporate focus groups with children ages 7-12, and formative evaluation using prototypes of interactives. Remedial evaluation will be carried out once the exhibit opens, and summative evaluation will use tracking and exit interviews to assess learning and understanding.

Information and Intelligent Systems Program

Collaborative Research: Telling the Story – Learning Math, Science and Engineering through Animation

NSF Award No. 0511979 (Information and Intelligent Systems Program)

\$319,186 December 1, 2005 – November 30, 2007

Chris Rogers, Tufts University (Entered 10/23/2007)

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The goal of this project is to introduce the concepts of computing and physics to children (and teachers) through the creation of stop-action and 3D-animated movies. By empowering children with new, usable tools for exploring the world and expressing ideas through animation, and by developing methodologies for incorporating such tools into Science, Technology, Engineering, and Mathematics (STEM) education, this project will broaden the class of students who are not merely exposed to but rather *engaged with* technology. This effort leverages emerging public fascination for computer animation, as well as recent technological advances that have moved the graphics power of yesterday's million-dollar visualization supercomputers into every desktop PC.

A proof of concept of this approach, based on stop-motion animation, has been prototyped by one of the principal investigators. Initial trials have been encouraging: in a high-school physics class for non-college-bound seniors, students who typically skipped class were now attending, some coming even during free time to complete their movies. Through animations, students were able to critically examine their own understanding of the physics and more effectively convey that understanding to teachers. The same technique is also being used to teach reading to 7 year olds and biology to 9 year olds, replacing book reports and lab notebooks with animated stories and documentaries. Informed by this experience, the proposed program will have two arms: one seeks to develop and evaluate teaching methodology based on moviemaking (Tufts University), while the other will advance new 3D computer animation tools useable in the classroom (Princeton University).

Intellectual Merit: New and potentially powerful technological teaching tools are often developed in the absence of strong educational research. This project will use accepted metrics (and develop new ones) to quantify the STEM learning improvement in high school physics as a result of using animations, comparing student understanding in conventional "hands-on" physics classes with those that include movie journaling. Results from this work will not only contribute to our understanding of how students learn physics and computing, but also help bridge the student's experience and intuition with modern scientific theory. Further development of moviemaking tools will allow students to move from the jerky animation of the stop-action world to the smooth animations of modern computer graphics. Unfortunately, existing animation systems are barely usable by professionals, let alone grade-school students. This proposal will address this research challenge by developing inexpensive and robust 3D scanning hardware, point-and-click animation interfaces, and methods for stylized (e.g. cartoon-like) rendering of 3D animation.

Broader Impacts: Anecdotal evidence from the prototype system (gathered over the last three years in five classrooms) already suggests the potential significant impacts of the work. Science-phobic students and computer-shy teachers enthusiastically argue about the underlying physics to improve their movies. Movie making gives teachers a multi-media portfolio to assess student learning and test student pre-conceived models. If formal evaluations agree with this experience, the results of this proposal have the potential to change the way students learn science at all ages, opening up a new channel to students to show their understanding and test their hypotheses. This may lead to innovations in teaching computing, math, biology, chemistry, engineering, and even story telling and literature. (Nonetheless, this study chooses an emphasis on physics education because of established metrics for evaluation in this subject.) Even more broadly, animation represents a new medium of expression – visual rather than written – that is compelling but currently limited to highly skilled professionals. We propose to develop tools that will make animation more accessible both to children and, more generally, to everyone outside the animation industry. Making this technology more widely available has the potential to affect the way we all communicate, learn, work, and play, turning us into media developers rather than media consumers.

Information Technology Experiences for Students and Teachers Program

****Surprising Possibilities Imagined and Realized through Information Technology (SPIRIT) Comprehensive Project for Students and Teachers**

NSF Award No. 0737679 (Information Technology Experiences for Students and Teachers Program)
\$1,195,829 January 1, 2008 – December 31, 2010
Alka Harriger, Purdue University (Entered 10/18/2007)
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Surprising Possibilities Imagined and Realized through Information Technology (SPIRIT) encourages women to pursue computer-related careers so as to provide a better gender balance in the Information Technology (IT) workplace. The SPIRIT project provides sixty-five high school teachers with professional development experiences using Alice, a programming tool that enhances STEM instruction while simultaneously demonstrating appealing aspects of IT. The teachers, along with counselors and students, also learn about a wide range of career options in IT. Before leaving the institute, the teachers develop a plan for using Alice-based lessons in their classrooms during the school year. The SPIRIT team serves as a resource to the teachers throughout the school year as they use Alice to support classroom instruction. It is expected that the Alice interventions will increase the interest level of the students, both for STEM subject areas as well as for IT. The summative evaluation plan is designed to determine if this expectation is met.

****ITEST Learning Resource Center**

NSF Award No. 0737638 (Information Technology Experiences for Students and Teachers Program)
\$2,766,662 October 1, 2007 – September 30, 2012
Joyce Malyn-Smith, Education Development Center (Entered 10/18/2007)
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This project is designed to implement Phase 2 of the ITEST Learning Resource Center at Education Development Center, Inc. Phase 2 emphasizes technical assistance for ITEST projects and building a national dissemination strategy. EDC provides ITEST projects with a comprehensive collection of Technical Assistance tools, resources, and services designed to support and strengthen the ITEST community by developing an understanding of projects' strengths and needs, addressing areas of highest impact, linking projects to existing resources, and building on the contributions of formal and informal learning environments. Technical Assistance deliverables include annual PI Summits, an ITEST web forum, publications, and a variety of informative online events (panel discussions, peer exchanges, webcasts, discussion lists). Individualized technical assistance for new and returning PIs, increased communication with resource centers for related NSF programs, and a more robust dissemination plan are also new features. Finally, ongoing project monitoring continues and contributes to the repository of data on ITEST projects including project models, evaluation plans, impacts, communities served, and participants.

****Learning through Engineering Design and Practice: Using our Human Capital for an Equitable Future**

NSF Award No. 0737616 (Information Technology Experiences for Students and Teachers Program)
\$1,079,985 September 1, 2007 – August 31, 2010
Tirupalavanam Ganesh, Arizona State University (Entered 10/18/2007)
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Arizona State University (ASU) in collaboration with Arizona Science Center, Boeing, Intel, Microchip, Motorola, Salt River Project, AZ Foundation for Resource Education, AZ Game & Fish Department, US Partnership for the Decade of Education for Sustainable Development, Mesa Public Schools, and Boys & Girls Clubs of the East Valley, offer a three-year extracurricular project resulting in IT/STEM-related learning outcomes for 96 participants in grades 7, 8, and 9. The project targets and engages female and minority youth traditionally under-represented in IT/STEM fields in multi-year out-of-school technological design and problem solving experiences. These include summer internships/externships and university research in the science center and industrial settings where participants develop socially responsible solutions for challenging real world problems. The program includes cognitive apprenticeships with diverse

mentors, opportunities to practice workplace skills such as leadership, teamwork, time management, creativity and reporting, and use of technological tools to gather and analyze complex data sets. Participants simulate desert tortoise behaviors, research and develop designs to mitigate the urban heat island, build small-scale renewable energy resources, design autonomous rovers capable of navigating Mars-like terrain, and develop a model habitat for humans to live on Mars. Together with their families participants gain first-hand knowledge of IT/STEM career and educational pathways.

In addition to youth outcomes, the adults associated with this project are better prepared to positively influence IT/STEM learning experiences for under-represented youth. The evaluation measures participant content knowledge, attitudes and interest in IT/STEM subjects, workplace skills and intentions to pursue IT/STEM educational and career pathways to understand participant reactions, learning, transfer and results. Informal curricula developed through this project, field-tested with youth at Boys & Girls Clubs and youth at Arizona Science Center will be available on the project Web site.

CyberTech Computer Science Program to Prepare Underrepresented Students for Careers in the Sciences

NAS Award No. 0423576 (Information Technology Experiences for Students and Teachers Program)
\$1,030,714 October 1, 2004 - September 30, 2008
Laurence I. Peterson, Kennesaw State University (Updated 11/02/07)
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CyberTech is an innovative, highly integrated computer science program targeting 600 students, 60 teachers, and 10 high schools, beginning in the student's freshman or sophomore year and culminating in the completion of AP Computer Science in their junior or senior year. The U.S. Department of Labor employment projections for 2000-2010 predict an increase of 75% in IT jobs requiring a bachelor's degree or higher. Non-white students in America's public schools are rapidly increasing, and represent the majority of students in many localities. They, along with women, are underrepresented in the IT workforce.

The intellectual merit of this rigorous program is based upon the highly qualified faculty at KSU; plans to provide AP certification of high school teachers incorporating research-based strategies promoting inclusiveness, empowerment, cooperative learning, student investigation and inquiry, the critical SCANS workplace competencies and skills, and student success in an exciting and challenging computer science curriculum.

The program was revised and streamlined last year from the original format to accommodate the availability of the high school students in the program. The program now brings students onto the KSU campus for an intense 20-day introductory programming experience (SummerTech) in June between the freshman and sophomore year using either Visual Basic.NET or Alice as the programming language depending upon the student's previous programming experience. Over 95% of the students entering SummerTech have successfully completed the program. Upon completion of SummerTech students take the Advanced Placement Computer Science course in the Fall or Spring semester following the summer programming experience. The AP Computer Science course is team taught at the students' high school by a KSU instructor delivering online curriculum to the classroom and a teacher in the student's high school who has taken both pedagogy and computer science content workshops at KSU. In June 2007, over 200 students participated in SummerTech and over 60% are enrolled in the subsequent AP Computer Science course. We expect more than 250 students to participate in SummerTech 2008.

The broader impact of this highly program is to significantly increase the participation of African-Americans, Hispanics, women, and first-generation college-bound high school students in science careers and to enhance the preparation of their computer science teachers.

***Robotics: Fundamentals of Information Technology and Engineering**

NSF Award No 0423059 (Information Technology Experiences for Students and Teachers Program)
#1,199,328 October 1, 2004 - September 30, 2007
Randal August, Northeastern University (Walter Buchanan, original PI)
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TechBoston and Northeastern University are working collaboratively in this comprehensive project to integrate an innovative robotics curriculum into science, technology, engineering and mathematics (STEM) courses in the Boston Public Schools and in other racially diverse and economically disadvantaged Massachusetts school districts. The project targets 90 STEM teachers in grades seven and eight, each of whom receive 80 hours of summer professional development and 40 hours of follow-up support in leading yearlong after-school robotics programs. More than 1,800 students are participating, with each having 20 to 80 hours of contact time during summer and after school. The project addresses the urgent need to enhance students' interest and performance in STEM courses, while fostering skills that are important prerequisites for IT careers. In the near term, project leaders are helping students in Massachusetts to meet statewide academic standards. Over the long term, the project will help to inspire and prepare a new generation of IT professionals. The project's intellectual merits derive from its innovative delivery platform (i.e. hands-on robotics projects) and its professional development framework (i.e. after-school programs as an incubator for new classroom teaching methods). In terms of broader impacts, the robotics curriculum is aligned with both state and national technology education standards, and the project team is committed to promoting statewide adoption and national replication. Special emphasis is placed on female and minority students. Pedagogical methods are tailored to these students' learning patterns, and strategies are provided to help middle school STEM teachers engage all students, regardless of gender or race.

***Enhancing Science and Technology Education and Exploration Mentoring (ESTEEM)**

NSF Award No. 0422703 (Information Technology Experiences for Students and Teachers Program)
\$868776 September 1, 2004 - August 31, 2007
Anita Komlodi, University of Maryland Baltimore County
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The Enhancing Science and Technology Education and Exploration Mentoring (ESTEEM) project, based at the Center for Women and Information Technology at the University of Maryland Baltimore County (UMBC), is a three-year, youth-based ITEST project that seeks to engage 336 middle school students in information technology (IT) learning experiences related to robotics, digital storytelling, animation, genealogy and nature. The centerpiece of the project is replication and adaptation of the NSF-funded TechBridge curriculum developed by the Chabot Space and Science Center in California. Specifically designed for girls, the ESTEEM project targets underrepresented middle school students from low-income communities in the Baltimore, Maryland area. The program provides quality IT experiences to girls, while also creating opportunity for meaningful participation of middle school boys. The focus of student activities is based on relevant research related to gender equity and STEM education. Six middle schools in the Anne Arundel School District are involved in the project. Students attend a 22-week afterschool program at school sites, participate in a four-week summer immersion experience at the University, and visit local businesses and non-profit organizations on field trips. Teachers at the participating schools receive IT training to introduce IT learning experiences in the classroom. UMBC undergraduate and graduate students in computer science, information systems and computer engineering serve as fellows to provide school support and to work with students in the project activities. Utilizing networks established by the Center for Women and Information Technology, IT role models from the private sector visit schools as speakers and assist in classrooms. ESTEEM has the potential to serve as a youth-based IT model for young girls in particular, and underrepresented middle school students in general.

National Middle School Aerospace Scholars (NaMAS)

NSF Award 0422698 (Information Technology Experiences for Students and Teachers Program)
\$1,193,506 September 1, 2004 – August 31, 2008
Sharon Sledge, San Jacinto College (Entered 10/18/2007)
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San Jacinto College (an Hispanic-serving institution), NASA-Johnson Space Center, and their partners propose a three-year comprehensive project targeting middle grades science, mathematics and technology teachers and students. The National Middle School Aerospace Scholars Program (NaMAS) will increase opportunities for teachers and students in eight states to learn about and experience Information Technology as utilized in the aerospace industry.

Many students and teachers have limited opportunities to learn about and experience IT. Two dramatic events of 2004 -- the Mars rover mission and the President's space agenda speech -- captured the imagination of America's youth, making this an ideal time to use space exploration as a hook for technology education. NaMAS provides a way to leverage this excitement.

One hundred and fifty teachers will each receive 120 hours of professional development and mentoring in IT concepts, skills, applications and pedagogical strategies, all tied to state/national standards. More than 18,000 students will be impacted and approximately 1,500 middle grade students will receive additional instruction through a summer robotics experience. Working in pairs, teachers will participate in four workshops (three at the Johnson Space Center and one online) and facilitate two distance learning events at their schools; they will then integrate their experiences with their classroom instruction.

This broadly disseminated, extensively evaluated project will increase teacher and student understanding of STEM activities and careers. The project will also enhance diversity by specifically targeting schools with high numbers of underrepresented students. The ultimate benefit to society is a more knowledgeable and capable workforce that will help ensure a healthy economy and an enhanced quality of life.

***DAPCEP Engineering and Information Technology Education Project**

NSF Award No. 0322934 (Information Technology Experiences for Students and Teachers Program)

\$896,333 September 1, 2003 - August 31, 2006

Margaret Tucker, Detroit Area Pre-College Engineering Program, Inc.

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The Detroit Area Pre-College Engineering Program (DAPCEP) is a request for a Youth-Based project to engage students in activities that will increase their access to information technology within the context of engineering and increase their opportunities to explore related college and career paths. The students use information technology to solve engineering problems. The focus of the project is on promoting fluency with information technology concepts and skills within the context of engineering. The project targets 120 African American and Latino students and 180 parents in a series of planned courses for 7th and 9th grades in automotive engineering. Students will receive 136 contact hours per year while parents receive 18 contact hours per year. DAPCEP is a three-year initiative to implement a two-year curriculum, with the third year of NSF support being used to support year one of the two-year curriculum for a new cycle. Students participate in the program for two years, 3 hours each Saturday for 6 weeks and for 4 weeks during the summer. Students will have the opportunity to stay on the University of Detroit campus for one of the two years of the project. The project has four major components: recruitment strategies, student courses, parent/guardian workshops and information dissemination.

Instructional Materials Development Program

Engineering is Elementary: Engineering and Technology Lessons for Children

NSF Award No. 0454526 (Instructional Materials Development Program)

\$2,275,620 June 1, 2005 - May 31, 2009

Christine Cunningham, Museum of Science (Updated 10/31/2007)

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<http://www.mos.org/EiE>

The Engineering is Elementary: Engineering and Technology Lessons for Children project is developing lessons to engage students in grades 1-5 in engineering activities integrated with their science lessons. The project addresses the need to develop a broad understanding of what engineers do and the uses and implications of the technologies they create. At the heart of engineering is an understanding of the engineering design process -- a flexible method of solving problems that is parallel to the inquiry process in science. The goals of the project are to increase the level of technological literacy of the students and to increase the understanding of technology and engineering of elementary teachers in order to enable them to teach these subjects to their students. The project is developing 20 units, each of which includes an

illustrated storybook, teacher background materials, teachers guide, assessment tools, student duplication masters, quick cards, references, and resources. The instructional effort is strengthened by the project Web site, posters, teacher professional development materials, and overviews for administrators and other stakeholders. By creating and testing lessons that are closely integrated with elementary science topics and linked to popular and effective science programs, the project strengthens the science program while introducing key engineering concepts and fostering positive attitudes toward engineering in ways that include girls and boys from a wide variety of ethnic and cultural backgrounds. The project seeks to expand children's images of engineering and to broaden their interests and expectations for the future.

Products include storybooks, unit binders, materials kits, a Professional Development guide and a Web site. For more detail please visit www.mos.org/EIE.

Engineering Inquiry-Based Curricula for Technology Education

NSF Award No. 0352504 (Instructional Materials Development Program)

\$1,581,869 April 1, 2004 - March 31, 2008

Julia M. Ross, University of Maryland, Baltimore County (Updated 11/12/2007)

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The University of Maryland, Baltimore County and the University of Maryland, Baltimore, in cooperation with technology education teachers from area high schools and industrial consultants, are addressing the need to increase the awareness of and interest in career opportunities in engineering and technology by developing modular technology education curricula that use real-world engineering applications and hands-on experiences to build students' problem-solving skills and technological literacy. The project is aligned with the International Technology Education Association *Standards for Technological Literacy* as well as the *National Science Education Standards*.

Specifically, we are developing five case studies to be presented in both Web-based and CD formats. The cases use real-world examples and practicing engineers to introduce students to engineering design, analysis and decision-making processes. Inquiry-based learning with hands-on experiences will be used to maximize student interest and understanding. Data will be collected to evaluate how interactive, authentic, problem-solving simulations impact and facilitate student learning. In-service training with the curriculum for technology education teachers will be provided prior to classroom use. In addition, a specific objective of the project is to increase the involvement of women and other underrepresented groups in engineering and technology by providing female and minority role models in the classroom and developing case studies that encourage interest and participation by all groups. Therefore, interest in and awareness of engineering and technology-based careers will also be assessed prior to and after exposure to the new curricula.

The first module, Engineering and Health Care, has been pilot tested by high school technology education students since spring 2005. A case study of hemodialysis is the focus of the module, which is comprised of a number of parts. First, students are introduced to a dialysis patient and his doctor who explain the disease and their experience with the procedure in a professionally produced video segment. The students then go through a series of hands-on activities, demonstrations, and computer simulations where they learn about the factors that influence dialysis. Assessment tools are built into the module and provide electronic feedback to students as they proceed through the module. After successful completion of the content portion of the module, the patient issues an engineering challenge to student teams, asking them to design and build a hemodialysis system that meets specific performance criteria. The students then use the computer module to run a mathematical model of a hemodialysis system in which parameters are varied and performance evaluated. Based on results with the simulator, students choose how to build their system. The systems are then built, tested, and evaluated, providing students with a true design experience. The final segment of the module provides short video segments with the doctor, a dialysis technician, and an engineer each discussing his or her role in the implementation and design of dialysis procedures. Career information is also provided. Engineering in Flight and Engineering Energy Solutions modules are also currently being pilot tested.

Materials World Modules 2002

NSF Award No. 0332499 (Instructional Materials Development Program)

R. P. H. Chang, Northwestern University (Updated 11/1/2007)

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The Materials World Modules (MWM) Program is an inquiry and design based science, technology, engineering and mathematics (STEM) educational program that bridges the gap between traditional science curricula and real-world applications. Created by MWM developers in collaboration with middle school and high school teachers, the modules include digital resources, video-based teacher training workshops, real-time teacher evaluations, comprehensive student assessments and cyberinfrastructure support.

The most recent MWM-2002 series of modules contain concept-based hands-on learning activities that culminate in design projects. Throughout the design project, students demonstrate their conceptual understandings gained from the activities.

Ten modules have been developed and tested: Bonding and Polarity, Materials and the Environment, Motion and Forces: Inquiry into Sports Equipment, Structure and Properties of Matter, Properties of Solutions: Real-World Applications, Biotechnology, Electrical Conductivity, Lights and Color, Environmental Catalysis, and Introduction to the Nanoscale: Surface Area to Volume Ratio. Three additional modules have been developed and will be field-tested during this academic year: Manipulation of Light in the Nanoworld, Nanotechnology, and Apples to Atoms: An Introduction to the Nanoscale.

Evaluation of the materials includes student outcomes, teacher satisfaction and alignment to standards. Other support is sought for large-scale dissemination.

For more information, please visit www.materialsworldmodules.org or contact mwm@northwestern.edu. (Previous Awards 9818861; 9353833)

Assessing Technological Literacy in the United States

NSF Award. No. 0138715 (Instructional Materials Development Program)

\$651,312 April 1, 2002 - December 31, 2006

Greg Pearson, National Academy of Engineering (Updated 10/10/2007)

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The National Academy of Engineering and the National Research Council Center for Education conducted this project, the goal of which was to determine the most viable approach or approaches for assessing technological literacy. Technological literacy includes an understanding of the nature of technology, the design process and the history of technology; a capacity to ask questions and make informed decisions about technology; and some level of hands-on capability related to the use of technology. The project focused on three distinct populations in the United States: K-12 students, K-12 teachers and out-of-school adults. It was overseen by a 16-person committee appointed by the National Research Council in consultation with the National Academy of Engineering. The committee included experts in the fields of engineering, cognitive science, assessment, curriculum development, technology education, informal education, and teacher education. As part of its data gathering, the committee collected and analyzed 28 assessment instruments, held a stakeholder workshop, and commissioned papers summarizing the literature on learning related to technology and engineering. The project report, *Tech Tally: Approaches for Assessing Technological Literacy*, was published in 2006. It contains 12 recommendations for improving assessment in this area. The 358-page report can be read online at the National Academies Press Web site, www.nap.edu; pdf downloads of individual chapters and hard copies of the entire report can be ordered from the same Web site.

Visualization in Technology Education

NSF Award No. 0137811 (Instructional Materials Development Program)

\$923,645 June 1, 2002 - May 31, 2005

Aaron C. Clark, North Carolina State University (Updated 10/10/07)

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Visualization in Technology Education (VisTE) is a standards-based initiative designed to promote the use of graphic visualization tools among students in grades 8-12. By using simple and complex visualization tools, students can conduct research, analyze phenomena, solve problems and communicate major topics identified in the *Standards for Technological Literacy* (STL) as well as topics aligned with national science and mathematics standards. VisTE has forged a national coalition of institutions and individuals committed to the development of these materials, including North Carolina State University, the North Carolina Department of Public Instruction, Research Triangle Institute, the Southern Regional Education Board, and the International Technology Education Association. Over three years, partnership members will create 12 modules reflecting the 20 STL standards and corresponding benchmarks. Combined, the modules will form a discrete course in graphic visualization. However, each of the 12 modules could be used in existing technology education courses as a stand-alone activity. Modules will be pilot tested in SREB "High Schools that Work" sites, selected to provide student diversity and to facilitate the collection of evaluation data. VisTE's final products and outcomes will include 12 standards-based modules (in electronic format) written for a diverse student audience; national dissemination of the materials through teacher training workshops, local and national presentations, and a web site; and a formal evaluation of the project's process and student outcomes.

Product: Wiebe, E. N., Clark, A. C., Ferzli, M., & Petlick, J. H. (2004). *VisTE: Visualization in Technology Education*. (CD). Clifton Park, NY: Thomson Delmar Learning. www.delmarlearning.com

A Proposal to Support the Next Generation of Curriculum Materials in Science, Mathematics and Technology

NSF Award No. 0103678 (Instructional Materials Development Program)

\$6,259,603 July 15, 2001 - June 30, 2008

Jo Ellen Roseman, American Association for the Advancement of Science (Updated 11/6/2007)

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The project is building on prior successful work to: (1) Extend the applicability of Project 2061's criteria for evaluating curriculum materials to the elementary school level and to a greater variety of topics. (2) Produce a collection of instructional components -- research summaries, representations, phenomena and questions/tasks that developers can use to create K-12 goals-based textbooks and other materials that focus on important ideas and skills in science, mathematics and technology. These components are also proving to be valuable to practicing teachers and to those designing preservice courses. (3) Create an expanded set of conceptual strand maps portraying students' growth of understanding for important topics such as weather and climate, basic functions of living things, energy conservation, and electricity and magnetism. This line of work culminated with the publication in April 2007 of 43 new conceptual strand maps in *Atlas of Science Literacy, Volume 2*. In addition, this project also created a public outreach campaign designed to build parents' awareness of science education and the role they can play in promoting their children's science literacy. African American and Hispanic/Latino parents and families were a target audience for the campaign. Development of the campaign began with public opinion/market research, including focus groups and a national telephone survey, and involved formal and informal science education providers in five diverse communities. The campaign included public service announcements for TV and radio, print advertising, brochures, annual public science events in the five communities, and a Web site created in partnership with TryScience.org. All of the campaign materials were produced in both English and Spanish.

Invention-Innovation-Inquiry: Units for Technological Literacy, Grades 5-6

NSF Award No. 0095922 (Instructional Materials Development Program)

\$995,039 September 1, 2001 - August 31, 2005

Kendall N. Starkweather, International Technology Education Association (Updated 10/23/2007)

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I³ is short for Invention, Innovation, and Inquiry: Units for Technological Literacy, Grades 5-6. Invention and innovation are the hallmarks of technological thinking and action as inquiry is for science. The project is designing 8-10 day units that develop technological literacy in students, grades 5-6; developing teaching and learning resources based on selected technological and science literacy standards; and disseminating the units to teachers. Each unit has standards-based content, suggested teaching approaches, and detailed learning activities including brainstorming, visualizing, testing, refining, and assessing technological designs. Students learn how inventions, innovations, and systems are created and how technology becomes part of people's lives. The engineering design process is at the heart of each unit as they seek to integrate mathematics and science. The units are based on *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000).

All units are developed through a rigorous process of writing, expert reviewing, and pilot and field-testing. Each unit is developed using the Understanding By Design approach (Wiggins and McTighe, ASCD, 1999). Then the units are pilot tested by technology education teachers in 5th and 6th grade classrooms. In the final phase units are field tested by general education 5th and 6th grade teachers. After each review, extensive revisions are made resulting in teacher-friendly units that focus on student learning of technological capabilities and understandings.

Through focus groups, site visits, and written reviews teachers have reported that students expanded their understanding of technology, used the engineering design process to solve problems, developed basic design skills, and related mathematics and science to real-world situations. One teacher noted that because of the I³ units her students "can claim a much broader understanding of technological literacy, innovation, inspiration, and invention."

These units are or will be available from ITEA: Invention: The Invention Crusade; Innovation: Inches, Feet, & Hands; Communication: Communicating School Spirit; Manufacturing: The Fudgeville Crisis; Transportation: Across the United States; Construction: Beaming Support; Power and Energy: The Whispers of Willing Wind; Design: Toying with Technology; Inquiry: The Ultimate School Bag; and Technological Systems: Creating Mechanical Toys. Go to the ITEA web site for information – <http://www.iteaconnect.org>.

***Tech*Know: Integrated Instructional Materials for Technological Literacy**

NSF Award No. 0095726 (Instructional Materials Development Program)

\$1,162,031 August 1, 2001 - July 31, 2004

Richard Peterson, North Carolina State University (Updated 3/18/05)

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This project is creating 20 modules of instruction based on technology education problem-solving activities that are part of the curriculum of the Technology Student Association (TSA), and that are consistent with standards for technological literacy as published by the International Technology Education Association (ITEA). Science and mathematics content are included in these middle school and high school TSA activities. The middle school units include Agricultural and Biotechnologies, Cyberspace Pursuit, Digital Photography, Dragster Design Challenge, Environmental Challenge, Flight Challenge, Mechanical Challenge, Medical Technologies, Structural Challenge, and Transportation Challenge. The high school units include Agricultural and Biotechnologies, Desktop Publishing, Film/Video Technology, Manufacturing Prototype, Medical Technologies, Radio Controlled Transportation, SciVis, Structural Engineering, System Control Technology, and Technology Challenge. The project will extend over four years. Materials are being piloted and field-tested by TSA and non-TSA teachers in North Carolina, Florida, Oklahoma and Virginia.

Products:

Peterson, R. E., Shown, T. S., Penick, J., Berenson, S. B., & White, R. (2005). *The TECH-know project: High school student edition 1*. Cincinnati, OH: Centre Pointe Learning.

Peterson, R. E., Shown, T. S., Penick, J., Berenson, S. B., & White, R. (2005). *The TECH-know project: High school teacher's guide 1*. Cincinnati, OH: Centre Pointe Learning.

Peterson, R. E., Shown, T. S., Penick, J., Berenson, S. B., & White, R. (2005). *The TECH-know project: Middle school student edition A*. Cincinnati, OH: Centre Pointe Learning.

Peterson, R. E., Shown, T. S., Penick, J., Berenson, S. B., & White, R. (2005). *The TECH-know project: Middle school teacher's guide A*. Cincinnati, OH: Centre Pointe Learning.

Technology Education Research Conference

NSF Award No. 0090761 (Instructional Materials Development Program)

\$30,000 October 1, 2000 - December 31, 2001

George Nelson, Western Washington University (Formerly at the American Association for the Advancement of Science) (Updated 10/5/2007)

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There is increasing interest in the teaching of technological literacy in schools. Technological literacy is the basis for the development of programs in Advanced Technological Education (ATE) Research into how students come to understand technological concepts lags behind similar research in science and mathematics education. This conference is the second conference of researchers in science and technology education to consider how students learn about technology. The first conference surveyed existing issues. This conference is to discuss specific models that would be useful in technology education and provide some guidance in planning research projects. The research will influence materials development and professional development projects in ATE and Instructional Materials Development.

Product: Papers from this (the second) conference are available in the Project 2061 section of the AAAS Web site at: <http://www.project2061.org/meetings/technology/toc2.htm>. Papers from the earlier (first) technology education research conference are available in the Project 2061 section of the AAAS Web site at <http://www.project2061.org/meetings/technology/toc.htm>.

Technology for All Americans -- Phase III

NSF Award No. 0000897 (Instructional Materials Development Program) and NASA Grant No. NCC5-519 \$1,428,618 September 1, 2000 - August 31, 2005

William E. Dugger, Jr., International Technology Education Association (Updated 11/2/2007)

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Standards for Technological Literacy: Content for the Study of Technology describes what students in the K-12 school system should understand about technology and how they should learn it. Phase III has developed standards for professional development of teachers, both inservice and preservice, standards for student assessment, and program standards. The project builds upon similar nationally developed standards in other disciplines. Previous Award 9626809.

Product: *Advancing excellence in technological literacy: Student assessment, professional development, and program standards*. ISBN 1-887101-03-9. Available from International Technology Education Association, 1914 Association Drive, Reston, VA 20191-1539, <http://www.iteaconnect.org/>

Technology Modules on the World Wide Web

NSF Award No. 9911569 (Instructional Materials Development Program)

\$999,990 July 1, 2000 - June 30, 2004

David T. Shaw, State University of New York at Buffalo (Updated 10/24/2007)

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This project is a collaboration between engineering and technology education faculty members from two SUNY campuses, to design and develop four technology education modules for grades 9 to 12. The modules are accessible through the world-wide web <http://www.eng.buffalo.edu/shaw/>, and also via CD-ROM. For those interested in the teacher's page, I.D. and password can be obtained by writing to dshaw@buffalo.edu. Topics of the modules are (1) safety light system, (2) drying by design, and (3) music in the digital world. The modules allow computer-assisted simulation, and are meant to supplement the

more typical hands-on activities of technology teachers. The primary pedagogic strategy is case-based learning. Each case involves a real-world technology situation, such as design and construct a musical instrument to produce the desired range of notes. Manuals are prepared to guide teachers through cases. National pilot field test sites are integral to the evaluation. The project draws upon materials previously developed in the National Science Foundation's Advanced Technological Education (ATE) program in areas such as information systems and semi-conductor manufacturing. The materials resonate with the national Standards for Technological Literacy and are directly related to technology education content and learning standards of New York's Mathematics, Science and Technology (MST) curriculum, as well as to Project 2061 benchmarks. (Previous Awards: 9818733; 9713363)

Integrated Mathematics, Science & Technology Plus (IMaST Plus)

NSF Award No. 9819002 (Instructional Materials Development Program)

\$1,749,228 July 1, 1999 - December 31, 2003

Franzie Loepp, Illinois State University (Updated 11/06/2007)

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The goal of IMaST Plus was to add a sixth grade curriculum to the previously developed seventh grade (NSF Award No. 9252954) and eighth grade (NSF Award No. 9550546) IMaST program. The 6th grade IMaST curriculum consists of seven, integrated mathematics, science, and technology, standards-based modules and professional development materials designed to enhance teacher and administrator teams' promotion of systemic reform. The 6th grade module titles are: Tools for Learning, Patterns of Mobility, Patterns Within Us, Patterns Around Us, Patterns in Weather, Patterns Above Us and Patterns Below Us; 7th grade—The Body Works, Living On the Edge, Shaping Our World, Manufacturing, and Forecasting; 8th grade—Animal Habitats, Human Habitats, Systems, and Communication Pathways. The IMaST curriculum is available through the RonJon Publishing Company, <http://ronjonpublishing.com/imast.html>.

***Learning by Design: A Middle School Science Curriculum**

NSF Award No. 9818828 (Instructional Materials Development)

\$1,805,373 September 1, 1999 - August 31, 2003

Janet L. Kolodner, College of Computing, Georgia Institute of Technology (Updated 9/10/03)

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Learning by Design (LBD) is a project-based inquiry approach to middle school science. Students learn science content, scientific reasoning, and project skills in the context of achieving design challenges. The investigators have developed a series of modules for middle school science that engages students in studies of earth science and physical science. Modules in each science cover about half the school year and half of the national standards in each science and are used instead of the standard way of covering the material. Informed by cognitive science research, each module uses complex realistic engineering design challenges, hands-on investigation and problem solving, collaborative learning and student reflection to promote deep learning of essential concepts and critical thinking skills. Students attempt a rough solution to a design challenge. During class discussion, gallery walks and pin-ups (presentations), students compare and contrast solutions and identify what else they need to learn for success. Students then engage in cycles of experimentation, evaluation, and revision of the design. The earth science challenges address earth's surface processes (erosion, accretion, water runoff) and geology (rocks and minerals, land forms, map reading, underground water). Challenges include designing and building a working model of an erosion management system and making suggestions about tunnel locations and methodologies for digging. Physical science challenges address force and motion and mechanical advantage. Challenges include designing and building a parachute, designing and building a miniature vehicle and its propulsion system that can go over several hills, and designing and building a machine to lift a heavy object. Assessments are designed to measure student achievement on standard measures and to measure student growth in scientific reasoning. Dissemination is by presentation of research on how teachers can use design to facilitate students learning of concepts. Choice of an established publisher for publication and broader dissemination is underway. (Previous Award 9553583.)

PI Conference for NSF Projects in Technology Education, Washington, DC, November 18-19, 1998

NSF Award No. 9816812 (Instructional Materials Development Program)

\$40,879 October 1, 1998 - September 30, 1999

Franzie Loepp, Illinois State University (Updated 11/6/2007)

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The goal of the PI Conference for NSF Projects Related to Technology Education was to create and enhance linkages among Advanced Technological Education (ATE), Instructional Materials Development (IMD) and Teacher Enhancement (TE) programs. A conference was held in Washington, D.C. on November 18 and 19, 1998. Approximately 40 principal investigators had the opportunity to "showcase" their projects. Selected leaders from the ATE and technology education communities were invited to participate as well, NSF program officers presented on "Relationships Among ATE, IMD and TE Projects." Panels of three principal investigators addressed issues such as: "Developing standards-based curricula," "Strategies for enhancing the impact of projects," and, "Working with publishers." A rapporteur listened throughout the conference and made reflective comments concerning the issues addressed. He also made recommendations for further research. Based on the rapporteur's report, panelists' one-page comments and reports, and the conference evaluation, the following article was prepared and published:

Custer, R. L., Loepp, F., & Martin, G. E. (2000, Fall). NSF funded projects: Perspectives of project leaders.

Journal of Technology Education, 12(1). Downloaded from

<http://scholar.lib.vt.edu/ejournals/JTE/v12n1/custer.html> September 15, 2003.

Making the Case for Technological Literacy

NSF Award No. 9814135 (Instructional Materials Development Program)

\$600,000 September 15, 1998 - August 31, 2002

William A. Wulf, National Academy of Engineering (Updated 9/10/03)

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The National Academy of Engineering and the National Research Council's Center for Science, Mathematics, and Engineering Education propose to increase public awareness for the need for technological literacy. This is achieved through three workshops and a symposium to define technological literacy, its importance to the nation and how it is best achieved. The workshops and commissioned papers on Teaching, Tools and Resources, and Implementing Technological Literacy facilitate constructive dialogue and information exchange among the principal stakeholders -teachers and educators in K-16, instructional materials developers, businesses and foundations. The four interconnected challenges to achieving technological literacy are a.) increasing the public understanding of technology, b.) infusing K-12 teaching with technology-relevant curricula, materials, assessments and teacher resources, c.) creating stronger and more meaningful links among educators, policy-makers, industry leaders and foundations, and d.) effectively integrating educational technology into the classroom. The outcome is a widely disseminated, visible, well supported document that "makes the case" for technological literacy and a plan for achieving it.

Product: *Technically speaking: Why all Americans need to know more about technology*. ISBN 0-309-0862-5. Available from National Academies Press, 500 Fifth Street NW, Lockbox 285, Washington, DC 20055, <http://www.nap.edu/>

Children Designing and Engineering

NSF Award No. 9730627 (Instructional Materials Development Program)

\$1,155,507 July 1, 1998 - June 30, 2002

(\$45,000 additional funding from Learning Links Conference)

Patricia Hutchinson, The College of New Jersey (Updated 11/13/2007)

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<http://childrendesigning.org>

The Children Designing and Engineering™ Project has developed twelve contextual learning units for grades K-5. The units apply a design and technology approach to real-world activities derived from the

work of partner businesses and industries. Representative of state and national standards for science, mathematics and technology, the units are intended to increase the scientific and technological literacy, capability, and responsibility of all students. The units for grades K-2 and 3-5 (six each) are based upon subject matter that is both interesting to young learners and relevant to business and industrial settings in such areas as communication, transportation, food production, safety and security, health, utilities, and industries. Each unit is comprised of a Scene-Setting Video or CDROM Storybook; a Teacher's Guide with lesson plans, technical instructions and teaching aids; a guided student portfolio; and a kit of tools, student resource booklets, and consumable materials. Through a subsequent grant from the State of New Jersey, formative and summative evaluation materials on CDROM have also been developed for some units.

The project demonstrates the potential of business, industry, and engineering communities to assist curriculum developers and educators in creating and disseminating integrated science, mathematics, and technology materials. During the NSF-funded stage of the project, *TIES Magazine* and the New Jersey Chamber of Commerce played critical roles in publicizing the development process and creating a diverse network of supporters. Since completion of field-testing and revision of the units, the New Jersey Business and Industry Association and the College of New Jersey Development Office have joined forces to support dissemination of the CD&E Program. As a result of this effort, the first 35 of seventy K-5 teachers in the Hamilton Public School District (Mercer County, NJ) received professional development and implemented CD&E during 2002-2003. According to personal correspondence, many of these teachers continued to use and adapt the CD&E approaches into 2007. Since 2003, New Jersey teachers in the Washington Township District; Trenton Schools; Ewing Township Schools; West-Windsor-Plainsboro Schools; Clinton Schools, North Wildwood; Green Brook; and Bordentown have received inservice and implemented CD&E units. In 2003 twenty teachers in the Toms River School District received professional development to prepare them to introduce CD&E through the district's Gifted and Talented Program and have subsequently implemented and adapted a number of units. Additionally, during the summer of 2003, 13 Philadelphia teachers received professional development in preparation for a two week CD&E summer camp for 150 students. Data on student learning gains as a result of this project were gathered and impressive results are available, fleshed out by records of observations and anecdotal findings. On the basis of these results, the Philadelphia project was extended to include an after-school program for the 2003-05 school years and expanded summer camps through 2005. CD&E units are in use in schools in New York, Ohio and Virginia.

In partnership with the Boys and Girls Club of Trenton and Mercer County (BGCTM), the College of New Jersey received a \$250,000 grant from the Martinson Family Foundation in late 2004 to implement a three-year (2005-2007) after school and summer camp program for 5- to 8-year-olds at the Boys and Girls Club's Trenton headquarters. The project also provided free professional development for twenty Trenton teachers and New Jersey Boys and Girls Club personnel during the summers of 2005 and 2006. As a result of these inservice courses, after school programs were begun with outside funding at three Trenton elementary schools.

Evaluation of learning of specific science and technology concepts taught during the 2006 BGCTM summer camp was undertaken as a pilot study, with funding from the State of New Jersey. Findings of this study guided evaluation of the 2007 summer program, and initial results indicate good understanding of concepts, especially at upper levels. Analysis of 2007 data is still underway. Over 250 children at the BGCTM participated in the CD&E programs from 2005 to 2007. Funding to expand the program to six satellite sites through 2010 and incorporate a middle school program is now being sought.

The Children Designing and Engineering units are available through Designed World Learning, LLC (www.designedworldlearning.com).

Products:

Learning Links - New Insights into Learning: Implications for Education and Business. Papers presented at the Learning Links Conference January 20, 2000.

"Children Designing and Engineering," *TIES Magazine*, May, 1999

"Saying It with Light," *TIES Magazine*, November, 1999

"Paper from Paper, not from Trees," *TIES Magazine*, May, 2000

" Ocean Spray: Berries by the Bog-full," *TIES Magazine*, March/April, 2001

"Designs on the USA," *Designing Magazine* (UK), May, 2001
"Transfer of Technology Education to the US: A Case Study," (with Ron Todd) *Proceedings of the DATA Millennium Conference*, England, 2000.
"Children Designing and Engineering," *Proceedings of the CRYPT Conference*, England, 2001.
"Children as Designers and Engineers," *Proceedings of the PATT Conference*, Scotland, 2003.
"Children Designing and Engineering" presentations were made at ITEA Conferences in 1999, 2000, 2001 and 2003.

Instructional Modules, K-2 (Selected modules are available from Designed World Learning, LLC
www.designedworldlearning.com)

Bright Ideas Playhouse (communication)
Earth Friendly Greeting Cards (recycling-based manufacturing)
Gerbusters & Co. (health and hygiene)
Opening Day at the Safari Park (entertainment and tourism)
Waterworks for Watertown (utilities)
Cranberry Harvest Festival (Agriculture/food production)
Draft versions were developed during 2005 and 2006 of two new units form implementation at the Boys and Girls Club:
A Playground for our Club (piloted 2006)
Aquarium Adventure (piloted 2007)

Instructional Modules, 3-5 (Selected modules are available from Designed World Learning, LLC
www.designedworldlearning.com)

Camp Koala (entertainment and tourism)
Juice Caboose (Agriculture/food production)
Paper Towels-A Kidsumer Report (recycling-based manufacturing)
Say it with Light, Inc. (communication)
Suds Shop (health and hygiene)
Solar Energy Savers (utilities)

Videos:

Communicating with Light
Cranberry Farm
Safari Park Tour
From Paper to Paper

CDROMs:

Gina the Germbuster (scene setter, guided instruction)
Germbusting Evaluation Instruments (formative and summative)
Greg the Groundhog Explores Shadows (scene setter, guided instruction)
Bright Ideas Evaluation Instruments (formative and summative)

***Designs II: A Middle School Physical Science and Technology Course**

NSF Award No. 9730469 (Instructional Materials Development Program)
\$1,385,314 May 1, 1998 - October 31, 2002
Philip M. Sadler, Harvard University
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DESIGNS is a one year, middle school, physical science and technology course. It is based upon engineering design projects previously developed and tested. "Design-under-constraint" challenges, in which students creatively optimize the functioning of existing devices and processes, are alternatives to traditional and discovery-based experiments. The challenges have been found to significantly change students' science process skills and change their preconceptions. The course addresses the physical science content standards of the science standards through challenges in the construction of batteries, bridges, electromagnets, solar heating and a gravity car. Each challenge begins with student construction of a standard device. The students are challenged to optimize the performance of a variable that has a large

range. The construction takes little time and the outcome is tested publicly. Students are asked to predict results of trials and explain the outcomes. Teachers are involved in the development and testing of the materials. The materials are distributed commercially. (Previous Award 9452767)

Standards for Technology Education Technology for All Americans Project

NSF Award No. 9626809 and NASA Grant No. NCC5-172 (Instructional Materials Development Program and Advanced Technological Education Program)

\$1,460,720 December 15, 1996 - November 30, 2001

William E. Dugger, Jr., International Technology Education Association (Updated 11/2/1007)

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Standards for technology education are needed to complement the national standards in mathematics and science. The first phase of the project articulated a rationale and structure for the study of technology -- a vision for the intellectual domain for technology education and its interface with science and mathematics. The International Technology Education Association (ITEA) published *Technology for All Americans: A Rationale and Structure for the Study of Technology*, which has gained consensus and acceptance by the technology education community and other constituencies. An advisory board of people with national reputations in various fields was utilized in the developmental process.

The report of the first phase of this project, *Technology for All Americans: A Rationale and Structure for the Study of Technology*, describes a model of technology conceptualized in terms of processes, knowledge, and contexts. The processes include designing and developing technological systems; determining and controlling the behavior of technological systems; utilizing technological systems; and assessing the impact and consequences of technological systems. Knowledge bases are the nature and evolution of technology; linkages based on impacts, consequences, resources, and other fields; and technological concepts and principles. Contexts of technology are informational systems; physical systems; and biological/chemical systems.

The report identifies dimensions that are the basis of technological literacy for all students. They are (a) Nature of Technology, (b) Technology and Society, (c) Design, (d) Abilities for a Technological World, and (e) The Designed World. There are 20 standards that span these five dimensions.

Using these components of technological literacy as a basis for analysis, phase two of this project developed content standards for what technological concepts and processes students should know and be able to do in Grades K-12 with benchmarks at Grades 2, 5, 8, and 12. An advisory group assisted the project in the best practice for developing the standards. Three teams, consisting of representatives from technology education, both teachers and technologists, as well as representatives from science, mathematics, and engineering, some of whom were involved in developing other standards, provided input for the content. The standards were compiled by a small project staff. Input and consensus were developed by presentations to diverse groups interested in education, by mail, and at www.iteaconnect.org. Third party evaluation was used to monitor the content and the process to assure that the standards are useful in a variety of contexts. Previous Awards: 9355826; 9641641.

Product: *Standards for technological literacy: Content for the study of technology*. ISBN 1-887101-02-0. available from International Technology Education Association, 1914 Association Drive, Reston, VA 20191-1539, <http://www.iteaconnect.org>

***World in Motion II: The Design Experience, Challenge II**

NSF Award No. 9450278 (Instructional Materials Development Program)

\$1,796,038 September 15, 1994 - October 31, 1997

John Boynton, Society of Automotive Engineers

The engineering design experience – designing, constructing, testing and evaluating, and communicating – is incorporated in three 6-8 week units for middle school students. Each unit is based on a technological

challenge that requires students to work as a design team to build and present their solutions to the challenge.

The design challenges include development of a toy, a vehicle, and an amusement park ride at grades 6, 7, and 8, respectively. The materials engage students in authentic engineering challenges that become the context for learning mathematics, science, technology education, social sciences, language arts concepts, and skills appropriate to middle school students. The students, teachers, and community members form learning teams in which students assume various engineering and marketing roles.

The products include print materials, hands-on kits, and videos and videodisk reference materials, complemented by software tools. The materials are brought to schools by engineers from industry who interact with the students and teachers as they engage the challenges.

***Professional LINKS Project**

NSF Award No. 9450249 (Instructional Materials Development Program)

\$766,368 October 1, 1994 - November 30, 2000

Keith Finkral, The College of New Jersey (Updated 9/10/03)

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The purpose of the Professional LINKS Project was to determine the efficacy of a collaborative effort between selected professional magazines and classroom teachers for producing curricular materials and strategies designed to (1) increase the scientific and technological literacy, capability and responsibility of all students as citizens of tomorrow, and (2) harness the potential of teachers and the power of professional magazines for developing and disseminating integrative science, mathematics and technology (S/M/T) materials (grades 6-12) nationwide on a timely and continuing basis. This effort would determine if the proposed approach should be continued on a longer term basis in order to (3) improve and prepare the materials for commercial distribution nationally, and (4) add to the research base regarding the role of design and technology and integrative S/M/T activities in changing teacher instructional behaviors and in enhancing student engagement, learning and performance.

During the project, with the development of the Internet, it became obvious that the materials and other work that had been accomplished would be more accessible if it were available electronically. Attention was given to (1) designing and developing an interactive Web site to support the development, publication, and dissemination of LINKS materials; and (2) placing materials on the LINKS web site and pilot-testing the LINKS Web site and support systems. Participants, who were trained in the WebQuest model developed at San Diego State University, indicated that it was more productive to develop curricular materials in a more conventional manner and have the materials reconfigured by curriculum developers who had more WebQuest experience. Information on the LINKS project and materials is available at www.tcnj.edu/~links.

Based on the experience gained through the Project, outreach activities were implemented through collaborative work with the Institute for Electrical and Electronic Engineering (IEEE) and PTC (Parametrics Technology Corporation). Through this experience and support, the LINKS team was able to secure outside funding to continue their work in developing Exploring Design and Engineering materials for use at the middle and high school levels.

Products:

Middle School Modules

Pack it up... Ship it Out! Students explore packaging, package engineering, the manufacturing process and the packaging industry.

Community by Design. Students explore traffic control, sound barriers and bridges.

The Big Thrill! Dream it, Plan it, Build it. Students design and build a model of a new theme park.

Materials & Processes. Students investigate concepts, processes, structures, classifications and use of materials.

High School Modules

Digital DJ Students explore sound, lighting, electronics and computer control technologies used in the music entertainment world.

Ready...Set...Sail! Students dive into the world of marine activity in the design of yachts and marinas.

Xtreme Automata Students investigate mechanisms and electrical circuits to build historic and current automatic devices.

Capstone Course Students design, develop and construct solutions to advanced design problems.

Publications:

Hutchinson, P. & Maskell, K. (1995). Introducing the Professional LINKS Project. *Ties Magazine* (7).

Todd, R., Hindhaugh, J. & Brotherhood, T. (1995). Control technology: Classroom theatrics. *Ties Magazine* (8).

Gordon, K. (1996). Agritechnology: Symbiotic systems growing concerns. *Ties Magazine*, (8).

Hutchinson, P. Senechal, K. (1996). Play's the thing. *Ties Magazine* (9).

Finkral, K. & Gordon, K. (1996). Child's play. *Ties Magazine* (9).

Todd, R. & Hughes, T. (1996). Project LINKS: Teaching control technology. *The Technology Teacher* (55).

TSM Integration Project (Formerly Integrating Middle School Technology Education Activities with Science and Mathematics Education)

NSF Award No. 9150085 (Instructional Materials Development Program)

\$412,771 June 1, 1991 - February 29, 1996

James LaPorte & Mark Sanders, Virginia Polytechnic Institute & State University (Updated 10/10/2007)
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A primary purpose of this project was to develop middle school activities in which students would apply principles of technology, science, and mathematics in the solution of real-world “engineering” (design under constraint) problems. Each activity included a “Design Brief” and a robust set of instructional materials for each of the three teachers—technology, science, and mathematics—involved in the teaching of these interdisciplinary activities. The activities were developed by teachers and curriculum writers from all three disciplines, and field tested thoroughly by teams of teachers across the U.S. Though designed for interdisciplinary (technology education, science, and mathematics) teaching teams, the instructional materials may be implemented in a technology education laboratory by a technology teacher willing and able to address all or some of the suggested science and mathematics components. Among the outcomes from this project was the publication of *TSM Connection Activities* and, more recently, *Engineering & Design Applications*. Both are collections of “engineering design” activities (as described above) that integrate technology education, science, and mathematics principles and instruction in the middle school. Each of these design activities challenge students to design, construct, and evaluate solutions to real-world “engineering” problems, and include detailed instructional suggestions for technology, science, and mathematics content.

Commercial Publications:

LaPorte, J. E. & Sanders, M. E. (2007). *Engineering & design applications: STEM*. Woodland Hills, CA: Glencoe/McGraw-Hill. 300pp. ISBN #9780078768125 MHID #0078768128. This unique book contains 9 robust engineering design activities designed to integrate content from each of the STEM disciplines. These include Pick-and-place Robot, Composite Beam, Cabin Insulation, Wind-powered Generator, Electromagnetic Crane, Rocket, Pollution-Free Vehicle, Hydroponic System, and Digital Photography. Each activity contains: (1) a design brief; (2) extensive science, technology, engineering, and mathematics content; and (3) thorough, detailed suggestions and explanations for teachers who seek to implement these integrative STEM instructional activities.

LaPorte, J. E. & Sanders, M. E. (1996). *Technology, science, mathematics connection activities: A teacher's resource binder*. Peoria, IL: Glencoe/McGraw-Hill. ISBN #0-02-636947-8. This is a 400 page binder with six activities: Power Boat; Composite Beam; Cabin Insulation; MagLev Vehicle; Plant Plant; and Rocket. Each section includes a design brief and detailed instructional suggestions for technology, science, and mathematics teachers.

Academic Publications:

- Brusic, S. & Sanders, M. E. (2000). Articulated curriculum vignette from grades K-12. *In Standards for technological literacy: Content for the study of technology*, pp. 215-219. Reston, VA: International Technology Education Association.
- Childress, V., LaPorte, J. E., & Sanders, M. E. (1994, March). The technology, science, mathematics integration project: Technology, science, and mathematics teachers working together. *TIES Magazine*, pp. 30-35.
- LaPorte, J. E. & Sanders, M. E. (1995). Technology, science, mathematics integration. In E. Martin (Ed.), *Foundations of Technology Education*. Yearbook 44 of the Council on Technology Teacher Education. Peoria, IL: Glencoe/McGraw-Hill.
- Sanders, M. E. (2003). *Interdisciplinary approaches to teaching technology education*. In K. Helgeson and A. Schwaller. (Eds.). *Selecting instructional strategies for technology education: Yearbook #52 of the Council on Technology Teacher Education*, pp. 65-86. New York: Glencoe/McGraw-Hill.
- Sanders, M. E. (1994). Principles # 11: Technology education content is best delivered in an interdisciplinary mode. *ASCD handbook*. Reston, VA: Association for Supervision and Curriculum Development.
- Sanders, M. E. (1994). Technological problem-solving activities as a means of instruction. *School Science and Mathematics*. 94(1) 36-43.
- Sanders, M. E. (1993). Science and technology: A new alliance. *Science Scope*, 16(6), 56-60.
- Sanders, M. E. & Binderup, K. (2000). *Integrating technology education across the curriculum*. Reston, VA: A monograph of the International Technology Education Association. Available: <http://www.iteawww.org/mbrsonly/TEresources/>
- Sanders, M. E. (1993). Science and technology: A new alliance. *Science Scope*, 16(6), 56-60.
- Sanders, M. E. & Binderup, K. (2000). *Integrating technology education across the curriculum*. Reston, VA: A monograph of the International Technology Education Association. Available: <http://www.iteawww.org/mbrsonly/TEresources/>

***Phys-Ma-Tech (Originally Frontiers of Applied Physics - High School Teaching Modules)**

(Renamed by Teacher Participants and approved by NSF)

NSF Award No. 8953369 (Instructional Materials Development Program)

\$498,733 August 15, 1989 - January 31, 1993

Jule D. Scarborough, Northern Illinois University (Updated 9/25/03)

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Only a small fraction of American high school students today take physics. Recognizing this, a partnership of University professors, high school teachers, and industrial scientists and engineers developed teaching materials and strategies to enhance secondary-level physics education through the integration of mathematical and technological applications into the curriculum. Instructional materials needed to accomplish this were defined, developed, and piloted in a number of cooperating school districts, and disseminated. Materials developed included suitable laboratory experiments. High school physics, mathematics, and technology teachers worked together on the project to insure that materials were appropriate for integrating these disciplines and to meet the needs of students across a broad spectrum of the secondary student population. Industrial scientists and engineers participated fully in the preparation of the materials; they helped define pertinent examples of current technology, provided access to industrial laboratories and other facilities, and shared insights on future directions of technological development. The modules are still relevant today and the results continue to be supported by more recent projects.

Products:

Because of the connection between this project and a more current one, information on this project is available on the Web site of the Strategic Alliance (Award 0053276) at

<http://www.ceet.niu.edu/orgs/nsfstali>

Hardcopy available for check out: Illinois Office of Education Services, 2450 Foundation Drive., Suite 100, Springfield, IL 26703 (phone: 800-252-4822 or 217-786-3010)

ERIC (Clearinghouse on Adult, Career, and Vocational Education) ED 355 366. Full text of curriculum and research and evaluation results. 728 pages

Publications:

Scarborough, J.D. (1993) Phys-Ma-Tech: Integrated models for teachers. *Journal of Technology Education*, 52(5), 26-30.

Scarborough, J.D. (1993) Operating Strategies, Barriers, and Attitudes. *Journal of Technology Education*. 52(6), 35-38.

Internships in Public Science Education Program

***Making the Nanoworld Comprehensible**

NSF Award No. 0120897 (Internships in Public Science Education Program)

\$515085 September 15, 2001 to August 31, 2004

Wendy C. Crone, University of Wisconsin Madison (Updated 9/10/03)

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www.mrsec.wisc.edu/edetc/IPSE/index.html.

This IPSE award, funded by the Office of Multidisciplinary Activities of the Directorate for Mathematics and Physical Sciences, involves a partnership between Materials Science and Engineering Center (MRSEC) on Nanostructured Materials and Interfaces at UW-Madison (UW) and the Discovery World (DW) science museum in Milwaukee aimed at bringing cutting-edge research on advanced materials and nanoscale science and technology into the museum and K-12 school settings. This multi-faceted project enables Internships for Public Science Education (IPSE) participants to enhance their communication skills substantially while bringing the excitement of state-of-the-art MRSEC research themes to pre-college and public audiences. Through the IPSE program, a diverse group of graduate and undergraduate students has teamed with UW MRSEC researchers, DW personnel, and K-12 educators to develop grade-appropriate curriculum materials.

The goals of the IPSE program are to:

- Educate the public and student populations about nanoscale technology through hands-on, interactive activities.
- Provide future leaders with the tools to present scientific knowledge to diverse audiences.
- Foster imagination, interest, and enthusiasm in science, technology, engineering, and entrepreneurship, especially as it relates to advanced and nanoscale materials.
- Provide a deeper understanding of scientific practices and the connections among scientists, engineers, and society.

Initially, activities and demonstrations were developed around existing MRSEC-created education products, making the materials science and engineering concepts associated with such advanced materials as ferrofluids, shape memory alloys, and amorphous metals accessible. More recently, new intern-lead initiatives have created instructional materials for DW and K-12 teachers and students around current research themes of carbon nanotubes, light emitting diodes, lithography, Giant Magnetoresistance (GMR), and societal implications of nanotechnology. DW also links IPSE participants and MRSEC graduate students with middle and high school students to provide information on scientific themes and career development related to materials science and engineering.

In the first 2 years of the grant, 25 graduate and undergraduate students have participated as interns from majors such as chemistry, physics, biomedical engineering, chemical engineering, food science, psychology, computer science, journalism, and the history of science. Following their IPSE experience, several former interns have continued in science education or public understanding of science, through such

career paths as NASA Television, health and science beat for a local newspaper, and teaching certificates. Since its inception, IPSE has touched over six thousand people through publications and presentations that bring science and nanotechnology to their attention and inspire the imagination, interest, and enthusiasm of future scientists and engineers.

Program results have been disseminated through meetings and publications of professional disciplinary and pan-disciplinary organizations, workshops for regional K-12 teachers held as part of the project, and a workshop held in partnership with the Association for Science-Technology Centers (ASTC). Activities and resources for teachers have been made available at the IPSE Web site located at www.mrsec.wisc.edu/edetc/IPSE/index.html. The UW-DW IPSE project can serve as a model for the professional development of technically oriented students, providing them with rich opportunities for sharing their scientific knowledge and enthusiasm with pre-college and museum audiences. This enhances the communication skills of IPSE participants while also making the public and K-12 teachers and students aware of exciting research developments. The project will thus contribute to science literacy and to the development of a diverse, technically trained workforce.

Math and Science Partnerships Program

The MSTP Project: Mathematics Across the MST Curriculum

NSF Award No. 0314910 (Math and Science Partnership Program - Targeted Award)

\$11,534,437 September 1, 2003 - August 31, 2008

David Burghardt, Hofstra University

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The MSTP Project: Mathematics Across the MST Curriculum is improving teaching and learning in middle-level mathematics in 10 school districts in New York. Core partners include Hofstra University, State University of New York at Stony Brook, New York State Education Department, and 10 Long Island school districts (Amityville Union Free School District, Brentwood Union Free School District, Freeport Central School District, Hempstead Union Free School District, Longwood Central School District, Riverhead Central School District, Uniondale Union Free School District, Westbury Union Free School District, William Floyd Central School District, Wyandanch Union Free School District). Core and supporting partners are developing and implementing a model for increasing the diversity of the teaching workforce; enhancing university faculty's understanding of middle school reform, learning standards, and assessments; increasing middle school mathematics, science, and technology teachers' understanding of mathematics content and pedagogy; and improving curriculum alignment among the mathematics, science, and technology disciplines. MSTP integrates three components: (1) collaborative professional development for school-based and higher education faculty; 2) curriculum revision and alignment; and 3) recruitment of underrepresented minority undergraduates in mathematics, science, and engineering into teaching careers. The project is establishing ten Collaborative School Support Teams, each consisting of two university mathematics, science, or engineering faculty and five school district personnel including middle school mathematics, science, and technology teachers, a middle school principal, and a human services professional who will provide leadership for home and school initiatives. Supporting partners include the Long Island Regional School Support Center, Boards of Cooperative Educational Services, professional teacher associations in science, mathematics, and technology, Brookhaven National Laboratory, and the Eisenhower Regional Alliance for Mathematics and Science Education. The partnership expects to directly engage 300 teachers, 20 higher education faculty, and 12,000 students per year.

National SMETE Digital Library Program

Collaborative Research: A Comprehensive Pathway for K-Gray Engineering Education

NSF Award No. 0532709 (National SMETE Digital Library Program)

\$ 519500 October 1, 2005 – December 31, 2009

Jacquelyn Sullivan, University of Colorado at Boulder (Updated 10/24/2007)

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The K-Gray Engineering Education Pathway is the engineering "wing" of the National Science Digital Library (NSDL). It provides a comprehensive engineering portal for high-quality teaching and learning resources in engineering, computer science, information technology and engineering technology. Project goals are to: (1) merge NEEDS and TeachEngineering into a unified K-Gray engineering educational digital library, (2) significantly grow high quality resources in the NSDL Engineering Pathway in a sustainable way, (3) align the unified curricular materials with appropriate undergraduate and K-12 educational standards, (4) grow the participation of content providers and users, (5) enhance quality control and review protocols for Engineering Pathway content, and (6) create a nonprofit strategy and partnership for the sustainability of the Engineering Pathway. This project also expands the Pathway's gender equity and ethnic diversity components by cataloging and reviewing curricular resources created by female-centric and minority-serving organizations. The K-Gray Engineering Education Pathway is having far-reaching impact by engaging K-12 communities and institutions of higher education, engineering professional societies, engineering research centers, NSF K-12 programs, and ABET. Key elements of the evaluation plan include a community-based needs analysis, definition and collection of usage metrics, and mid-term and final evaluations. Dissemination activities include email delivered through project and collaborating institution networks, electronic materials deployed on Web sites offering related educational materials, and in-person presentations at conference technical sessions and workshops, with each phase designed to provide audiences with greater command of K-Gray resources and applications.

Annals of Research on Engineering Education

NSF Award No. 0434960 (National SMETE Digital Library Program)

\$849,421 October 15, 2004 - September 30, 2008

Norman Fortenberry, National Academy of Sciences (Updated 10/5/2007)

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<http://www.AREEonline.org>

The National Academy of Engineering, in partnership with several engineering journals (including the *Journal on Engineering Education*, *Computer Science Education*, and the *Journal of Research on Science Teaching*) published by professional societies and commercial publishers, is hosting a web portal linking education research papers in engineering (including computer science) and related science (including mathematics) disciplines. This virtual Annals of Research on Engineering Education (AREE) is serving to present, in a unitary fashion: the most rigorous research on engineering education in a manner that builds upon rather than competes with existing outlets within engineering disciplines; a forum for researchers on engineering education to discuss applicable standards for the evaluation of engineering education research; a reference site offering annotated bibliographies of the most recent research on engineering education research; a discussion forum through which engineering faculty and administrators with limited ability (or time) to perform research on engineering education can learn of research findings with immediate implications for improved classroom practice; a gateway to existing archives of relevant engineering education conferences; and a gateway to relevant education research in non-engineering disciplines.

***Collaborative Research: TeachEngineering -- Hands On Engineering Resources for K-12**

NSF Award No. 0325492 (National SMETE Digital Library Program)

\$112,272 January 1, 2003 - March 31, 2005

Michael A. Mooney, Colorado School of Mines

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This Collections project builds on extensive K-12 engineering curriculum developments funded by the NSF GK-12 program with several engineering colleges collaborating to create an on-line digital library of engineering resources (the TeachEngineering Collection) for use by K-12 teachers and engineering college faculty conducting outreach in their communities. Each institution is already partnered with numerous local school districts to promote engineering as a vehicle for math and science integration. Lessons and activities that introduce engineering to K-12 students while serving as integrators of science and mathematics concepts will populate the Collection. The lessons and activities in the TeachEngineering Collection relate to everyday encounters in the lives of youngsters, thus providing a context for student learning. Collections curricula meet explicit minimum quality criteria and are aligned with national science, mathematics and technology educational standards. Activities can be constructed at low cost with readily available materials

-- an "engineering on a shoestring" approach to encourage adoption of the Collection. The Collection also provides a portal to several "living laboratories" -- structures, facilities and processes instrumented with sensors, providing data on-line in real time. The project team also is reaching out to end-users by promoting workshops that train teachers and faculty to use the Collection. The American Society for Engineering Education involvement guarantees long-term sustainability, with responsibility for certification and testing of new curricular components, and nationwide dissemination and promotion of the Collection. The collaborators are designing the system architecture, developing the search engine, and refining and testing the system and contents, including the "living laboratories" component, in collaboration with K-12 teachers. Integration and interoperability with other NSDL collections are being addressed. Concurrently, the Collection content is being standardized, converting a variety of K-12 engineering curricula into searchable, standards-based documents with a common look and feel. In a set of second-level tasks, the team is populating and testing the Collection, integrating it into the Tufts Digital Library, completing the loading and testing of the initial contents, conducting teacher and faculty workshops, and transferring the Collection oversight to ASEE. Moving K-12 engineering outreach curricula from individual sites to a unified and useful library provides accessible resources for the K-12 community and stimulates the involvement of engineering faculty and professionals in K-12 education. Broader impacts of this work are engaging more engineering programs in K-12 outreach, providing the expanded opportunities to dramatically increase general STEM literacy and expanding the pool of youngsters eagerly prepared for a future in engineering.

Collaborative Research: TeachEngineering - Hands-on Engineering

NSF Award No. 00341676 (National SMETE Digital Library Program)

\$273,265 January 1, 2003 - December 31, 2005

Martha N. Cyr, Worcester Polytechnic Institute (Updated November 1, 2007)

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This Collections project is built on extensive K-12 engineering curriculum development funded by the NSF GK-12 program with several engineering colleges collaborating to create the on-line digital library of engineering resources (the TeachEngineering Collection) for use by K-12 teachers and engineering college faculty conducting outreach in their communities. Each institution is already partnered with numerous local school districts to promote engineering as a vehicle for math and science integration. Lessons and activities that introduce engineering to K-12 students while serving as integrators of science and mathematics concepts populate the Collection. The lessons and activities in the TeachEngineering Collection relate to everyday encounters in the lives of youngsters, thus providing a context for student learning. Collections curricula meet explicit minimum quality criteria and are aligned with national science, mathematics and technology educational standards. Activities can be constructed at low cost with readily available materials -- an "engineering on a shoestring" approach to encourage adoption of the Collection. The Collection also provides a portal to several "living laboratories" -- structures, facilities and processes instrumented with sensors, providing data on-line in real time. The project team also is reaching out to end-users by promoting workshops that train teachers and faculty to use the Collection. The American Society for Engineering Education involvement guarantees long-term sustainability, with responsibility for certification and testing of new curricular components, and nationwide dissemination and promotion of the Collection. The collaborators designed the system architecture, developed the search engine, and have refined and tested the system and contents, including the "living laboratories" component, in collaboration with K-12 teachers. Integration and interoperability with other NSDL collections is in place, enhancing the overall NSDL. The Collection content has been standardized and provides standards-based documents with a common look and feel for a variety of K-12 engineering curricula. Moving K-12 engineering outreach curricula from individual sites to a unified and useful library provides accessible resources for the K-12 community and stimulates the involvement of engineering faculty and professionals in K-12 education. Broader impacts of this work are engaging more engineering programs in K-12 outreach, providing the expanded opportunities to dramatically increase general STEM literacy and expanding the pool of youngsters eagerly prepared for a future in engineering. As part of next generation Collection building, the team is part of a larger NSDL Pathways project for "K to Grey Engineering." The Engineering Pathway provides the full spectrum of engineering resources from PreK to working professionals. The TeachEngineering Collection is a part of the Pathway. (Previous Award 0226191, Subsequent Award 0532755)

***Collaborative Research: TeachEngineering - Hands-on Resources for K-12**

NSF Award No. 0226322 (National SMETE Digital Library Program)

\$575,887 January 1, 2003 - December 31, 2004

Jacquelyn F. Sullivan, University of Colorado Boulder

jacquelyn.sullivan@colorado.edu

This Collections project builds on extensive K-12 engineering curriculum developments funded by the NSF GK-12 program with several engineering colleges collaborating to create an on-line digital library of engineering resources (the TeachEngineering Collection) for use by K-12 teachers and engineering college faculty conducting outreach in their communities. Each institution is already partnered with numerous local school districts to promote engineering as a vehicle for math and science integration. Lessons and activities that introduce engineering to K-12 students while serving as integrators of science and mathematics concepts will populate the Collection. The lessons and activities in the TeachEngineering Collection relate to everyday encounters in the lives of youngsters, thus providing a context for student learning. Collections curricula meet explicit minimum quality criteria and are aligned with national science, mathematics and technology educational standards. Activities can be constructed at low cost with readily available materials -- an "engineering on a shoestring" approach to encourage adoption of the Collection. The Collection also provides a portal to several "living laboratories" -- structures, facilities and processes instrumented with sensors, providing data on-line in real time. The project team also is reaching out to end-users by promoting workshops that train teachers and faculty to use the Collection. The American Society for Engineering Education involvement guarantees long-term sustainability, with responsibility for certification and testing of new curricular components, and nationwide dissemination and promotion of the Collection.

The collaborators are designing the system architecture, developing the search engine, and refining and testing the system and contents, including the "living laboratories" component, in collaboration with K-12 teachers. Integration and interoperability with other NSDL collections are being addressed. Concurrently, the Collection content is being standardized, converting a variety of K-12 engineering curricula into searchable, standards-based documents with a common look and feel. In a set of second-level tasks, the team is populating and testing the Collection, integrating it into the Tufts Digital Library, completing the loading and testing of the initial contents, conducting teacher and faculty workshops, and transferring the Collection oversight to ASEE. Moving K-12 engineering outreach curricula from individual sites to a unified and useful library provides accessible resources for the K-12 community and stimulates the involvement of engineering faculty and professionals in K-12 education. Broader impacts of this work are engaging more engineering programs in K-12 outreach, providing the expanded opportunities to dramatically increase general STEM literacy and expanding the pool of youngsters eagerly prepared for a future in engineering.

National Digital Library for Technological Literacy

NSF Award No. 0121650 (National SMETE Digital Library Program)

\$893,277 September 15, 2001-August 31, 2004

Kendall N. Starkweather, International Technology Education Association (updated 10/23/2007)

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This award provided funding to establish a central source and comprehensive digital collection for technological literacy resources. The International Technology Education Association (ITEA) and the Eisenhower National Clearinghouse (ENC) collaborated to create the Innovation Curriculum Online Network (ICON), The National Digital Library for Technological Literacy, so that K-12 classroom teachers and college and university faculty would be able to locate digital resources concerned with technological literacy content and pedagogy.

ENC shut the site down in September, 2005. All of the resource links that were on the ICON site were added to the NSDL site at <http://nsdl.org>.

Research and Evaluation on Education in Science and Engineering (REESE)

Transforming Elementary Science Learning through LEGO™ Engineering Design

NSF Award No. 0633952 (REESE)

\$998,145 September 15, 2006 – August 31, 2009

Chris Rogers, Tufts University (Entered 10/23/2007)

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The primary motivation for this activity is to address the need for improved learning and teaching of science in the upper elementary grades. The investigators propose to address this need through the development, implementation, and evaluation of innovative engineering-based science curriculum. The first specific objective of this activity is to measure what and how students learn from engineering design challenges tailored to particular science concepts. The second objective is to establish best practices for designing engineering curricula that are more effective at promoting students' deep understanding of science content. The third objective is to determine how to use engineering contexts to improve the practice of science instruction in the elementary grades. This activity seeks to advance theory, design, and practice in the emerging field of elementary-school engineering education, which the investigators view as an authentic tool for motivating and deepening the learning of science.

To accomplish the proposed goals, several research methods will be employed. During year one, investigators will collaborate with Boston-area teachers to develop a series of curriculum modules that pose engineering design challenges whose solutions require understanding of specific science content standards. The learning objectives of these modules will be aligned with the National Science Education Standards (NSES) for grades K-4 and the Massachusetts Science and Technology/Engineering Curriculum Frameworks for grades 3-5. The instructional sequences and assessments will be designed according to three sets of requirements: (1) the concerns of collaborating classroom teachers, (2) the criteria for science curriculum evaluation set forth by the American Association for the Advancement of Science, and (3) the analytical, creative, and practical domains of Sternberg's Triarchic Theory of Intelligence. Student toolkits for all of the curriculum modules will include LEGO™ MINDSTORMS for prototype construction and ROBOLAB™ software for algorithm development. These instructional materials have been proven to be engaging and authentic tools for children's engineering.

In the summers of years one and two, week-long professional development workshops will be held to train two waves of participating teachers in the engineering-based curriculum modules. With technical support from Tufts engineering students, the trained teachers will implement the intervention curriculum in their classrooms for three consecutive years. Teachers' implementations of both the engineering-based curriculum and the conventional science curriculum will be observed, analyzed, and compared to answer the following three driving research questions: (1) How do learning gains generated by engineering-based curriculum modules compare to learning gains generated by conventional science curriculum modules in the third through fifth grades? (2) What characteristics of instructional sequences enable them both to familiarize students with engineering and promote mastery of science fundamentals? (3) How do teachers adapt to curriculum modules that embed science content within engineering design challenges?

Research on Learning and Education

CAREER: Exploring Cognitive, Social, and Cultural Dimensions of Visualization in Computer Science Education

NSF Award No. 0406485 (Research on Learning and Education Program)

\$266,925 December 1, 2003 - March 31, 2006

Christopher Hundhausen, Washington State University (Updated 11/2/2007)

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An approach in which students become teachers by using algorithm visualization technology not only to construct their own visualizations, but also to present those visualizations to their instructor and peers for feedback and discussion will be studied within the context of a third-year, undergraduate computer science

course on computer algorithms. This approach will be used to develop a studio-based algorithms course in which the construction and discussion of visualizations are the central activities of the course. Specifically, students will use algorithm visualization technology to construct their own visual solutions to algorithm design and analysis problems. In a variety of regularly scheduled review sessions, they will present their solutions to instructors and peers for feedback, discussion, and evaluation. This research will yield several products and outcomes from which science educators, educational researchers, visualization technologists, and cognitive anthropologists stand to benefit.

***Understanding and Teaching Spatial Competence**

NSF Award No 0337360 (Research on Learning and Education Program)

\$662,733 December 15, 2003 - November 30, 2005

Janellen Huttenlocher, University of Chicago

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The focus of the program is on the acquisition of spatial representation and reasoning. The researchers believe that in order to achieve their long-term goal of devising optimal education programs in spatial competence, they must first come to understand the nature of spatial learning and determine the types of experiences that lead to higher achievement in the domain, about which relatively little is known. Their previous research indicates that the development of spatial cognition is highly sensitive to input and thus is malleable. The current project brings together researchers from across cognitive science. They will explore three, presumably interrelated, aspects of spatial intelligence: First, one part of the team will investigate how spatial expertise can be enhanced directly by training the mental processes that operate on spatial representations. Second, another part of the team will investigate how spatial reasoning can be enhanced through maps and language. Third, the remaining part of the team will investigate how spatial reasoning can be enhanced by applying measurement and graphs to quantitative information.

Optimizing the Impact of Online Professional Development for K-12 Teachers

NSF Award No. 0309401 (Research on Learning and Education Program)

\$1,775,212 July 1, 2003 – December 31, 2007

Glenn Kleiman, North Carolina State University, (formerly at Education Development Center)

glenn_kleiman@ncsu.edu 919-513-8509 (Updated 11/5/2007)

Many changes in K-12 education have created an increased and critical need for effective professional development for teachers. These changes include new standards; new curriculum and assessments; changes in student demographics; advances in classroom technology; and a growing shortage of qualified teachers. To address this need, many educational organizations are turning to web-based, online professional development, which can provide teachers with flexible scheduling and access to resources, mentors, and peers that would not be available otherwise. A significant body of research enables us to define principles of effective professional development in face-to-face settings, and some research is available showing that online courses can be effective at the college and high school levels. However, very little research is available about the effectiveness of online professional development in which the goals are to impact both the content knowledge and the classroom practices of K-12 teachers. The proposed project will begin to establish a solid research base about online professional development by addressing three major questions, which fall under ROLE Program Quadrant III, Research on STEM Learning in Education Settings: 1. What is the comparative impact on teachers' content knowledge and instructional practices of alternative models of online professional development, face-to-face models, and hybrid models that combine the two? 2. How do the types of interactions among participants and between participants and workshop leaders differ across different online professional development models, and are these differences related to participants' satisfaction, knowledge acquisition, and changes in practice? 3. What are the factors that maximize the impact of online professional development on teachers' content knowledge and instructional practices? To address these questions, the project will develop and implement a series of contrastive professional development workshops, including several online models, hybrid models that integrate some face-to-face meetings into the context of online workshops, and a more traditional onsite workshop model. The workshops will focus on topics selected from the middle school mathematics curriculum, and seek to both deepen participants' understanding of the mathematics and enhance their approaches to teaching this content. Within each content area, the goals, learning activities, teaching approach, and time requirements

for participants will be held as constant as possible across workshop models. Multiple measures, including assessments of participants' content knowledge within the context of teaching tasks, participant surveys and interviews, analyses of lesson plans and student work, classroom observations, student surveys, and discourse analyses will be employed to address the three main research questions. The results will inform educational policy makers, school and district administrators, professional development providers, faculty in teacher preparation programs, and teachers, as well as the research community.

CAREER: Advancing Technological Fluency of Underrepresented Youth and their Teachers through Project-Based Learning Opportunities

NSF Award No. 0238524 (Research on Learning and Education)

\$558,827 May 1, 2003 - April 30, 2008

Brigid Barron, Stanford University (Updated October 31, 2007)

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This five-year research program is designed to advance our understanding of how to effectively engage diverse groups of youth in learning core IT concepts in ways that motivate them to continue learning in their future education. Basic research and design-oriented research will be conducted in three inter-related phases. The first phase will focus on expanding what we know about students' access, interest, and experiences with new technologies-with an emphasis on identifying barriers to equity and revealing learning resources. Survey and interview work will be carried out with a large and diverse group of students across socio-economic strata in California's Silicon Valley region to investigate their access to, and interest in, various kinds of learning opportunities. The research will document how creative learning opportunities are distributed across different communities and their effects on student interests. It will also contribute to defining different profiles of student fluency and how these are associated with learning ecologies constituted by the interweaving contexts of self, family, peer group, school, and community. The second phase of the work will focus on co-developing courses with teachers. A core guiding principle of these courses will be a primary focus on the student as designer and a learning goal will be to help students understand design as a human process in which everyone can be involved. The course material will build fluency in the context of projects in which students design, program, and implement information systems that address issues of youth interest. This approach will allow students to be authentic contributors of knowledge and processes while simultaneously building understanding of the core concepts and capabilities outlined in the NRC Fluency report-such as programming, information design, and human-computer interaction. In the third phase, the teaching and learning processes in these courses will be studied systematically, with a particular focus on collaborative design work. A key goal of this research is to contribute to theories of collaborative learning. Productive collaborative design practices will be identified and the ways that such collaborations are often less than productive and can be made more productive will be articulated. Learning properties of collaborative technology design work beyond cognitive outcomes will be identified for empirical study, including motivational, relational, and meta-communicative outcomes.

***CAREER: Using Portfolios to Promote Knowledge Integration in Engineering Education**

NSF Award No. 0238392 (Research on Learning and Education Program)

\$210.141 July 1, 2003 - June 30, 2005

Jennifer Turns, University of Washington (Updated 3/29/05)

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The central idea of the proposed work is to explore portfolio creation as a means of promoting (and studying) knowledge integration by engineering students. The portfolio activities will build on existing strengths of the engineering curriculum by providing students with opportunities to reflect on their accomplishments, see and articulate connections between engineering and their accomplishments, and develop more integrated conceptual structures associated with engineering. Three objectives are to (a) document the nature of engineering students' conceptual structures in their engineering discipline, with specific attention to how integrated the conceptual structures are; (b) use what is known about portfolios in education to develop an intervention that makes it possible for engineering students to document and refine their conceptual structures in engineering; and (c) identify the learning affordances and cognitive challenges associated with the intervention. The work will be accomplished through studies associated with

two types of portfolios - - cross-curricular professional portfolios and course-based professional portfolios. In the case of cross-curricular portfolios, engineering students will be asked to develop a professional portfolio in which they draw on artifacts from their entire educational experience. In the case of the course-based portfolio, the effects of portfolio construction will be explored in the context of individual courses. The education plan builds on the portfolio and knowledge integration emphases of the work. The plan includes commitments to: (a) continue using portfolio assignments in the PI's courses; (b) support portfolio development by faculty and students interested in portfolios; (c) provide mentoring/research experiences for undergraduates, and (d) create teaching modules that build on the portfolios. In terms of the broader impacts of the project, underrepresented minorities will be over-sampled from the available student populations. The portfolios will represent a unique and useful information source for employers, students, and others with interest in engineering education. Also, the impact of the work will be on the engineering graduates who are better prepared to contribute to the engineering profession.

***CAREER: Understanding and Supporting the Acquisition of Manufacturing Automation System Integration Skills**

NSF Award No. 0238269 (Research on Learning and Education)
\$452,960 June 1, 2003 - May 31, 2008
Sheng-Jen Hsieh, Texas A&M University (Updated 9/10/03)
hsieh@tamu.edu

The principal goals of this project are to: (1) understand how automated manufacturing system integration expertise develops; (2) develop a web-based system - called the System Integration Problem-Solving Environment (SIPSE) - that can be used both to monitor the development of system integration skills and to teach them; (3) develop a pedagogy for teaching system integration concepts and skills that can be used as a basis for developing curricula and materials for education in system integration and other similar domains; and (4) develop a curriculum for a undergraduate-level course on Automated Manufacturing System Integration. The proposed effort will build upon existing cognitive skills acquisition research in investigating how expert engineers develop automated manufacturing system integration skills and how to help novices develop these skills more efficiently. The project will integrate research and education by (1) involving graduate and undergraduate students in data collection and analysis, programming, interface design, and graphics design tasks; (2) inviting manufacturing automation students to participate in evaluating SIPSE; (3) adding an instructional module to SIPSE; (4) developing and evaluating a syllabus and curriculum materials for a new course on manufacturing automation system integration; and (5) presenting research results and investigating opportunities to make SIPSE available in high school and informal education settings. It will broaden participation of underrepresented groups by involving students and faculty from minority and/or rurally located institutions in using and evaluating the results of the proposed research. It will enhance the research infrastructure in the area of manufacturing automation by making SIPSE available over the Internet for use by researchers. Research results will be broadly disseminated in academic journals and professional conferences, on the Web, and by making presentations to high schools and in informal education settings, such as children's museums. Direct beneficiaries of this effort will include automated manufacturing system end users, system integrators, and automation product manufacturers.

Teacher Enhancement Program

Tufts' Pre-College Engineering for Teachers

NSF Award No. 0138766 (Teacher Enhancement Program)
\$1,738,424 July 1, 2002 - June 30, 2008
Christine Cunningham, Tufts University (Updated 10/31/2007)
Christine.Cunningham@tufts.edu (617) 589-0255

This project provides professional development experiences for K-12 teachers in the state of Massachusetts to help them address the Science and Technology/Engineering Curriculum Framework adopted by the state in 2001. This framework clearly states that schools should provide a comprehensive science and technology/engineering program enrolling all students preK-12. The project will build upon work that has already been done to infuse engineering literacy into K-12 schools. PCET is a collaboration between Tufts

University, Worcester Polytechnic Institute, and University of Massachusetts-Lowell. Each of these engineering schools acts as a local resource for the teachers participating from that section of the state, with Tufts University serving as the lead institution. The project model involves developing a cadre of 96 mentor teachers through a series of annual Summer Institutes and assisting these teachers in the development of curriculum materials and adoption strategies for their local contexts. These mentor teachers will also, with the help of project staff, design and deliver similar training sessions to an additional 460 satellite teachers in their schools. Science and technology teachers have been identified as the target audience for these professional development experiences. Project work will begin with teachers in grades 9-12, and work backward through middle and elementary grade bands (6-8, 3-5, K-2) in subsequent years.

Elementary, Secondary, and Informal Education: Technology Teacher Inservice

NSF Award No. 0138671 (Teacher Enhancement Program)

\$645,421 September 1, 2002 - August 31, 2004

Paul Post, The Ohio State University (Former PI: Karen Zuga) (Updated 10/5/2007)

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This project will create, pilot, field-test and disseminate standards-based Professional Development materials via the web that will support in-service needs of practicing technology education teachers. The Standards for Technological Literacy have been published, and this project will help teachers to implement them in the classroom. A consortium of institutions will develop the materials. The materials to be produced include two content primers in biotechnologies and medical technologies, seven video vignettes of teaching technology education to the standards, and a monograph that explores the ideological history of technology education, technology knowledge as language, inquiry, design, and engineering. Materials are available at: <http://www.coe.uga.edu/ttie/>

Teaching Technology from Everyday Stuff: Sustaining Professional Development On-Line

NSF Award No. 0096627 (Teacher Enhancement Program)

\$1,577,323 June 1, 2001 - May 31, 2006

Gary Benenson, CUNY City College (Updated 10/5/2007)

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<http://citytechnology.ccny.cuny.edu>

This project has developed and tested a professional development model that combines on-line forums and a project web site with hands-on workshops. The on-line forums were led by teachers who have implemented the materials in their own classrooms, as well as by professional engineers recruited through the Institute of Electrical and Electronics Engineers (IEEE). The professional development plan supports the use of the Stuff that Works! series of teacher guides, which are published by Heinemann (www.heinemann.com). These curriculum materials, which were supported by prior NSF funding, use everyday materials, artifacts, and systems to teach analysis and design, and connect these activities with national standards for math, science, ELA, and social studies, as well as technology. Current activities include additions to the project web site: "Kids' Page" resources for children are currently available and alignment with state standards is under development. Teacher workshops and classroom implementation have been undertaken by urban and rural school systems, science centers, and/or regional professional development organizations in Alaska, Arizona, Nevada, California, Florida, Louisiana, Massachusetts, Minnesota, Mississippi, Missouri, Montana, New Jersey, New York, Ohio, Tennessee, Virginia, West Virginia, and Wisconsin. (Previous Awards 9618767; 9055410).

Products:

Benenson, G., Neujahr, J., Iverson, B. (2005) City Technology Guide for Professional Developers (Third Revision). New York, NY: City Technology Project.

http://citytechnology.ccny.cuny.edu/Professional_Developers.html

Benenson, G. (2007). Far From Home: K-12 Engineering as Engine for Equity. Selected Papers from the 18th International Conference on College Teaching and Learning. Jacksonville: Florida Community College at Jacksonville.

Benenson, G. (2006). The Upside of Upside-Down Design. Technology and Children 11(1), 4-7.

City Technology (2006). City Technology Web Site. <http://citytechnology.ccny.cuny.edu/>

Design In The Classroom (Science by Design: A Professional Development Packet for Middle-School Science Teachers)

NSF Award No. 9986854 (Teacher Enhancement Program)

\$1,200,000 May 15, 2000 - April 30, 2004

David P. Crismond, CUNY City College (Formerly at University of Missouri and Georgia Institute of Technology) (Updated 11/1/2007)

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The *Design In The Classroom* (DITC) materials are made for upper-elementary and middle-school technology education, science and math teachers and their teacher educators, or anyone else who wants support in using design tasks with students, grades 5-10. By reviewing *DITC's* tutorial pages and watching its QuickTime videos, users can learn about designing, see how student designers work, hear about design-oriented teaching strategies and pedagogy, and view activities from different standards-based curricula being used by STEM classroom teachers and their students.

The complete set of *DITC* materials (189 movies with a total running time of 12 hours, 227 HTML pages, and links to resources) is available over the Internet, or via a single DVD-ROM or 3 CD-ROM disks. The *DITC on DVD* collection holds 3.5 hours of selected movies on 2 DVD disks for full-screen viewing using a home player. All copies of *DITC* materials are available from the PI at the address above.

The *DITC* Web site has three main sections: Getting Started; Select Design Tasks, and Learn About Design. "Select Design Tasks" showcases 10 engaging design challenges (e.g., model car, parachute, bridge, electromagnet, clay boat) from recently developed curricula (*Learning By Design*, *Challenges In Physical Science*, *Stuff that Works!* and *Design It*). *DITC* users can view how a design activity gets implemented via its Video Timeline. Teachers have found these Timelines, which show the day-by-day implementation of selected units, helpful in conceptualizing and planning lessons. The Key Concepts sections within many units present the core science and technology concepts: ideas that teachers need to know to guide students in making *informed design decisions* and to learn more efficiently using these problem-based learning tasks. Videos can be watched side-by-side in "contrasting videos sets," to make teaching strategies and student thinking more apparent and easier to discuss with other colleagues.

Under the "Learn About Design" tab, users can find video-based tutorials that provides non-designers with a brief overview of a generic design model. Teachers can listen to: students talking about their design thinking, education and design experts describing features of good design challenges and ways to support students in designing collaboratively and creatively. The "Design Cases" section illustrates how teachers regularly act as designers in their professional work, and has different experts describing how creating music, developing educational curriculum, developing scientific models, and writing essays all involve the kinds of design thinking that is within reach of most people. *DITC* interviews are quite popular with users. The interviews feature different experts describing their research on formative assessment, the "backward design" process, gender and design, case-based reasoning, and the ways in which design tasks may serve as transfer tasks for testing understanding of discipline concepts. (Previous award 9252894)

Products: Crismond, D. P. (2005) *Design in the classroom*. (DVD) (Also available as CD set and on-line)
Crismond, D. P. (2005). *DITC on DVD (Design in the classroom) teacher professional development materials: A users' manual*.

Research Experiences in Industry

NSF Award No. 9911885 (Teacher Enhancement Program)

\$1,298,650 June 1, 2000 - May 31, 2004

Sandra H. Harpole, Mississippi State University (Updated 10/10/2007)

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This three-year "Teacher/Student Development through Research Experience" project (TSD) involved 25 teachers per year, grades 7-12, in a high tech workplace/research experience. Each of these teachers

mentored at least four of their peers for a minimum of 60 hours. The summer experience included three weeks in an internship at various industries in the Southeast, including Northrop Grumman Ship Systems, Tennessee Valley Authority and Mercedes. A fourth week was spent at Mississippi State where the teachers received help with the transfer to the classroom component. A 3-day work experience in a local industry (local to the teacher's place of employment), and academic year follow-up sessions followed this. The content sessions were concurrent with and interspersed with the internship at the industries. The sessions included work with the SCANS report. They were delivered using the industrial model of just-in-time-learning. The workplace mentors were engineers, scientists and workers at the industries as well as university faculty, scientists, and highly qualified teachers. Teachers ideally participated as teams from the same school. The ideal team had a science, mathematics and a technology education teacher. To ensure participation from districts with limited resources and a high minority enrollment, a commitment was made by two such school districts to participate in the project. Five teachers from each district participated. Previous Award 9731286.

Curriculum Resources for K-8 Technology Education

NSF Award No. 9911808 (Teacher Enhancement Program)

\$399,833 May 1, 2000 - April 30, 2005

Edward D. Britton, National Center for Improving Science Education, WestEd (Updated 11/6/2007)

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This project will create a resource guide to curriculum materials in technology education at the elementary and middle school grades. Resources will be compared with standards for technology education published by the International Technology Education Association. Several classes of curricular resources will be reviewed and/or described: Materials that can serve as core curricula for technology education, other substantial curricula that integrate technology with science and other subjects, and classroom materials that can supplement the teaching of technology education. A guide to trade books also will be included. The topical content of substantial curricula will be compared to the ITEA Standards and its benchmarks through a page-by-page empirical analysis. Pedagogical features also will be analyzed for all products, including teacher support materials, types of assessment used, characteristics of activities included, etc. The guide will be commercially published in spring 2004 and address the needs of technology and science educators, curriculum specialists at the district and state levels, and curriculum developers.

Product: Britton, E., De Long-Cotty, B., & Levenson, T. (2005). *Bringing technology education into K-8 classrooms: A guide to curricular resources about the designed world*. Thousand Oaks, CA: Corwin Press. (Joint publication with International Technology Education Association, National Science Teachers Association Press, and WestEd.

Technology Education Leadership Project (TELP)

NSF Award No. 9731278 (Teacher Enhancement Program)

\$1,197,826 March 1, 1998 - August 31, 2002

Leon L. Copeland, Sr., Robert Gray, University of Maryland Eastern Shore (Updated 11/1/07)

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The Technology Education Leadership Project (TELP) provided two-week leadership development workshops for 90 Maryland technology education teachers during the summers of 1998 and 1999. The workshops included technical instruction in the nine core technologies in the Maryland curriculum framework for technology education: mechanical, electrical, electronic, structural, fluid, optical, thermal, bio, and materials. The leadership workshops also included instruction in facilitative leadership, information systems, and the teaching/learning strategies used in Maryland technology education courses: investigation; modular technology activity packages; topic investigations; engineering design and development; product generation; and research and experimentation. Four weekend institutes supplemented the summer workshops during each of the three years of the project. These sessions dealt with the implementation of the core technologies and the teaching/learning strategies outlined above, the use of instructional technology, standards for technology education, and the planning, delivery, and assessment of the teacher enhancement programs in each of the school districts. These weekend workshops met in locations across the state. During each of the second and third summers, the leadership group of master

teachers provided five days of teacher enhancement activities in each of the school districts across the state. This instruction covered the core technologies, information systems, teaching/learning strategies and instructional technology.

MSTE: Integrating Mathematics, Science and Technology in the Elementary Schools

NSF Award No. 9618962 (Teacher Enhancement Program)

\$4,165,323 April 15, 1997 - March 31, 2003

Thomas T. Liao, SUNY Stony Brook (Updated 11/5/2007)

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MSTE: Integrating Mathematics, Science, and Technology in the Elementary Schools, is a five-year effort based at The State University of New York at Stony Brook. This collaborative effort also involves the New York State Education Department, Hofstra University, Brookhaven National Laboratory, and 20 school districts in New York. The goal of this project is to develop models for the infusion of technology education into the elementary schools. To accomplish this goal, activities focus upon the integration of experiences in technology with contemporary approaches in mathematics and science in the elementary schools. Participants utilize exemplary curriculum materials and activities in technology education to enrich the elementary school experiences in mathematics and science. The project is organized to enhance teachers' pedagogical abilities; strengthen their content knowledge in mathematics, science, and technology; and provide leadership expertise among the 20 three-person teams, each representing one of the collaborating school districts. Each team is comprised of a content specialist in mathematics, science, or technology and two experienced teachers, one from grades K-3 and the other from grades 4-6. These teams will participate in two years of sustained enhancement activities at The University at Stony Brook, Hofstra University, and Brookhaven National Laboratory. The MSTE Project will prepare teachers in the use of exemplary curriculum materials to provide instruction that highlights the rich relationships among the disciplines. During the third and fourth years of the project, each of the 20 MSTE teams will conduct regional summer enhancement workshops and academic year meetings for 30 elementary school teachers from their local geographic areas. An Implementation and Resource Guide is being developed for use by leadership teams in their summer workshops for teachers in their local regions. The MSTE Project will devote its fifth year to a statewide leadership development effort, preparing teams of teachers and content specialists from across the State of New York to serve as leaders in subsequent teacher enhancement efforts.

Product: *MSTE implementation and resource guide* (March, 2003). Available from Jacqueline Kampf, MSTE Project Administrative Assistant, Stony Brook University, jkampf@notes.cc.sunysb.edu (631) 632-6744

***Project UPDATE/TEI (Upgrading Practice through Design and Technology/Engineering**

Education/Teacher Enhancement Initiative)

NSF Award No. 9555711 (Teacher Enhancement Program)

\$1,200,000 January 1, 1996-December 31, 1999

Ronald D. Todd, The College of New Jersey (Updated 9/10/03)

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Project UPDATE/TEI is a teacher enhancement project designed to prepare elementary teachers to use a design and technology approach to integrate science, mathematics, and technology. The project prepared a cadre of 40 teachers that worked in teacher/leader (T/L) teams to train a cohort of more than 400 teachers in schools in 6 states. The T/L teams provided guidance to the project's leadership in the development of design and technology enhancement support materials including an Implementation Resource Guide and videos. These materials were specifically designed to combine contemporary pedagogy with the delivery of technical content in the science, mathematics, and technology areas. The T/L teams also assisted with the delivery of two graduate level courses, providing leadership at 10 demonstration sites, and assisting with outreach workshops and seminars. This project extended and implemented the curriculum materials developed through an NSF funded instructional materials development project (Previous Award 9154125). Professional development training, materials, and services are available on a nominal cost basis.

Technology and Invention in Elementary Schools (TIES)

NSF Award No. 9555650 (Teacher Enhancement Program)

\$205,494 June 1, 1996 - May 31, 2000

Walter S. Smith, Texas Tech University (formerly Ball State University and University of Akron)

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The Technology and Invention in Elementary Schools (TIES) Project was designed for teachers in grades 3-6 in schools predominantly serving minority student populations in northeastern Ohio and in Native American schools in New Mexico. Based on research on the encouragement of underrepresented students in science, problem solving, and the change process for teachers to incorporate an innovative teaching procedure, TIES was designed to achieve the following goals:

- Change the teachers' method of instruction vis-à-vis technology and problem solving.
- Improve the teachers' ability to encourage underrepresented students in science.
- Enable teachers to use already developed materials and produce new teaching materials that weave together technology, problem solving, and historical perspectives.
- Produce a cadre of elementary school teacher-leaders to assist their colleagues to develop these skills as they pertain to their own schools.
- Improve the TIES teachers' students' achievement in problem solving and technology and attitude toward science.

Supported by a grant from the National Science Foundation, each summer for three years, 1997-1999, 32 teachers (total N=96) attended TIES in groups of four from four schools in Akron, one school in Barberton, one school in Canton, and two Bureau of Indian Affairs schools in New Mexico. Sessions were held at the University of Akron and at Inventure Place, a new generation science center that emphasizes problem solving and creativity in conjunction with the invention process. Teachers were instructed by university and Inventure Place staff as well as by honored inventors such as the inventor of fiber optics and scientists and engineers from private industry. Further, teachers learned about the effects, positive and negative, of technology on a watershed with instructors from the Cuyahoga Valley Environmental Education Center. During the succeeding academic year, the teachers were supported by Akron faculty and scientists or engineers already working with that school and instructed their fellow teachers in technology and problem solving.

Publications:

Miller, N., & Smith, W. S. (1999). Taos Pueblo students hunt leprechauns in science and language arts. *The Technology Teacher*, 59(3), 13-16.

Owens, K. D., Welton, E. N., Borland, A., & Alexsonshk, J. (2002). Technology and invention in elementary schools: Reaching students with hearing impairments. *Journal of Science Education for Students with Disabilities*, 9, 28-36.

Owens, K.D., Clark-Thomas, B., & Broadway, F. S. (2002). A circle of learning through invention convention. *Journal of Elementary Science Education*, 14(1), 15-27.

NYSTEN New York State Technology Education Network

NSF Award No. 9353514 (Teacher Enhancement Program)

\$1,611,803 June 30, 1995 - August 31, 1997

M. David Burghardt, Hofstra University

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The NYSTEN project prepared a staff development network of 120 Math, Science and Technology Education mentors with enhanced technological, pedagogical and leadership skills. Twenty-four teams of 5 mentors, one for each of the 24 State department districts, conducted regional staff development workshops for the 3200 middle and high school technology education teachers. These workshops were presented to teams of mathematics, science and technology education teachers recruited from the schools. Mentors assisted by expert consultants developed field-tested and refined an Implementation and Resource Guide for teachers which blends contemporary pedagogy and authentic assessment into the delivery of the Technology Education content. The content in this guide is in the four areas of Computer Control and

Interfacing, Bio-related Technology, Electronics, and Computer-Aided design and Drawing (CADD). In the final year 3 person teacher teams from 15 other states participated in a National Dissemination Workshop.

Materials Technology Workshop for High School Science Teachers

NSF Award No. 9253386 (Teacher Enhancement Program)

\$466,096 April 1, 1993 - June 30, 1997

Jennifer Lewis, University of Illinois at Urbana-Champaign (Updated 11/6/2007)

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<http://matse1.mse.uiuc.edu/~tw/home.html>

This three-year project, sponsored by the University of Illinois at Urbana-Champaign, provided a four-week workshop each year for 25 high school teachers. The workshops consisted of lectures, demonstrations, and hands-on laboratories on topics in technology, such as solar cells, superconductors and cement. University faculty conducted the workshops and developed a series of eight materials science and technology (MAST) teaching modules in concert with the workshop participants. These MAST modules were tested in high schools, and after evaluation were modified if necessary. The MAST module series has been published and is available for web-based dissemination. Printed modules are available from Judy Brewer, c/o MAST Modules, Materials Science and Engineering Department, 1304 W. Green Street, Urbana, IL 61801

Engineering Concepts for the High School Classroom

NSF Award No. 9253171 (Teacher Enhancement Program)

\$418,360 January 1, 1993 - December 31, 1996

Carol B. Muller, MentorNet; formerly at Dartmouth College (Updated 10/5/2007)

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<http://engineering.dartmouth.edu/teps/>

Seven-day workshops were conducted for 24 high school science (biology, chemistry and physics) and mathematics teachers from across the nation. The teachers experienced firsthand an unusual systematic instructional strategy that employs open-ended problem solving techniques commonly used by engineers in designing products, services, and various solutions to problems. During the first three days the participants worked in interdisciplinary teams of four to devise a product to address a problem or need in an assigned field, e.g. safety or energy conservation. Workshop participants were encouraged to call upon companies as they developed their solutions and were encouraged to consider how to capitalize on the industrial interests and talent available. In addition, a key test of a team's solution to a problem was found in the presentation to a review board. During the second half of the workshop participants were teamed with other teachers from the same discipline. The task was again problem solving with teachers working to develop curricular modules for use in their high school classrooms which incorporate the problem solving techniques they have learned. Each teacher who participated presented at least one in-service program in their home district during the year following their participation in the workshop. NSF's sponsorship of the program lasted for four years, with four teachers from the previous year returning to the workshop to serve as "master teachers." These teaching assistants developed a manual for dissemination and use in future workshops. Evaluation found that 2/3 of the teachers incorporated these techniques in their teaching during the following school year, and 90% incorporated at least part of the model in their teaching.

Product:

Frye, E. (1997). *Engineering Problem Solving for Mathematics, Science, and Technology Education*. Hanover, NH: Dartmouth Project for Teaching Engineering Problem Solving. (Accessible on the project Web site.)

Teacher Professional Continuum Program

Communities of Effective Practice: A Professional STEM Development Model for Teachers of American Indian Students

NSF Award No. 0554472 (Teacher Professional Continuum Program)

\$299,854 May 1, 2006 – April 30, 2009

Kurt Becker, Utah State University (Updated 11/5/2007)

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This pilot project establishes and implements a professional development model with teachers of Native American students by creating a culturally relevant science, technology, engineering and mathematics (STEM) teacher in-service model for 30 grade 4-6 teachers from schools from two nations in Utah. The in-service program relies on community advisory panels, current standards and best practices in science, mathematics and technology education, by implementing engineering and technology education activities as a means of teaching science and mathematics. The goal is to improve teacher preparation in science and mathematics for Native Americans by creating culturally relevant curriculum materials with the help of community advisory panels and providing each teacher participant with at least 100 hours of structured professional development. The long-range goal is to develop an in-service model that can be transported to other Native American nations and schools. STEM and education faculty, community teachers, parents and leaders, as well as, tribal elders are to work together to assure the professional development model and materials are developed in a culturally inclusive manner. The evidence-based outcome of this project is that Native American students effectively learn mathematics and science with the longer-term influence being improvement in student achievement.

A National Symposium to Develop an Effective Model for the Professional Development of K-12 Engineering and Technology Education Teachers

NSF Award No. 0533572 (Teacher Professional Continuum Program)

\$199,747 September 1, 2005 – August 31, 2008

Rodney Custer, Illinois State University (Updated 10/8/2007)

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The primary focus for the National Symposium is to develop research-based models for the professional development of K-12 engineering and technology teachers. Science and mathematics educators have used effective, research-based, professional development programs and materials to strengthen the skill set for practicing science and mathematics teachers. However, technology education, as a less mature field of study, has less experience in developing and delivering research-based professional development practicing technology teachers. With the emerging alignment of technology education with engineering, the need for effective professional development models has become more critical.

The goal of the National Symposium was to assemble a group of key stakeholders with specialized expertise in professional development from science, mathematics, engineering and technology to share expertise and explore models for standards-based professional development. Key goals of the symposium were to: (a) examine the applicability of existing teacher professional development models for engineering and technology education; and (b) develop a foundation for developing models for technology education professional development, based on contemporary pedagogy. The National Symposium was organized around carefully selected thematic sessions focused on specific aspects of professional development. Each session began with invited presentations of scholarly papers, followed by discussion to probe and clarify key ideas. A discussant was designated to initiate the conversations and a session moderator facilitated each session with a major goal of maintaining a focus on the development of models of professional development for engineering and technology. The ultimate goal of the presentations was to produce: (a) a preliminary professional development framework for engineering and technology education; and (b) a set of issues to focus the agenda for subsequent model and framework development.

The National Symposium is developing a framework for engineering and technology education professional development based on a synthesis of the professional development literature and the expertise shared at the symposium. Following the Symposium, three key individuals (one each from science,

mathematics, and technology education) were commissioned to synthesize the conference themes and to develop papers focused on proposed agenda for professional development.

The Symposium was held in Dallas, TX in February 2007. Fifty-two individuals from across the STEM disciplines, including professional developers, teacher educators, technology supervisors, curriculum specialists, and technology teachers, participated in the symposium. A set of preliminary perceptions emerged from the symposium. These include:

- There is a need for increased dialogue among the STEM disciplines
- The concept of pedagogical content knowledge specific to engineering and technology education is insufficiently developed and needs to be explored in depth
- The models for professional development are more fully developed in science and mathematics than planning, implementation and research in engineering and technology education.
- The models for professional development developed for mathematics and science are applicable to engineering and technology education
- Engineering and technology professional developers could benefit substantially from the work of mathematics and science professional developers
- The delivery of mathematics and science content are key professional development challenges for engineering and technology education teachers
- Shifting the emphasis to the identification and delivery of targeted concepts represents a significant professional development challenge for engineering and technology education teachers.
- There is a need to incorporate research from the cognitive sciences into professional development

The complete set of proceedings is currently being compiled for dissemination, which will be done electronically and broadly to key stakeholders. The proceedings will also be posted to the Symposium Web site.

Strengthening STEM Education through the Use of Standards-based Assessments for Robotics Competitions

NSF Award No. 0455835 (Teacher Professional Continuum Program)

\$197,500 August 1, 2005 – June 30, 2007

Rosanne White, Technology Student Association (Updated 11/6/2007)

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The purpose of this project is to establish standards and rubrics for assessing robotics competitions in the middle and high school grades. Robotics competitions are growing in popularity as a method for infusing science, engineering, and technology in hands-on activities that engage students in design and development. However, curricular materials for this field have not been developed.

“Strengthening STEM Education Through The Use of Standards-Based Assessments for Robotics Competitions” was a two-day symposium held in May 2006 at Georgetown University in Washington DC. The symposium gathered stakeholders in STEM education and robotics, curriculum specialists and teacher educators to examine how standards-based instruction, through robotics competitions, addresses components of curricula, instruction, student assessment and professional development.

Co-curricular educational programs that promote the integration of science, technology, math and engineering principles in the classroom through hands-on activities such as robotics competitions provide teachers with a focus and structure for STEM (Science, Technology, Engineering and Mathematics) curricula. Unfortunately, the necessary standards-based content and resource materials are not included in most of today’s competitions used by teachers. The research and content for the 2006 Robotics Education Symposium centered on the use of robotics competitions to advance high school STEM education. The grant research and symposium activities concentrated on the correlation of recognized standards to curriculum content, student skills and assessment and teacher resources related to the use of robotics competitions to teach STEM.

Each year, thousands of students participate in curriculum-based competitions such as robotics. Robotics competitions incorporate many STEM disciplines and are meant to enhance learning environments for students and to assist teachers. Missing from the equation are universally accepted student assessments that would demonstrate the usefulness of robotics competitions as part of standards-based instruction.

Faculty presentations and data supported the finding that although robotics competitions contribute to STEM education, these programs tend to lack sufficient curriculum integrated materials. Additionally, robotics competitions used by teachers to augment STEM education should be standards-based and include tools for instruction as well as student assessment.

A facilitator led discussions with qualified framers (teacher educators, STEM educators, robotics and competitions experts, assessment professionals and members of education, science, and technology professional associations) to develop the components for an assessment rubric for the use with standards-based robotics competitions. The resulting “crosswalks” or grids identified content areas affecting math, science, technology and career skill education. Content areas for each subject included educational standards, robotics curriculum, competition examples and professional development. The crosswalks provide the framework for a rubric based on the current published standards for technology, science, mathematics and career and professional development.

High school STEM teachers, teacher educators, curriculum experts and NOCTI (National Occupational Competency Testing Institute) have adapted the four crosswalk documents to create the *Standards-Based Robotics Competition Curriculum Development Framework*, as originally outlined in the grant. The *Standards-Based Robotics Competition Curriculum Development Framework* is accessible via www.tsarobotics.org.

Industry-Education Partnership: A Model for the Teacher Professional Continuum

NSF Award No. 0353441 (Teacher Professional Continuum Program)

\$2,381,580 April 1, 2004 - March 31, 2008

Sandra Harpole, Mississippi State University (Updated 10/10/2007)

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This is a comprehensive, national, 5-year Teacher Professional Continuum (TPC) project to develop a learning community model that spans the educational continuum. It connects teacher research participation experience (TRE) projects and science, technology, and mathematics (STM) industry and university scientists/professionals to research the factors that contribute to the success of such a model. The TPC educational research will mine both the Principal Investigator's and other national TRE projects, education and industry (E/I) partnership immersion projects, and provide new education/workplace experiences for STM participants covering the teacher continuum. The project includes Local Learning Community cohorts that include two preservice science/mathematics teachers, two middle school teachers, a 7-12 science, mathematics and/or technology teacher, one middle/high school guidance counselor, a two-year Community College faculty member, and a four-year IHE science educator and/or science STM faculty member. (Previous Award 9911885)