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# Conference 2008 - Integrating Science and Mathematics Education Research into Teaching IV: Resources and Tool for Improved Learning

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**Final Report for Period:** 05/2009 - 04/2010

**Submitted on:** 08/01/2010

**Principal Investigator:** McKay, Susan R.

**Award ID:** 0736967

**Organization:** University of Maine

**Submitted By:**

McKay, Susan - Principal Investigator

**Title:**

Conference 2008 - Integrating Science and Mathematics Education Research into Teaching IV: Resources and Tool for Improved Learning

### Project Participants

#### Senior Personnel

**Name:** McKay, Susan

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Dr. McKay is a professor of physics and founding Director of the Center for Science and Mathematics Research at the University of Maine, which recently changed its name to the Maine Center for Research in STEM Education, to reflect its expanded mission. She also provided leadership to establish the Master of Science in Teaching Program and serves as its graduate coordinator. Dr. McKay's research interests include: condensed matter theory, phase transitions and critical phenomena, systems with quenched disorder, spin glasses, random-field ferromagnets, applications of network theory, complex fluids, non-linear systems, and chaos. She managed and supervised all aspects of planning, implementing, and evaluating the project from its inception.

**Name:** Norton, Stephen

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Dr. Norton is a professor of Earth sciences and a member of the Climate Change Institute at the University of Maine. He served as the director of the University's K-12 Teaching Task Force and is a teacher and advisor in the MST program. Dr. Norton's research interests include paleolimnological analysis of lake and bog sediments for their contained information about acidic deposition (including metals) and its direct and indirect impacts on lakes and ombrogenic bogs, chemical manipulations of ecosystems or ecosystem components, and assessment of the impact of land surface pollution such as road salt. Dr. Norton serves on the Project Management Team, Project Development Committee and the Academy Advisory Committee. He was instrumental in recruiting presenters in Earth science for the conference and facilitated all aspects of planning, implementing, evaluating and following-up on the project

**Name:** Thompson, John

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Dr. Thompson an associate professor of physics and co-operating associate professor of education at the University of Maine. He co-directs the Physics Education Research Laboratory, teaches courses in the Master of Science in Teaching Program, and advises graduate and undergraduate student theses in physics education research. He served on the Project Development Committee and the Academic Advisory Committee and was instrumental in recruiting presenters in the physics education field and all aspects of planning and implementing the project.

**Name:** Maurais, Owen

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Mr Maurais worked for 31 years in public education as a teacher, special education director, assistant superintendent and superintendent of schools. He is the executive director of the Penobscot River Educational Partnership, an action-centered collaborative effort of local schools, the University of Maine and state Child Development Services that works to enhance the learning of PreK-12 students by continually improving teaching and the educational experience. Mr. Maurais served as a link between this community and those planning, implementing, evaluating and following-up on the project.

**Name:** Pandiscio, Eric

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Dr. Pandiscio is an associate professor of mathematics education in the College of Education and Human Development at the University of Maine. He specializes in the teaching and learning of mathematics, especially mathematics teacher preparation and teaches and advises research students in the Master of Science in Teaching program. His research interests focus on how students learn geometry and he collaborates with University faculty and classroom educators within the Penobscot River Educational Partnership. Dr. Pandiscio served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting mathematics education presenters and facilitating all aspects of planning and implementing the project. Dr. Pandiscio was course instructor for the Summer Academy course 'Explorations in Classical Geometry.'

**Name:** Gellen, Amie

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Ms. Gellen, Center Assistant Director, was a practicing civil engineer before earning a Master's Degree in Education. Prior to joining the Center, she was on the Director's Council of the NSF CETP Maine Mathematics and Science Teaching Excellence Collaborative and a Lecturer in Mathematics, with expertise in mathematics teacher preparation, particularly for elementary and middle school teachers. Ms. Gellen served as the Conference Director and played a lead role in administering all aspects of planning, implementing, evaluating and following-up on the project.

**Name:** Amar, Francois

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Amar is an associate professor of chemistry at the University of Maine. He worked collaboratively to introduce Peer Led Team Learning into general chemistry and is co-director of the department's InterChemNet Project, which uses a web-based laboratory course management system with support for advanced instrumentation and integrated assessment. Dr. Amar has worked with secondary teachers to adapt InterChemNet for high school and middle school and serves as research advisor to graduate students in chemical education research. He served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting chemical education presenters for the conference.

**Name:** Wittmann, Michael

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Wittmann is an associate professor of physics and co-operating associate professor of education at the University of Maine. He co-directs the Physics Education Research Laboratory, teaches courses in the Master of Science in Teaching Program, and advises graduate and undergraduate student theses in physics education research. Professor Wittmann and his collaborators have developed research-based curricula to teach concepts of quantum mechanics to students without physics backgrounds. He served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting presenters in the physics education field for the conference.

**Name:** Bruce, Mitchell

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Bruce is an associate professor of chemistry at the University of Maine. He worked collaboratively to introduce Peer Led Team Learning into general chemistry and is co-director of the department's InterChemNet Project, which uses a web-based laboratory course management system with support for advanced instrumentation and integrated assessment. Dr. Bruce has worked with secondary teachers to adapt InterChemNet for high school and middle school and serves as research advisor to graduate students in chemical education research. He served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting chemical education presenters for the conference.

**Name:** Geiger, Jon

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Geiger is Director of Educational Programs and Affiliated Staff Scientist at The Jackson Laboratory in Bar Harbor, Maine

where he oversees all residential and outreach educational programs. Dr. Geiger collaborates with the Center on a number of educational programs including Biomedical Research Experiences for Teachers and Students internship programs. He served on the Project Development Committee and the Academy Advisory Committee. Dr. Geiger also facilitated the Open Space forum at the conference <http://www.jax.org/>.

**Name:** Franzosa, Robert

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Franzosa is a professor of mathematics at the University of Maine. He earned the 2003 University of Maine Presidential Outstanding Teaching Award and was one of the principal investigators for the NSF CETP Maine Mathematics and Science Teaching Excellence Collaborative. His work includes research in the areas of dynamical systems and applied topology, applied mathematical consulting, and the development of general education mathematics courses that incorporate inquiry-based strategies. His education outreach efforts include directing or co-directing collaborative networks and summer academies that introduce teachers to best practices and curriculum materials for teaching mathematics. He served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting mathematics education presenters for the conference. Dr. Franzosa was course co-instructor for two Summer Academy courses entitled, 'Web Based Resources to Assist in Calculus Instruction' and 'Using Sliders in Mathematics Instruction'.

**Name:** Schaffler, Molly

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Schaffler is an assistant professor in the Department of Earth Sciences, an experienced physical and life sciences teacher, and a member of the Climate Change Institute at the University of Maine. She held a NSF postdoctoral fellowship, which supported her development of a course for teachers on community-based research projects. She teaches this course and a course in research-based curriculum adaptation for the Master of Science in Teaching program and works extensively with K-12 teachers to help them incorporate cross-disciplinary environmental monitoring projects into their science curricula. Dr. Schaffler served on the Project Development Committee and the Academy Advisory Committee and was instrumental in recruiting Earth science and life science education conference presenters. Dr. Schaffler was a co-instructor for the Summer Academy course entitled, 'Classroom Inquiry into Climate Using Computer Models and Linked Laptops', an outgrowth of the Inquiry-based Dynamic Earth Applications of Supercomputing project at the University of Maine. This NSF-funded ITEST project connects researchers at the University of Maine with middle school students and teachers to use computer modeling and visualization of geological processes in the classroom. [http://www.arch.eece.maine.edu/ideas/index.php/Main\\_Page](http://www.arch.eece.maine.edu/ideas/index.php/Main_Page). Dr. Schaffler is involved with several other projects that developed from this project.

**Name:** Rawson, Paul

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Rawson was a co-instructor for the Summer Academy course entitled, 'Aquaculture Workshop: Domestication of Aquatic Organisms'. He is an associate professor in the School of Marine Sciences at the University of Maine. His research and teaching interests focus on the ecological genetics of marine invertebrates, with an emphasis on shellfish. Current research in his lab investigates the forces which shape the evolution of physiological traits in a variety of marine invertebrates using a combination of population genetic, phylogenetic, quantitative genetic, and molecular genetic methodologies and physiological assays.

**Name:** Greenberg, Neil

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Greenberg is a Ph.D candidate and an assistant scientist and facility manager with the University of Maine School of Marine Sciences Aquaculture Research Center. He was a co-instructor for the Summer Academy course entitled, 'Aquaculture Workshop: Domestication of Aquatic Organisms'.

**Name:** Brickley, Annette

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Brickley was the professional development director for the Challenger Learning Center of Maine, a private, non-profit,

corporation offering educational programs for students and families throughout Maine with the mission of providing diverse programs that educate students and teachers in order to inspire an active lifelong passion for space and Earth science. Ms. Brickely was a co-instructor for the Summer Academy course entitled, 'Understanding Climate Change' and continues to collaborate with Center faculty and staff on projects that are an outgrowth of the conference. <http://www.clcofme.org/>

**Name:** Byrne, Deirdre

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Byrne was a research assistant professor for the School of Marine Sciences at the University of Maine. Her research interests are in the circulation and thermohaline balances of the ocean on global and regional scales with current research focusing on the Atlantic meridional overturning circulation (AMOC), a component of the global thermohaline circulation (THC), and its role in seasonal to decadal climate change. She was a co-instructor for the Summer Academy course entitled, 'Understanding Climate Change'

**Name:** Zoellick, Bill

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Zoellick is the Executive Director of Acadia Partners for Science and Learning. He received an M.Ed degree from the University of Illinois where he studied curriculum evaluation with Dr. Robert E. Stake at the Center for Instructional Research and Curriculum Evaluation. After graduating from Illinois, he pursued a career in computer science and is the author of a widely used text on file structures. He returned to educational research to work with natural resource education. At Acadia Partners he is responsible for overall education and research program coordination and administration. He was a co-instructor for the Summer Academy course entitled 'Building Inquiry-based, Student-driven Research into Science and Mathematics Programs' and he continues to collaborate with Center faculty and staff on projects that are an outgrowth of the conference. <http://www.acadiapartners.org/>

**Name:** Davis, Yvonne

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Yvonne Davis was formerly Director of Career and Technical Education for the State of Maine. She brings expertise in the development of programs that meet the needs of a diverse population of learners. At Acadia Partners for Science and Learning, she is responsible for coordinating work with schools and individual teachers and participates in teacher observation and in curriculum development. She was a co-instructor for the Summer Academy course entitled Building Inquiry-based, Student-driven Research into Science and Mathematics Programs <http://www.acadiapartners.org/>

**Name:** Koons, Peter

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Koons is a professor of geological sciences at the University of Maine. His research interests involve the application of continuum mechanics to understanding the interaction of the earth and atmosphere at many different time scales. His research group at the University of Maine links individuals with research interests ranging from short term climatic variation to mantle:crust interaction. They have been investigating the influence of atmospheric processes on the development of mountain ranges from the scales of the entire mountain range to that of single large river catchments like that of the Indus or the Tsangpo. Dr. Koons was a co-instructor for the Summer Academy course entitled Classroom Inquiry into Climate Using Computer Models and Linked Laptops, an outgrowth of the NSF-funded ITEST project Inquiry-based Dynamic Earth Applications of Supercomputing project at the University of Maine. This project connects researchers at the University of Maine with students and middle school teachers to utilize computer modeling and visualization of geological processes in the classroom. [http://www.arch.eece.maine.edu/ideas/index.php/Main\\_Page](http://www.arch.eece.maine.edu/ideas/index.php/Main_Page).

**Name:** Segee, Bruce

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr Segee is an associate professor of electrical and computer engineering at the University of Maine. His research is focused in the area of instrumentation, industrial automation, and computer control of machinery. He was a co-instructor for the Summer Academy course entitled Classroom Inquiry into Climate Using Computer Models and Linked Laptops, an outgrowth of the NSF-funded ITEST project Inquiry-based Dynamic Earth Applications of Supercomputing at the University of Maine. This project connects researchers at the University of Maine with students and middle school teachers, to utilize computer modeling and

visualization of geological processes in the classroom. [http://www.arch.eece.maine.edu/ideas/index.php/Main\\_Page](http://www.arch.eece.maine.edu/ideas/index.php/Main_Page).

**Name:** Zhu, Yifeng

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Zhu is an assistant professor of electrical and computer engineering at the University of Maine. His current research projects focus on cluster supercomputing, job scheduling, caching, middlewares, metadata management, networking, and energy-aware computing. He is associated with the High Performance Computing Lab and is the director of the research lab Archsys: Computer Architecture and Systems Lab. Dr. Zhu was a co-instructor for the Summer Academy course entitled Classroom Inquiry into Climate Using Computer Models and Linked Laptops, an outgrowth of the NSF-funded ITEST project Inquiry-based Dynamic Earth Applications of Supercomputing at the University of Maine. This project connects researchers at the University of Maine with students and middle school teachers to utilize computer modeling and visualization of geological processes in the classroom. [http://www.arch.eece.maine.edu/ideas/index.php/Main\\_Page](http://www.arch.eece.maine.edu/ideas/index.php/Main_Page).

**Name:** Neivandt, David

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Neivandt is a faculty member in the Department of Chemical and Biological Engineering at the University of Maine. During his time at the University of Maine, he has investigated wet-end retention chemistry in the pulp and paper industry, the creation of biodegradable grease resistant coatings, the functionalization of sensor surfaces for neurotoxin detection, non-classical transport mechanisms of signal peptideless proteins, controlled gelation of polymers for drug delivery, and surface modification of colloidal systems for rheological optimization. Professor Neivandt worked with the Middle School Collaborative on classroom implementations and research projects involving teachers and students. <http://www.umche.maine.edu/chb/faculty/dneivandt.htm>

## Post-doc

**Name:** Christensen, Warren

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Dr. Christensen received his Ph.D. in Physics Education Research from Iowa State University in 2007. His thesis explored student thinking on calorimetry and entropy at the level of introductory calculus-based physics. He was a Post-doctoral Research Associate for the Maine Center for Research in STEM Education for two years. In that position he has co-taught a seminar course in Education Research Methodology and a course on inquiry-based curriculum development that enrolled students take in conjunction with a immersive research internship at Jackson Laboratory. He served as a mentor and thesis committee member for Master of Science in Teaching students and assisted in developing a Chemical Education Research Course with Center faculty in the Chemistry Department. At the conference, he co-facilitated a workshop entitled 'Critically Analyzing Scientific and Education Research Literature: Activities for Students and Teachers. He served on the Project Development Committee and was instrumental in recruiting presenters in the physics education field for the conference. He also worked with teacher collaboratives as part of the follow-up to the conference. He is currently a tenure-track faculty member at North Dakota State University in the Department of Physics.

## Graduate Student

**Name:** Murphy, Casey

**Worked for more than 160 Hours:** Yes

**Contribution to Project:**

Ms. Murphy is a student in the Master of Science in Teaching (MST) Program with a physical sciences focus. She worked closely with the Conference Director preparing the conference program and administering numerous details for planning, implementing, and evaluating the project. Ms. Murphy worked collaboratively with other MST students, Center staff, and Summer Academy course instructors on the logistics of the conference and follow-up activities. She assisted the 9th Grade Science Teachers

Collaborative that participated in this project with their discussions, unit development, assessment development and management of learning data for the unit.

**Name:** Vandeventer, Joel

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. VanDeventer was a student in the MSaster of Science in Teaching (MST)Program with a physics education focus. His research involved contextual mathematics within physics classes. His thesis was entitled, 'Comparing student performance on isomorphic math and physics vector representations'. Mr. VanDeventer was the technology coordinator for the conference and Summer Academy. He worked collaboratively with other MST students, Center staff, and Summer Academy course instructors to secure and provide all the technology needed for the events.

**Name:** Hall, William

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Hall is a student in the Master of Science in Teaching program with a focus on mathematics education. His research involves student understanding of integration. His thesis is entitled, 'Student misconceptions in integration with respect to symbolic representation'. Mr. Hall was on the conference and Summer Academy technology team. He assisted with the development and implementation of two Summer Academy mathematics courses entitled, 'Web Based Resources to Assist in Calculus Instruction' and 'Using Sliders in Mathematics Instruction' and follow-up activities for the Summer Academy website.

**Name:** Stahley, John

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Stahley is a student in the Master of Science in Teaching program with a focus on mathematics education. His research involves student understanding of derivatives. His thesis is entitled, 'Students' qualitative understanding of the second derivative and how they approach it graphically'. Mr. Stahley was on the conference and Summer Academy technology team. He assisted with the development and implementation of a Summer Academy mathematics course entitled 'Explorations in Classical Geometry' and follow-up activities for the Summer Academy website.

**Name:** York, Jason

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. York was a student in the Master of Science in Teaching program with a focus on mathematics education. His research involves student understanding of basic concepts in calculus. His thesis was entitled 'Student understanding of the derivative of a composition of functions'. Mr. York was the conference and Summer Academy transportation coordinator. He assisted with the development and implementation of a Summer Academy mathematics course entitled 'Mathematics with Technology' and follow-up activities for the Summer Academy website. He taught mathematics at Lawrence High School in Fairfield, Maine.

**Name:** Hayes, Kate

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Hayes was a student in the Master of Science in Teaching (MST) program with a focus on physics education. Her research involved student understanding of problem-solving in the classroom. Her thesis is entitled 'A qualitative analysis of student behavior and language during group problem solving'. Ms. Hayes assisted planning and logistics for the conference. She graduated from the MST program and currently teaches chemistry at Bangor High School in Bangor, Maine.

**Name:** Nagpure, Bhupendra

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Nagpure was a student in the Master of Science in Teaching (MST) program with a focus on physics education. His thesis was entitled 'The effects of reasoning about vector components on student understanding of two-dimensional acceleration'. Mr. Nagpure assisted with planning and logistics for conference. After graduating from the MST program, he entered a doctoral program in Mechanical Engineering at Boston University.

**Name:** Clegg, Katie

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Clegg is a student in the Master of Science in Teaching (MST) program with a focus on life sciences. Her thesis is entitled 'Student learning of photosynthesis'. Ms. Clegg assisted with the development and implementation of a Summer Academy course entitled 'Aquaculture Workshop: Domestication of Aquatic Organisms' and follow-up activities for the Summer Academy website. She is a science teacher at Nute High School in Milton, NH.

**Name:** Whitmore, Elizabeth

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Whitmore is a student in the Master of Science in Teaching (MST) program with a focus on Biological Sciences. Her research involves first-year biology students and the impacts of an orientation experience held at Acadia National Park on the Schoodic Peninsula. Her thesis is titled 'The effects of a pre-semester interaction on study habits and academic performance of students in a freshman biology class'. Ms. Whitmore was part of a graduate student team that did extensive work on the project website, and created and presented this resource at the Center's 2009 No Question Left Behind conference.

**Name:** Mitchell, Nitisha

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Mitchell is a student in the Master of Science in Teaching (MST) program with a focus on Life Sciences. Her research involves students enrolled in anatomy and physiology classes at the University of Maine and her thesis is titled, 'Student understanding of the cardiovascular system'. Ms Mitchell was part of a graduate student team that did extensive work on the project website and created and presented this resource at the Center's 2009 No Question Left Behind conference.

**Name:** Hutchinson, Maggie

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Hutchinson is a student in the Master of Science in Teaching (MST) program. Her research involves stoichiometry and algebra and her thesis is titled 'College students' understanding of the relationship between algebra and stoichiometry.' Ms. Hutchinson was part of a graduate student team that did extensive work on the project website and created and presented this resource at the Center's 2009 No Question Left Behind conference.

**Name:** Garay, Tim

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Mr. Garay was a student in the Master of Science in Teaching program with a focus on physics education. His research involved student perceptions of physics and his thesis was titled 'The effect of a video game environment on students' interpretation of kinematics graphs.' Mr. Garay assisted in lesson planning and delivery and completed the data analysis of the pre- and post-tests for the Middle School classroom research projects.

**Name:** Jones, Mary Jean

**Worked for more than 160 Hours:** No

**Contribution to Project:**

Ms. Jones is a student in the Master of Science in Teaching program with an interdisciplinary focus on physics education, mathematics, and technology. Her research involves the extent to which students are able to recognize and use data and graphs as evidence in scientific explanations and her thesis is titled 'Student use of evidence: the use of data and graphs as evidence in supporting hypotheses among high school students'. Ms. Jones assisted in lesson planning and delivery and completed the data analysis of the pre- and post-tests for the 9th Grade Science Teachers Collaborative that participated in this project.

**Name:** DaSilva, Erik

**Worked for more than 160 Hours:** No

**Contribution to Project:**



Mr. DaSilva is a student in the MST program with a focus on earth sciences. His research involves measurement and analysis of ninth graders' ability to apply procedural skills to Earth systems. His thesis is titled, 'Procedural skills: The missing link in ninth graders' comprehension of geography's influence on climate'. He assisted the 9th Grade Science Teachers Collaborative that participated in this project, including discussion and unit development, and management of the learning data for the unit.

### **Undergraduate Student**

### **Technician, Programmer**

### **Other Participant**

### **Research Experience for Undergraduates**

## **Organizational Partners**

### **Jackson Laboratory**

The Jackson Laboratory partnered with the Maine Center for Research in STEM Education (RiSE Center) to support the conference, through sub-awards to the RiSE Center from the Howard Hughes Medical Institute, and the Bank of America Company, trustee of the Lloyd G. Balfour Foundation. Dr. Jon Geiger, Director of Educational Programs and Affiliated Scientist at the Jackson Laboratory, assisted with conference planning and served as the facilitator for the Open Space section of the conference program. <http://www.jax.org/>

### **Howard Hughes Medical Institute**

The Howard Hughes Medical Institute supports a collaborative program between the Maine Center for Research in STEM Education at the University of Maine and the Jackson Laboratory, Biomedical Research Experiences for Teachers and Students. Part of this program includes the adaptation and implementation of curriculum materials that are aligned with state and national science standards and include current research and the scientific concepts and skills related to them. Master of Science in Teaching (MST) students spend a semester at Jackson Laboratory, conducting research with one of the research groups there and taking a course on inquiry-based teaching and learning. The grant includes some funds to support conferences in order to disseminate the curriculum materials and generally improve science and mathematics education. <http://www.hhmi.org/>

### **BANK OF AMERICA N. A. (USA)**

Bank of America Company is the trustee of the Lloyd G. Balfour Foundation, which is a co-supporter of the Master of Science in Teaching students participating in the program described under Howard Hughes Medical Institute, Biomedical Research Experiences for Teachers and Students, including workshops for teachers to improve science and mathematics teaching. Funds from the Balfour Foundation helped to support this conference.

### **Maine EPSCoR FBRI**

Maine EPSCoR Forest Bioproducts Research Initiative (FBRI)

The FBRI, with support from the National Science Foundation under Grant No. EPS-0554545, provided funding for the conference and supports four ongoing RiSE Center collaborative networks and related activities that grew out of the project during the following year: University of Maine: Mathematics and Science Future Teachers Club (MSFTC), High School Physics Teachers' Collaborative (HSPTC), Mathematics Cross-Tier-Teaching-Team (CTTT), and the Middle School Collaborative (MSC). These projects complement and support the goals of the RiSE Center by building dynamic sustainable collaborations among practicing and future K-12 teachers, STEM researchers, and discipline-base education researchers and promoting broadened participation in (STEM) fields. . <http://www.forestbioproducts.umaine.edu/>

### **Acadia Partners for Science and Learning**

With funding through a Maine Department of Education Mathematics and Science Partnership Grant, Acadia Partners for Science and Learning, a non-profit organization that was created by Acadia National Park to increase the effectiveness and communication of research and science results in the national parks by promoting science literacy and resource stewardship, supported the conference and summer academy. The organization collaborated with the RiSE Center on a Summer Academy workshop and plays an ongoing role in numerous educational outreach collaborations with the Center. <http://www.acadiapartners.org/>

### **Challenger Learning Center of Maine**

The Challenger Learning Center of Maine, is a private, non-profit corporation offering educational programs for students and families throughout Maine. Their mission is to provide diverse programs that educate students and teachers in order to inspire an active lifelong passion for space and Earth science. With support from the NASA New Investigator Program, the organization collaborated with project participants on a Summer Academy workshop and plays an ongoing role in another educational outreach collaboration with the RiSE Center. <http://www.clcofme.org/>

### **University of Maine NSF ITEST Project: I**

University of Maine NSF ITEST Project: IDEAS Inquiry-based Dynamic Earth Applications of Supercomputing, (DRL 0737583)  
The ITEST project connects researchers at the University of Maine with students and middle school teachers, both at the University (during a summer workshop) and at participating schools (during the academic year) to utilize computer modeling and visualization of geological processes in the classroom. The organization collaborated with us on a Summer Academy workshop and two Master of Science in Teaching students have been involved in evaluating the impacts of this project as part of their thesis research. <http://www.micdl.org/initiatives/5>

### **Maine Mathematics and Science Alliance**

Dr. Francis Eberle, then director of the Maine Mathematics and Science Alliance, co-organized a session of the conference focused on Maine's STEM Initiative with Professor Susan McKay. This session attracted business leaders, representatives of non-profits, K-16+ STEM educators and researchers. This session served as a follow-up to Maine's initial STEM Summit.

### **Other Collaborators or Contacts**

#### **Maine Learning Technology Initiative (MLTI)**

Ms. Bette Manchester, then Director of Special Programs and Distinguished Educator, and members of her staff at MLTI identified a need for content-specific professional development for science and mathematics teachers to help them use technology more effectively in their classrooms. They suggested that the Maine Center for Research in STEM Education develop programs for science and mathematics teachers to support their use of technology in general, and the laptop computers available in Maine to all middle school students, as part of the science and mathematics curriculum. The Summer Academy funded through this project and some of the workshops and invited presentations were designed to provide this type of professional development. <http://www.mainelearns.org/>

#### **Penobscot River Educational Partnership**

This school/university collaboration serving the Penobscot River Valley is an action-centered collaborative effort of local schools, the University of Maine and state Child Development Services that works to enhance the learning of PreK-12 students by continually improving teaching and the educational experience. Their executive director, Mr. Owen Maurais, assisted with the publicity for the conference and encouraged teachers within the partnership to attend. He also assisted with program development, to ensure that it would be useful to teachers. They also invited Dr. Susan McKay to meet with their curriculum coordinators to discuss ways to make the conference match teacher needs and to help publicize the conference and summer academy. This professional development network is also a partner in the RiSe Center's recently funded Math Science Partnership (MSP) grant from NSF. <http://www.preppdn.org/>

#### **Schoodic Education and Research Center**

The Summer Academy course, 'Building Inquiry-based, Student-driven Research into Science and Mathematics Programs', was held at the Schoodic Education and Research Center and facilitated by Organizational Partner, Acadia Partners for Science and Learning, to take advantage of the field work opportunities at this coastal Maine location. <http://www.nps.gov/acad/serc.htm>

#### **Darling Marine Center**

The Summer Academy course, 'Aquaculture Workshop: Domestication of Aquatic Organisms', was held at the Darling Marine Center and facilitated by Organizational Partner, Dr. Paul Rawson, to take full advantage of the field work opportunities at this coastal Maine location. <http://www.dmc.maine.edu/>

#### **University of Maine Conferences and Institutes Division**

Ms. Marlene Charron collaborated with the conference organizers to arrange for meals, facilities, directional signs, equipment for presentations, and all other logistics to make the conference run smoothly. She was assisted by Ms. Leisa Preble, secretary for the Maine Center for Research in STEM Education, and Ms. Patricia Byard, administrative assistant, who handled registration and other arrangements for participants. <http://www.umaine.edu/conferences/>

## Activities and Findings

### **Research and Education Activities: (See PDF version submitted by PI at the end of the report)**

#### Executive Summary - Research and Education Activities:

This grant funded the conference 'Integrating Science and Mathematics Education Research into Teaching: Resources and Tools for Improved Learning', which was hosted by the Maine Center for Research in STEM Education (RiSE Center), formerly the Center for Science and Mathematics Education Research, at the University of Maine on June 22nd - 25th, 2008. The grant also supported the Summer Academy, a collection of eight courses for STEM (science, technology, engineering, and mathematics) educators, which took place from June 25th - 27th, 2008. The Conference and Summer Academy were planned with input from teachers, researchers, and graduate students, some of whom were pre-service teachers from the RiSE Center's Master of Science in Teaching (MST) Program. A web-based forum for the Summer Academy was developed by a team of MST student, which provided a vehicle for the exchange of information on materials and ideas from the Conference and Summer Academy and follow-up activities.

Summer Academy participants and additional teachers joining these groups had the opportunity to pilot activities from the short courses in their classrooms during the 2008-2009 and 2009-2010 school years. Outcomes from these pilots, including impacts on student learning, were then presented to networks of mathematics and science educators at various ongoing RiSE Center outreach and collaborative meetings. Participants also reconvened to share insights on classroom implementation activities at a session following the Center's conference, No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms, which was held June 22nd - 23rd, 2009 at the Schoodic Education and Research Center, Winter Harbor, Maine.

As a result of these events, multiple partnerships developed and many of the teachers who had participated in the Conference and Summer Academy became part of more structured collaboratives or other types of partnerships. Additional teachers joined these groups. The collaboratives provided the opportunity for teachers to meet approximately monthly, to share their experiences and resources and discuss items of importance to them. In general, the discussion topics and activities for these meetings were selected by teachers.

Two of the collaboratives, the 9th Grade Science Teachers and the Middle School Science and Mathematics Teachers Collaboratives, each chose to teach common curricular units and use common assessments. They worked with RiSE Center faculty, other STEM faculty, and MST students to understand content better, investigate research-supported resources available for the topics to be taught, develop common assessments, analyze student learning and aspirations data that was collected, and use that data to guide modifications in their teaching practice. The involvement of MST students in this process proved particularly valuable for the students and the teachers. Collaboration in the use of common research-based curricula and assessments, which began with these groups following the Conference and Summer Academy, is a crucial piece of the Maine Physical Sciences Curriculum Partnership, which was recently funded by the National Science Foundation, with the RiSE Center and 42 Maine schools as core partners.

### **Findings: (See PDF version submitted by PI at the end of the report)**

#### Executive Summary - Findings:

Participants indicated in their written evaluations and through formal and informal conversations that the Conference, Summer Academy, and follow-up projects connected to this award have met an essential need for the STEM education community to share research findings and experiences in implementing research-supported practices in their classrooms. As documented in the Activities section, many existing partnerships were strengthened and new ones were created connecting participants horizontally (across disciplines and institutions) and vertically (across grade levels). The strength of existing collaborative networks was greatly enhanced by this project.

The Conference and Summer Academy programs and follow-up activities provided current and future educators with opportunities for hands-on exploration of emerging research-based curricula that bring cutting-edge STEM content into grades 6-16 classrooms. Evaluations from the Conference and Summer Academy indicated the need for greater support in assessment of student learning. This finding led to an increased emphasis on assessment in the follow-up projects and at the Maine Center for Research in STEM Education's 2009 Conference, 'No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms.' The focus on common assessments in the collaboratives led to more careful definition of learning outcomes, which made the lessons more valuable and avoided using activities without significant learning goals.

Data from the collaboratives and ongoing projects illustrate the effectiveness of this project's research-informed model of using teams of STEM researchers, future and practicing STEM teachers, and STEM education researchers to bring cutting-edge STEM content into middle,

secondary, and post-secondary classrooms. The effectiveness of this approach is demonstrated by the evidence of student learning, along with verification of positive changes in teacher practices and the development of pre-service teachers' understanding of research-based best practices, as described in the Activities section.

Engineering design was used and assessed as a way for students to learn STEM content at the middle school level. Assessments pre- and post-instruction showed that middle school students changed their views of scientists in positive ways through these experiences. A noteworthy shift was that more students indicated in surveys after doing the engineering units that not all scientists work in laboratories. Since many Maine children come from rural areas where being outdoors and being involved with the natural environment are valued, this change suggests a strategy to encourage more Maine students to pursue study of STEM fields and related careers.

### **Training and Development:**

#### Training and Development

The Conference, Summer Academy, and follow-up projects provided training for participants at all levels. STEM and STEM Education undergraduate and graduate students attending the events learned research findings about teaching and learning and their implications for improved classroom practice. Seven graduate students involved in STEM education research from other universities received travel awards to attend and present their work. Master of Science in Teaching students received extensive training through their participation in this project. They assisted with (1) planning the conference program, including researching potential presenters; (2) providing technology support for all presentations, workshops and courses; and (3) running the Conference workshops and Summer Academy courses. As a team, they took the lead role in building the website to support the ongoing exchange of information among participants and others interested in resources from the Summer Academy and follow-up projects. They worked closely with teachers in the collaboratives and other follow-up projects, attending their meetings, searching for research-based curricular materials on topics of interest to the teachers, collecting and analyzing pre- and post-instructional data, observing in classrooms, and, in one case, co-teaching a collaborative's common unit. Further, five MST students developed thesis projects related to this award and, in conducting the research for those projects, obtained invaluable experience studying student learning, teacher professional development, and teacher practice.

At the Conference and Summer Academy, all participants, including STEM educators at the middle school, high school and postsecondary levels, students, and postdoctoral research associates received training in current research-supported resources that could be used in their teaching practice. They also had the chance to network and learn from discussions with colleagues about common challenges and interests in their work. They had many opportunities to try out new, hands-on research supported curricular materials. Researchers in the teaching and learning of STEM at all levels learned about the work being done by others and discussed new ideas and potential collaborations. Through the workshops and Summer Academy, they became very familiar with curricular materials being developed by others, how they were assessed, and ways that they could be used most effectively. All participants had opportunities to learn about research-supported strategies to broaden participation in STEM.

Teachers continued their professional development through the follow-up projects after the Summer Academy. They learned, through these experiences, more about content in their field, pedagogical content knowledge, research into teaching and learning, development of meaningful assessments, and the value of professional learning communities in their work. Within these communities, they selected common curricular materials, worked together on lesson plans, observed colleagues teach, reviewed student learning and attitude data pre- and post-instruction, and presented their work to their peers. They worked collaboratively with pre-service teachers, sharing their knowledge and learning new skills. One group, the Ninth Grade Science Teachers Collaborative, also prepared and gave a very well-received presentation of their work to the Curriculum Coordinators Group of the Penobscot River Educational Partnership. Thus this award provided a significant, ongoing training experience for participating teachers, much of it centered on their classrooms. The opportunity to work as part of a supportive community rather than in isolation was a major attraction for these teachers, some of whom are the only teacher in their field in their school. Faculty and graduate students who participated in the follow-up projects also learned about the areas listed above for teachers. Further, they acquired a better understanding of the learning environment in middle and high schools and research questions of importance to teachers at those levels.

### **Outreach Activities:**

#### Outreach Activities

This project's Conference and Summer Academy reached 118 in-service and pre-service teachers. It provided them with hands-on experiences with emerging research-based curricula that help students learn content in a more meaningful way. Teachers learned about strategies that advance participation of underrepresented groups and help more students succeed in STEM classrooms. These events supported the development of networks of teachers and faculty working together to improve student learning in STEM.

Once they returned to school, Summer Academy participants piloted activities from the short courses in their classrooms and shared outcomes from these pilots, including impacts on student learning, at a variety of ongoing outreach and collaborative meetings organized by the Maine Center for Research in STEM Education (RiSE Center). Participants also reconvened to share insights on classroom implementation activities at the RiSE Center's 2009 Conference, No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms, held in June, 2009 at the Schoodic Education and Research Center near Winter Harbor, Maine.

This project has strengthened three existing collaboratives (High School Physics Teachers Collaborative, Middle School Science and Mathematics Teachers Collaborative, and Mathematics Cross Tier Teaching Teams) and brought together participants who subsequently formed the Penobscot Bay STEM Teachers Working Group and the Ninth Grade Science Teachers Collaborative. In addition, Summer Academy follow-up projects and other partnerships involving faculty and teachers were created or strengthened. Further, this project has led to increased involvement by RiSE Center faculty and students in outreach projects provided by others, such as those run by the Challenger Learning Center, the UMaine Department of Electrical and Computer Engineering, and the Climate Change Institute. More details and examples of Outreach Activities are provided in the Activities section of this report.

### **Journal Publications**

### **Books or Other One-time Publications**

### **Web/Internet Site**

**URL(s):**

[www.umaine.edu/center](http://www.umaine.edu/center)

**Description:**

This URL contains the conference program, resources developed from the conference and summer academies and related follow-up.

### **Other Specific Products**

### **Contributions**

**Contributions within Discipline:**

Contributions within Discipline:

The Conference and Summer Academy supported by this grant have brought together middle and secondary school teachers, post-secondary science and mathematics educators and discipline-based education researchers science and mathematics, and others involved in improving science and mathematics education. The interdisciplinary emphasis of this conference and its breadth of grade levels represented have led to new collaborations extending beyond the conference, as described in the Activities section of this report. The short courses developed for the Summer Academy have been requested at other venues and met a need for specific ways for teachers to use technology and guided-inquiry in their classrooms to teach the STEM disciplines. The support provided by the project to pilot projects developed from the Summer Academy courses in the classroom offered teachers enriched experiences with the materials.

These experiences led to strengthened collaboratives among teachers, with two groups choosing to teach common material and use common assessments. The outcomes from these assessments were analyzed by Master of Science in Teaching (MST) students and then presented to the teachers. This type of collaboration worked very well in both groups. It provides a model for future and current teachers to support each other's work and learning.

The Open Space session held at the conference was particularly effective in getting groups to talk about productive ways to continue and implement the ideas of the conference. In particular, the Maine Center for Research in STEM Education (RiSE Center), formerly the Center for Science and Mathematics Education Research, has moved toward developing an infrastructure to bring STEM researchers, STEM education researchers, and teachers together to implement research-supported curriculum materials and coordinated professional development for teachers. In response to Open Space discussions, the RiSE Center has successfully pursued funding to continue the Maine High School Physics Teachers Collaborative and the Mathematics Cross Tier Teaching Teams, and the Middle School Collaborative. This collaborative model has been included as an integral part of the RiSE Center's recently funded Maine Physical Sciences Curriculum Partnership targeting physical sciences teaching and learning in grades 6-9 and teacher recruitment and preparation for these grades.

Travel grants were provided for seven doctoral students conducting STEM education research to attend the conference and Summer Academy, thus supporting capacity building for education research in these fields.

Discussions at this conference led to a successful conference grant, funded by the NSF TUSE program, focusing on interdisciplinary work to transform research in undergraduate STEM education. The first conference that was part of this grant was held at the University of Maine in June of 2010. This funded project provides evidence that the 2008 conference provided an effective venue for important interdisciplinary conversations to move STEM teaching and learning, and research in STEM education, forward.

### **Contributions to Other Disciplines:**

#### Contributions to Other Disciplines:

The Conference and Summer Academy initiated collaborations between the Maine Center for Research in STEM Education (RiSE Center), formerly the Center for Science and Mathematics Education Research, faculty and other STEM faculty and researchers. These collaborations will improve the pedagogical and scientific value of curricula, workshops, and other outreach projects initiated by faculty from either group. Examples of strengthened or new collaborations include those with the University of Maine School of Marine Sciences, the Inquiry-based Dynamic Earth Applications of Supercomputing (IDEAS) involving electrical and computer engineers and earth scientists at the University of Maine (an NSF-funded ITEST project), the Jackson Laboratory, the Maine Space Grant Consortium, Acadia Partners in Science and Learning, and the Challenger Learning Center of Maine. Five MST thesis projects are connected with these collaborations, as described in the Activities sections of this report.

Since this conference, MST students have been hired to work with electrical engineering faculty on course development and assessment and in the laboratories of a biophysicist and a chemical engineer to help with their outreach to secondary teachers and students.

The collaboration with the Jackson Laboratory in hosting this conference strengthens the other collaboration that the RiSE Center has with that laboratory: Biomedical Research Experiences for Students and Teachers funded by the Howard Hughes Medical Institute. In this project, MST students and teachers on sabbatical spend a semester immersed in a research group, experiencing first hand the process of curiosity-driven research, a very important part of STEM. These research interns bring a valuable perspective to the laboratory and take back to their classrooms improved understanding of the scientific process and experience in adapting research supported curriculum materials for their students.

### **Contributions to Human Resource Development:**

#### Contributions to Human Resource Development:

The Conference and Summer Academy provided content-focused, research-supported professional development for 88 in-service and pre-service science and mathematics teachers and 60 post-secondary faculty and graduate students. These events also provided the opportunity for those involved in STEM education research to hear about recent research findings and discuss their work with other researchers in the field. A team of eight MST students were involved in preparing summer academy materials and building the website as a place for teachers to find these materials, provide information about their experiences in using them, and explore related links. In building this website and executing various aspects of the conference and assisting with Summer Academy courses, the MST students researched available materials, learned about professional development for educators and building and testing a website. These skills are an important part of the education of these future STEM educators. Travel grants were provided for seven doctoral students conducting STEM education research to attend the conference and Summer Academy, thus supporting capacity building for education research in these fields.

The continuing activities and collaborations that developed from the Conference and Summer Academy built expertise among pre- and in-service STEM educators, thus providing ongoing human resources development.

Interactions between STEM educators at middle, secondary and postsecondary levels and STEM education researchers helped improve teacher preparation and professional development, and conversations among these groups led to a more seamless educational system and better understanding of each other's communities and students.

This project supported the development of both future and practicing teachers in STEM. Improvements in STEM education are crucial in order to meet workforce needs in both the short and long term.

### **Contributions to Resources for Research and Education:**

#### Contributions to Resources for Research and Education:

The Conference, Summer Academy, follow-up projects, website for the teaching community, and the ongoing collaborative networks all strengthen research into teaching and learning and STEM education, as discussed above. The RiSE Center's website provides archival copies of the conference program, materials used in workshops, summer academies, and collaboratives. Additional support materials are added to this website as they are developed. It is also possible for those using the site to contact RiSE Center faculty and staff to share experiences, provide feedback or ask questions about specific materials. The MST student theses related to follow-up projects to the Conference and Summer Academy document in detail some of the changes in student understanding using these materials.

The common units and assessments implemented by the Middle School Science and Mathematics Teachers Collaborative and the Ninth Grade Science Teachers Collaborative, the Student Science Attitudes and Aspirations survey and content questions developed for the Astrobiology Curriculum Pilot Evaluation Project, and the collection of questions measuring student understanding of climate are all valuable resources for teachers developed and used in projects from partnerships initiated or strengthened through the Conference and Summer Academy.

### **Contributions Beyond Science and Engineering:**

#### **Contributions Beyond Science and Engineering:**

The conference has strengthened collaborations, bringing together people with the knowledge and passion to improve STEM education and aspirations toward STEM careers for Maine students. The conference session on Maine's STEM Initiative contributed to the formation of an active statewide Maine STEM Collaborative, which has held a second STEM Summit since this conference. These summits attract leaders from Maine businesses and government, as well as those directly involved in student teaching and learning in STEM, and build awareness of the connection between strong STEM education and economic development.

This conference, the Summer Academy, and follow-up projects also provided resources for teachers using laptop computers in their classrooms. Maine has made a significant investment in technology by making laptops available to all middle school students and is in the process of expanding this program to high schools. It is important that these computers be used effectively for student learning in STEM and STEM teacher professional development, such as that provided by this project, is essential.

After discussions at the Conference, the Maine Department of Education and the RiSE Center conducted a detailed evaluation of a curriculum in astrobiology being piloted by ten schools in Maine. This study is a model for further evaluations and evidence-based decision making about STEM curricula. Further, this collaboration is significant because it brings together the research and content expertise of the RiSE Center and the decision makers of the Maine Department of Education to help improve STEM education and teacher professional development.

Improving STEM education is crucial for a positive economic future for our country. Economic improvement and its link to STEM education is particularly important for a state like Maine that is transitioning from a resource-based economy to one that has a larger technology sector. This conference, the Summer Academy, and follow-up projects are significant in improving STEM education and building capacity for future improvement.

The partnerships strengthened or initiated through the work of this grant, and the new projects funded, will have substantial impact on moving Maine forward in its STEM education. In particular, the RiSE Center and 42 Maine schools are the core partners in a recently funded Math Science Partnership grant targeting physical sciences teaching and learning in grades 6-9. Supporting partners include conference participants such as Acadia Partners for Science and Learning, the Institute for Broadening Participation, the Maine Department of Education, and the Maine Mathematics and Science Alliance, all of which participated in this conference. The partnership that made this grant successful was strengthened through all of the work of this project, and many of the key ideas of the grant were developed through conversations at this and other conferences. This grant will have a major economic impact on Maine, both in terms of immediate job creation and long-term strengthening of STEM education to provide a highly qualified workforce for new technology sectors.

### **Conference Proceedings**

#### **Categories for which nothing is reported:**

Any Journal

Any Book

Any Product

Any Conference

## **Findings**

Participants indicated in their written evaluations and through formal and informal conversations that the Conference, Summer Academy, and follow-up projects connected to this award have met an essential need for the STEM education community to share research findings and experiences in implementing research-supported practices in their classrooms. As documented in the Activities section, many existing partnerships were strengthened and new ones were created connecting participants horizontally (across disciplines and institutions) and vertically (across grade levels). The strength of existing collaborative networks was greatly enhanced by this project.

As part of this project, pre-service teachers from the Master of Science in Teaching (MST) program created an on-line forum for sharing research-based teaching and assessment strategies. This website includes links to other sites that are useful for Summer Academy participants and other teachers. The preparation of this site was a unique educational opportunity for MST students, requiring them to determine, from many options, the most useful materials to include.

Through this project, pre-service and practicing teachers and STEM education researchers, including faculty, graduate students and postdoctoral research associates, were informed about research and reportedly then used more research-supported practices in their classrooms. At the conference Open Space session, where there was an opportunity for self-directed small group discussions with participant-created agendas, three of the nine groups convened around topics related to classroom strategies for broadening participation in STEM fields.

The Conference and Summer Academy programs and follow-up activities provided current and future educators with opportunities for hands-on exploration of emerging research-based curricula that bring cutting-edge STEM content into grades 6-16 classrooms. Evaluations from the Conference and Summer Academy indicated the need for greater support in assessment of student learning. This finding led to an increased emphasis on assessment in the follow-up projects and at the Center's 2009 Conference, *No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms*. The focus on common assessments in the collaboratives led to more careful definition of learning outcomes, which made the lessons more valuable and avoided using activities without significant learning goals.

By providing participants with opportunities to collect and work with student learning data, the project strengthened the culture of evidence needed for the continuous improvement of STEM education. Teachers in the collaboratives and other follow-up projects worked together with data to document the outcomes of their practice and guide improvements. They also saw how other members of their professional communities were measuring outcomes and using data to inform practice. Further, this award provided the opportunity for teachers to discuss their teaching regularly with peers and disseminate their findings more widely to additional colleagues.



Data from the collaboratives and ongoing projects illustrate the effectiveness of this project's research-informed model of using teams of STEM researchers, future and practicing STEM teachers, and STEM education researchers to bring cutting-edge STEM content into middle, secondary, and post-secondary classrooms. The effectiveness of this approach is demonstrated by the evidence of student learning, along with verification of positive changes in teacher practices and the development of pre-service teachers' understanding of research-based best practices, as described in the Activities section.

Engineering design was used and assessed as a way for students to learn STEM content at the middle school level. Assessments pre- and post-instruction showed that middle school students changed their views of scientists in positive ways through these experiences. A noteworthy shift was that more students indicated in surveys after doing the engineering units that not all scientists work in laboratories. Since many Maine children come from rural areas where being outdoors and being involved with the natural environment are valued, this change suggests a strategy to encourage more Maine students to pursue study of STEM fields and related careers.

Specific aspects of this project that expanded its impacts and fostered the sustainability of its follow-up activities are:

- Planning committees for the Conference and Summer Academy that involved middle and high school science and mathematics teachers, faculty and graduate students, including pre-service teachers;
- Involvement of Master of Science in Teaching (MST) students in work with groups of in-service teachers;
- Inclusion of participants from across the country, while also providing space for a substantial number of Maine future and practicing teachers;
- Development of MST thesis projects linked to the follow-up work from the Summer Academy and the collaboratives;
- Inclusion of an Open Space session near the end of the Conference for participants to form discussion groups to plan ways to use what they have learned to improve STEM education;
- Use of the Conference to reinforce the goals of the Maine STEM Summit and connect with the business community, while at the same time increasing awareness of STEM discipline-based education research among that group;
- Structure of the Summer Academy to include other funded projects, which benefited all involved and led to other sources of continuing funding and additional partnerships; and
- Use of a second conference funded separately as a place to disseminate findings, reconvene groups of participants, and form new, related partnerships.

More details about the Findings from specific parts of this project are presented in the Activities section and on the Maine Center for Research in STEM Education website: [www.umaine.edu/center/](http://www.umaine.edu/center/).

**Final Report for period: May 1, 2008-April 30, 2010**

**Principal Investigator: McKay, Susan R.**

**Organization: University of Maine**

**Title: Conference 2008 – Integrating Science and Mathematics Education Research into Teaching IV: Resources and Tools for Improved Learning**

### **Research and Education Activities**

**Overview of Activities:** This grant funded the conference “Integrating Science and Mathematics Education Research into Teaching: Resources and Tools for Improved Learning”, which was hosted by the Maine Center for Research in STEM Education (RiSE Center), formerly the Center for Science and Mathematics Education Research, at the University of Maine on June 22<sup>nd</sup> – 25<sup>th</sup>, 2008. The grant also supported the Summer Academy, a collection of eight courses for STEM (science, technology, engineering, and mathematics) educators, which took place from June 25<sup>th</sup> – 27<sup>th</sup>, 2008. The Conference and Summer Academy were planned with input from teachers, researchers, and graduate students, some of whom were pre-service teachers from the RiSE Center’s Master of Science in Teaching (MST) Program. A web-based forum for the Summer Academy was developed by a team of MST student, which provided a vehicle for the exchange of information on materials and ideas from the Conference and Summer Academy and follow-up activities.

Summer Academy participants and additional teachers joining these groups had the opportunity to pilot activities from the short courses in their classrooms during the 2008-2009 and 2009-2010 school years. Outcomes from these pilots, including impacts on student learning, were then presented to networks of mathematics and science educators at various ongoing RiSE Center outreach and collaborative meetings. Participants also reconvened to share insights on classroom implementation activities at a session following the Center’s conference, *No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms*, which was held June 22<sup>nd</sup> – 23<sup>rd</sup>, 2009 at the Schoodic Education and Research Center, Winter Harbor, Maine.

As a result of these events, multiple partnerships developed and many of the teachers who had participated in the Conference and Summer Academy became part of more structured collaboratives or other types of partnerships. Additional teachers joined these groups. The collaboratives provided the opportunity for teachers to meet approximately monthly, to share their experiences and resources and discuss items of importance to them. In general, the discussion topics and activities for these meetings were selected by teachers. Two of the collaboratives, the 9<sup>th</sup> Grade Science Teachers and the Middle School Science and Mathematics Teachers Collaboratives, each chose to teach common curricular units and use common assessments. They worked with RiSE Center faculty, other STEM faculty, and MST students to understand content better, investigate research-supported resources available for the topics to be taught, develop common assessments, analyze student learning and aspirations data that was collected, and use that data to guide modifications in their teaching practice. The involvement of MST students in this process proved particularly valuable for the students and the teachers. Collaboration in the use of common research-based curricula and assessments, which began with these groups following the Conference and Summer Academy, is a basic piece of the Maine

Physical Sciences Curriculum Partnership, which was recently funded by the National Science Foundation, with the RiSE Center and 42 Maine schools as core partners.

In planning and holding the Conference and Summer Academy, supporting follow-up activities, and encouraging collaborations, the RiSE Center succeeded in addressing the eight goals of the proposed project. Below we list, in bold font, each goal and then discuss the activities that were used to achieve that goal.

**1. Provide a venue for educators, scientists, and mathematicians to disseminate information about how they are conducting research into student learning in their fields and how this research is changing middle, secondary, and post-secondary science and mathematics curriculum and instruction.**

The major venue provided by this award was the five-day national conference with a follow-up Summer Academy, as described above. Events were targeted to benefit STEM teaching and learning at the middle, high school and postsecondary levels. Conference participants included pre-service undergraduates, middle and secondary mathematics and science teachers, informal STEM educators from non-profits, STEM and STEM education faculty, graduate students and postdoctoral research associates involved in discipline-based education research. Travel grants were provided for seven doctoral students conducting STEM education research to attend the Conference and Summer Academy, thus supporting capacity building for education research in these fields.

At the Conference, 21 invited speakers presented current research activities and findings in their fields of expertise. There were four contributed talks and 26 poster presentations. Also included were 24 two-hour interactive workshops led by STEM educators and education researchers involved in research-based curriculum development, studies of student learning, and teacher preparation. Workshop topics included resources for encouraging diversity in STEM fields, technology integration, science literacy, student assessment, environmental science, geology, chemistry, mathematics, physics, astronomy, engineering, life science, and Earth science, along with sessions on the role of gender, ethnicity, and culture in STEM education.

Two special sessions were held during the conference. The first, “The Maine STEM Initiative - Building Partnerships and Strategies”, was moderated by Francis Eberle; then the Executive Director of the Maine Mathematics and Science Alliance and now Executive Director of the National Science Teachers Association, and Susan R. McKay; Professor of Physics and RiSE Center Director. This session brought together business leaders, STEM educators and researchers, and non-profit leaders to discuss ways to fostering partnerships and strategies for broadening participation and strengthening achievement by Maine students in STEM fields. A second special session, “Strategies and Challenges for Scaling-Up Research-Supported Practices”, included a panel of experts in this area: Anita Bernhardt, Science and Technology Specialist in the Maine Department of Education; Francis Eberle; Nicole Gillespie, Senior Program Officer, Science Knowles Science Teaching Foundation; Sally Goetz Shuler, Executive Director, National Science Resources Center and Bill Zoellick, Executive Director, Acadia Partners for Science and Learning.

At the Summer Academy, teachers gained expertise in guided-inquiry instructional strategies, maximizing learning through curiosity-driven research opportunities for their students, and integrating technologies in mathematics and science classrooms. The summary table below provides the titles of the eight courses offered. Summer Academy courses were activity-oriented and provided participants with concrete examples of current research-based curricula aimed at improving student learning in STEM. One of the Summer Academy courses was held at the Schoodic Education and Research Center, to take advantage of the field work opportunities at this coastal Maine location. The aquaculture workshop, at the Aquaculture Research complex at the Darling Marine Center, provided similar field opportunities.

Conference program details and presentation abstracts are given at:

<http://www.umaine.edu/center/conference-workshops/national-conference/2008-biennial-summer-conference/2008-summer-conference/>

Information about the Summer Academy is given at:

<http://www.umaine.edu/center/conference-workshops/national-conference/2008-biennial-summer-conference/2008-summer-academy-workshop-descriptions/>

CONFERENCE PARTICIPANTS	
Attendees	184
Grades 6-12 teachers	78
Graduate students/Pre-service educators	10
Graduate students	30
University faculty/staff/researchers	50
Members of non-profits, the Maine Department of Education, consultants working on mathematics and science education, etc.	16
Invited speakers & keynote speakers	22
Contributed speakers	4
RESEARCH PRESENTED	
Invited and Contributed Talks	23
Two-hour Afternoon Workshops	24
Posters presented during poster session	26

SUMMER ACADEMY COURSE TITLE	Number of Participants
Classroom Inquiry into Climate Using Computer Models and Linked Laptops	19
Understanding Climate Change	8
Aquaculture Workshop: Domestication of Aquatic Organisms	8
Explorations in Classical Geometry	7

Building Inquiry-based, Student-driven Research into Science and Mathematics Programs	15
Web Based Resources to Assist in Calculus Instruction	8
Mathematics with Technology	9
Using Sliders in Mathematics Instruction	12
TOTAL (some participants attended more than one course)	<b>86</b>

The Conference and Summer Academy provided the largest venue of this project to meet this goal. To maintain and strengthen the connections and collaborations established at this meeting, the RiSE Center hosted teacher meetings, called collaboratives, throughout the school year, and a smaller second conference, separately funded, the following year (see below). In addition, faculty, staff, and students participated in the adaptation process of materials and development and implementation of assessments with smaller groups described in more detail under Goals 5 and 6, which provide examples of horizontal and vertical partnerships. In fact, many of the partnerships formed or strengthened through this project had both horizontal and vertical elements.

Use of a second conference (separately funded) to disseminate work from 2008-2009 and strengthen collaborations - No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms (June, 2009)

The RiSE Center and The Jackson Laboratory, with support from the Howard Hughes Medical Institute, and the Bank of America Company, trustee of the Lloyd G. Balfour Foundation, and Maine EPSCoR at the University of Maine, funded by the National Science Foundation under Grant No. EPS-0554545, hosted the 3<sup>rd</sup> biennial “No Question Left Behind: Bringing Guided-Inquiry Curricula into Science and Mathematics Classrooms (NQLB)”, a one-and-a-half-day conference on June 22–23, 2009 at the Maine Schoodic Education and Research Center. This gathering was, by design, a smaller event, attracting primarily pre- and in-service teachers from Maine as well as a group of invited speakers and workshop presenters from across the country. Eighty-seven STEM educators, including 50 in-service teachers, attended the NQLB conference. Nearly sixty percent of teachers from the 2008 conference were in attendance. During the 2008-2009 school year, Summer Academy participants had piloted activities from the mini-courses in their classrooms and collaborative groups had formed. Outcomes from these pilots, including impacts on student learning, were presented at the NQLB conference’s poster session. Participants from the 2008 conference reconvened for the afternoon at the end of the NQLB conference to share insights on classroom research and implementation activities. Teachers representing all eight mini-courses were in attendance. During these two-hour sessions, participants shared information and data regarding ways that individual Summer Academy mini-courses have influenced teaching and learning in classrooms and provided support for implementing curricula in the future.

During the poster session at the NQLB conference, a poster featuring the Summer Academy website was presented. Computers were available allowing participants to explore the resources in detail. One teacher indicated the following morning that he had stayed up well into the early morning hours exploring the site and book marking many useful items. The Summer Academy website has continued to be expanded throughout the project to include information and materials from the 2008 Conference and Summer Academy and associated curriculum pilots. It features research-supported teaching resources for STEM educators and is an outgrowth of the RiSE Center's 2006 and 2008 biennial national conferences and summer academies. The website also provides a forum for teachers to exchange information, provide feedback and share classroom research and experiences. RiSE Center MST students Maggie Hutchinson, Nitisha Mitchell, Casey Murphy, Randy Stahley, and Elizabeth Whitmore participated in the website creation and presented the poster, which was a very educational project for this group of pre-service science and mathematics teachers.

### Emphasis on engineering design

Engineering design, an area that is receiving increasing attention in Maine and nationally, was reinforced at the NQLB conference in one of the five invited talks, two of the 10 workshops and two of the 14 posters. For example, Dr. Carolyn Malstrom, Director of Curriculum for Biomedical Sciences for Project Lead The Way, Inc., presented a talk titled, "Project Lead The Way<sup>®</sup> Curricular Programs Promote STEM Achievement". She facilitated the interactive workshop, "Project Lead The Way<sup>®</sup> Biomedical Sciences<sup>™</sup> Program - Hands-on Investigative Science" and presented a poster at the conference. Also, Dr. David J. Neivandt, Associate Professor of Chemical & Biological Engineering at the University of Maine and three middle school teachers from the RiSE Center's Middle School Science and Mathematics Teachers Collaborative facilitated a NQLB workshop featuring curricula developed through a Maine EPSCoR Forest Bioproducts Research Initiative (FBRI) Research Experience for Teachers. Development of assessments and implementation of these curricula in middle school classrooms took place in the second year of the project. (See Goal 6, Item C) An engineering lesson on strengths of materials, "Middle School Engineers: Mirroring current research being conducting at the University of Maine Advanced Engineering Wood Composites Center (AEWC)" was part of this workshop. The AEWC is conducting engineering research on hybrid wood composites, which are six to seven times stronger than wood alone. Inquiry is used in this middle school lesson to make and test wood composite planks to determine the most durable recipe. The group also presented a poster at the NQLB conference titled "Wood Your Students Use Real Data?". These engineering curriculum materials were adapted and refined through the Middle School Science and Mathematics Teachers collaborative.

Details and presentation abstracts from this smaller conference can be found at:  
<http://www.umaine.edu/center/conferences-workshops/no-question-left-behind/nqlb-2009/>

**2. Generate a forum for an exchange of research-based teaching and assessment strategies that (a) advance participation of underrepresented groups and (b) lessen achievement gaps between student populations in STEM classroom activities.**

At the 2008 conference, talk and workshop topics included resources for encouraging diversity in STEM fields, with sessions on the role of gender, ethnicity, and culture in STEM education. In addition, a special session, entitled, “The Maine STEM Initiative - Building Partnerships and Strategies” brought together business leaders; STEM educators; and non-profit leaders to discuss ways to fostering partnerships and strategies for broadening participation and strengthening achievement by Maine students in STEM fields. Maine has 10% fewer high school students indicating an interest in STEM careers when they take the PSAT than the national average. This session focused on a variety of strategies for increasing this number, including changes in career education and STEM education, and the importance of opportunities for students to job shadow or learn about STEM careers in other ways. A panel discussion/workshop provided resources for students, teachers, and faculty for encouraging diversity in STEM. The panel included these experts: Sharon Barker, Director of the UMaine Women’s Resource Center; Sara Willett from the UMaine Wabanaki Center; Patricia Bernhardt, Life Science Teacher at the James F. Doughty Middle School; Chris Cash, Outreach Coordinator and Sandra Thomas, Executive Director of the Institute for Broadening Participation; and Susan McKay, Professor of Physics and RiSE Center Director.

At the Open Space session, a forum for self-directed small group discussions with participant created agendas, three of the nine groups convened around topics related to classroom strategies for broadening participation in STEM fields.

Below are the titles of the talks and workshops at the Conference that provided research-based teaching and assessment strategies that advance participation of underrepresented groups and lessen achievement gaps between student populations in STEM classroom activities

- How Inclusive is Mathematical Inquiry?
- “Seeing” Gender: Encouraging Girls in STEM Fields
- Panel Discussion and Conversation: Encouraging Diversity in Stem – Resources for Students, Teachers, and Faculty
- Using Research in Your K-12 Classroom: Ethnomathematics at Work!
- Balancing the Equation – Strategies for Engaging Girls in STEM Fields
- The Maine STEM Initiative - Building Partnerships and Strategies

In the year following the Conference, a Middle School Science and Mathematics Teacher Collaborative meeting focused on strategies for gender equity in the classroom. Ms. Patricia Bernhardt, middle school science teacher at the James F. Doughty School in Bangor, ME provided a review of practical strategies to promote gender equity. In the projects spawned by this conference and summer academy, where possible, data is disaggregated to see whether or not curriculum materials work differently for different groups of students.

The RiSE Center is also linked to the Maine Girls Collaborative Project (MGCP), through participation in conferences by leaders from this group, membership of RiSE Center Director Susan McKay and Assistant Director Amie Gellen on the MGCP Champions Board, and collaborative minigrant work by Ms. Gellen and interested teachers. These collaborations build ongoing awareness and help those impacting students and teachers keep informed about research into ways to encourage girls to participate in STEM. Sharon Barker, Director of the UMaine

Women's Resource Center and PI on the MGCP grant (part of a national project funded by NSF in partnership with the American Association of University Women) was the facilitator of the conference 2008 workshop "Encouraging Diversity in STEM – Resources for Students, Teachers, and Faculty". At the NQLB Conference, the MGCP arranged a multi-site workshop "Inspiring Girls in the STEM Fields: From Research to Practice", led by Mary Madden, UMaine Associate Research Professor in the Center for Research and Evaluation. In addition to those at the NQLB conference, participants from the University of Maine at Machias, the University of Maine at Presque Isle and the University of Maine were linked from remote sites to be part of this event.

**3. Give current and future educators opportunities for hands-on exploration of emerging research-based curricula that bring cutting-edge STEM content into grades 6-16 classrooms and broaden participation in STEM fields.**

The Conference and Summer Academy schedules were packed with hands-on explorations of curricula meeting this goal. The week included 24 two-hour interactive hands-on workshops led by STEM education researchers, teachers, and faculty involved in research-based curriculum development and teacher preparation. At the Summer Academy, teachers received in-depth professional development in guided-inquiry pedagogical strategies, increasing student learning through research opportunities, and integrating technologies in their classrooms. (See Overview and Goal 1).

Each Summer Academy course had an MST student assigned as an assistant, ensuring hands-on explorations for future teachers as well, and many of these connections between students and course participants continued as follow-up projects developed. Thus, these professional development opportunities set the stage for teachers, RiSE Center faculty, and MST students to continue work on classroom implementations and assessments of student learning, as described below under Goals 6 and 7, the horizontal and vertical partnerships connected to the Conference and Summer Academy. As indicated in the descriptions of these partnerships below, additional hand-on opportunities with research-based curricula continued during the years following the conference. These follow-up projects further supported the achievement of this goal.

**4. Increase the number of pre-service and practicing teachers (a) who are informed about research into student learning within their STEM discipline and (b) who use research-supported practices to convey cutting-edge STEM content, advance participation of underrepresented groups, and lessen achievement gaps between student populations in their classrooms.**

The conference participants included 88 pre-service and in-service teachers, and provided the opportunity for them to learn about developments in research and practice related to student learning in their fields. Of the 68 Summer Academy evaluations returned by middle and secondary teachers, over 85% indicated, in the free response questions, some specific aspect of the course that they planned to use in their classroom. A follow-up survey of in-service Summer Academy participants was administered in March 2009 to gather information on impacts of the program and ways that the Conference and Summer Academy have influenced teaching. Teachers were asked to reflect on their experiences and provide feedback regarding things they



have done differently in the classroom during the past year and how the Conference and Summer Academy supported those changes.

Participants reported the following average ratings on Summer Academy evaluations immediately following the events. (1 Not Beneficial, 2 Somewhat Beneficial, 3 Neutral, 4 Beneficial, 5 Very Beneficial). Interestingly, the highest rating was for introducing participants to new resources useful in their teaching.

<b>To what extent did I find programs beneficial for...</b>	<b>Overall Average (all Summer Academy courses)</b>
networking with colleagues	4.2
developing my own pedagogical strategies	4.0
supporting or contributing to my teaching philosophy	4.1
hearing about research into teaching and learning in my field	3.7
introducing me to new resources available for my teaching	4.6
improving my knowledge of content of specific topics or in general	4.2
encouraging me to read or study more in areas related to my teaching	4.0
developing useful technical skills	4.1
helping me to make specific changes in one or more of the units that I teach	4.2
assisting with developing or locating meaningful assessments	3.3

Participants reported the following on Summer Academy follow-up survey in March 2009

<b>March 2009 2008 Summer Academy Follow-up Survey (30 responses)</b>	
<b>As you reflect on the 2008 conference/summer academy, please indicate how you found the conference beneficial</b>	<b>Beneficial &amp; Very Beneficial in this Way</b>

networking with colleagues	80%
developing my own pedagogical strategies	77%
supporting or contributing to my teaching philosophy	80%
hearing about research into teaching and learning in my field	77%
introducing me to new resources available for my teaching	83%
improving my knowledge of content of specific topics or in general	77%
encouraging me to read or study more in areas related to my teaching	70%
developing useful technical skills	70%
helping me to make specific changes in one or more of the units that I teach	77%
assisting with developing or locating meaningful assessments	33%

Over 100 pre- and in-service teachers participated in one or more of the continuing projects from the Conference and Summer Academy; thus the reach of this award was extended to those who had not been part of the initial event.

**5. Increase the number of faculty collaborating across disciplines to do research into student and teacher learning of specific content in their respective disciplines, classroom strategies that broaden participation in STEM fields, and research regarding the preparation and retention of exceptionally well qualified middle and high school STEM educators (i.e., horizontal partnerships).**

The interdisciplinary nature of the conference led to cross-disciplinary collaborations that were begun as an outgrowth of conversations and presentations at the 2008 Conference. Below are several examples:

**A. TRUSE (Transforming Research in Undergraduate STEM Education) Conference.** During informal discussions at the 2008 conference, RiSE Center faculty member John Thompson, Associate Professor of Physics and Cooperating Associate Professor of Education, and Marcy Towns, Associate Professor of Chemistry at Purdue University began exploring the possibility of a grant proposal for a conference bringing together STEM discipline-based education researchers from different fields to share methodology and pursue possible areas of fruitful collaboration related to undergraduate STEM teaching and learning. Dr. Thompson and Dr. Towns, along with Chris Rasmussen, Associate Professor of Mathematics at San Diego State University and Warren Christensen, former RiSE Center postdoctoral teaching and research associate and now Assistant Professor of Physics at North Dakota State University, submitted a conference grant proposal to the NSF program Transforming Undergraduate STEM Education,

which was funded. The first conference funded through this proposal, with a goal of transforming research in undergraduate STEM education, brought together researchers in mathematics, physics, and chemistry education to the University of Maine in June 2010.

**B. Strategies for interactive learning in large astronomy classes.** David Batuski, UMaine Professor of Physics, and Conference invited speaker Edward Prather, who earned his Ph.D. at the University of Maine and is now Associate Research Scientist, Senior Lecturer, and Director of the Center for Astronomy Education at the University of Arizona, are collaborating on interactive learning in the large introductory astronomy 'lecture' classroom. This work came out of discussions at the Conference. Dr. Prather was also an invited speaker and workshop provider at the 2009 NQLB Conference, furthering this collaboration.

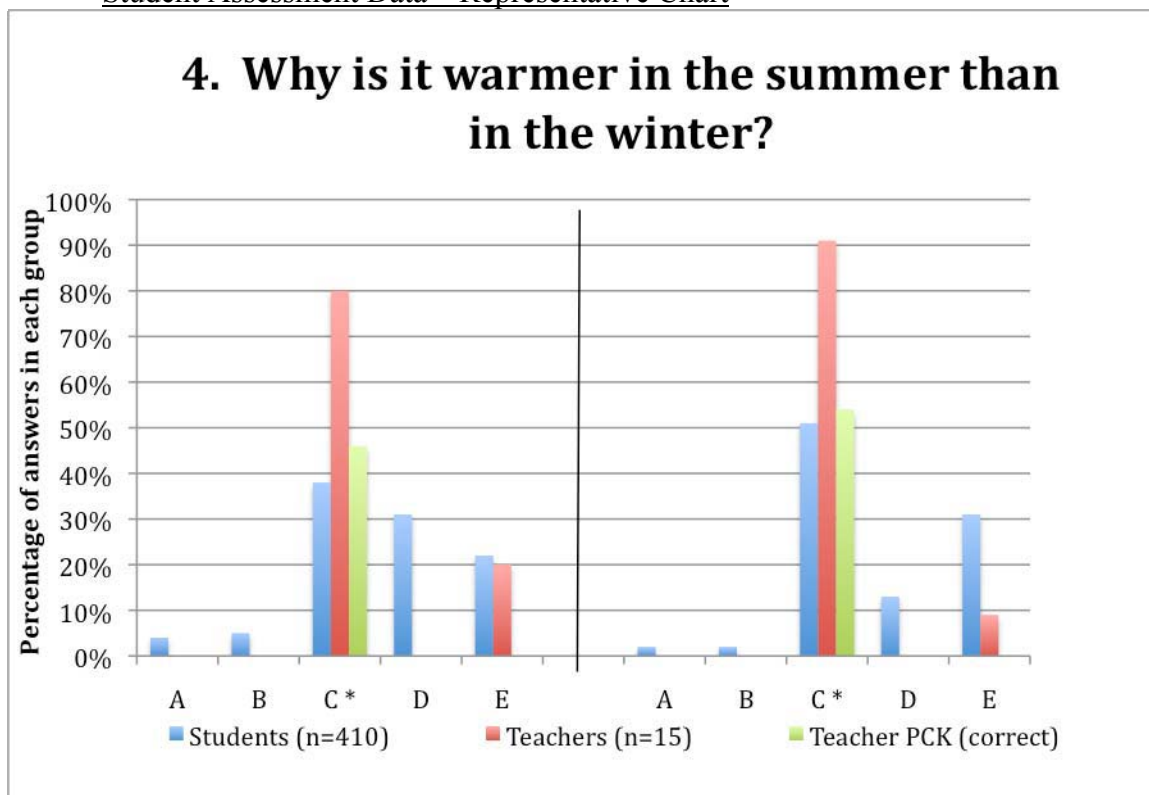
**C. ITEST-IDEAS collaborations with others on integrating technology into science, mathematics, and engineering teaching.** RiSE Center faculty member Molly Schaufler, UMaine Research Assistant Professor in the Climate Change Institute, was a co-instructor for the Summer Academy workshop, “Classroom Inquiry into Climate Using Computer Models and Linked Laptops”. She is a project leader for the Inquiry-based Dynamic Earth Applications of Supercomputing (IDEAS) project at the University of Maine. As an outgrowth of the conference, several faculty from the IDEAS project met several times during the year with other education leaders and researchers from the Center for Digital Learning, Gulf of Maine Research Institute, University of Southern Maine, Foundation for Blood Research, the Island Institute, Acadia Partners in Science and Learning, and others to discuss professional development for teachers, with a focus on technology. Members of this group are conversing with Google about collaborating on developing Google tools for use in STEM education. Dr. Schaufler has also become involved in technology-related proposals submitted by the Island Institute (to the NSF ITEST program) and Acadia Partners for Science and Learning (State Math Science Partnership) related to climate change and the use of data in science classrooms.

**D. Connecting Climate to Curriculum.** Through the conference and summer academy, RiSE faculty member Molly Schaufler became more involved in ongoing work with Annette Brickley, then Professional Development Director of the Challenger Learning Center of Maine, a NASA Educator Resource Center. Ms. Brickley was a facilitator for the Summer Academy workshop, “Understanding Climate Change”. Since the conference, they have worked together, acquired continuing funding from the State Math Science Partnership program for **Connecting Climate to Curriculum: C’s to Shining C’s**. In this project, they work with the UMaine School of Marine Sciences, two MST students, and 12 middle and high school science teachers from four regional school districts and the regional CTE. Content areas connected to the project include life sciences, physical sciences, and technical education, aligned with the Maine Learning Results. The project began as part of the 2008 Summer Academy and, to date, approximately 300 students from Bangor, Hermon, Old Town, and Hampden, ME have been impacted. The group met monthly or bi-monthly during the past year to work in learning communities to research, adapt, implement, and assess classroom instructional units that engage students in climate inquiries across the curriculum. Each teacher participant invited a teaching colleague from their school to join the group, thus expanding the reach of the project. Teachers implemented lesson study plans and observed in each others’ classes, and are now working in their own professional learning communities to improve lesson plans. They have received State

funding to continue meeting and collaborating on classroom projects during the 2010-2011 school year.

Student learning from this project is measured using a set of common assessments and the data is analyzed by MST students and then reviewed by the teachers. Below is a sample of pre- and post-test results for the classic question about what causes the seasons. The left panel provides pre-instruction responses, while the right panel shows the results after instruction. The green column indicates the predictions of teachers about their students' responses. Blue and red columns are student and teacher responses respectively. These preliminary results suggest a gain from 38% to 50% in students' understanding of the concept in question (n=164), and also suggest that teachers over-estimate what their students understand, a common finding among a variety of questions. This question is one of over 30 questions on climate and related concepts used to probe student and teacher understanding of these topics.

Student Assessment Data – Representative Chart



4. "...why is it warmer in the summer than in the winter?"

- a. "... because the winter clouds block heat from the Sun."
- b. "... the Sun gives off more heat in the summer than in winter."
- c. "... because Earth's tilt changes the angle of sunlight hitting Earth."
- d. "... the Earth orbits closer to the Sun in the summer than in the winter."
- e. "... because the Northern Hemisphere is closer to the Sun in summer than in the winter."

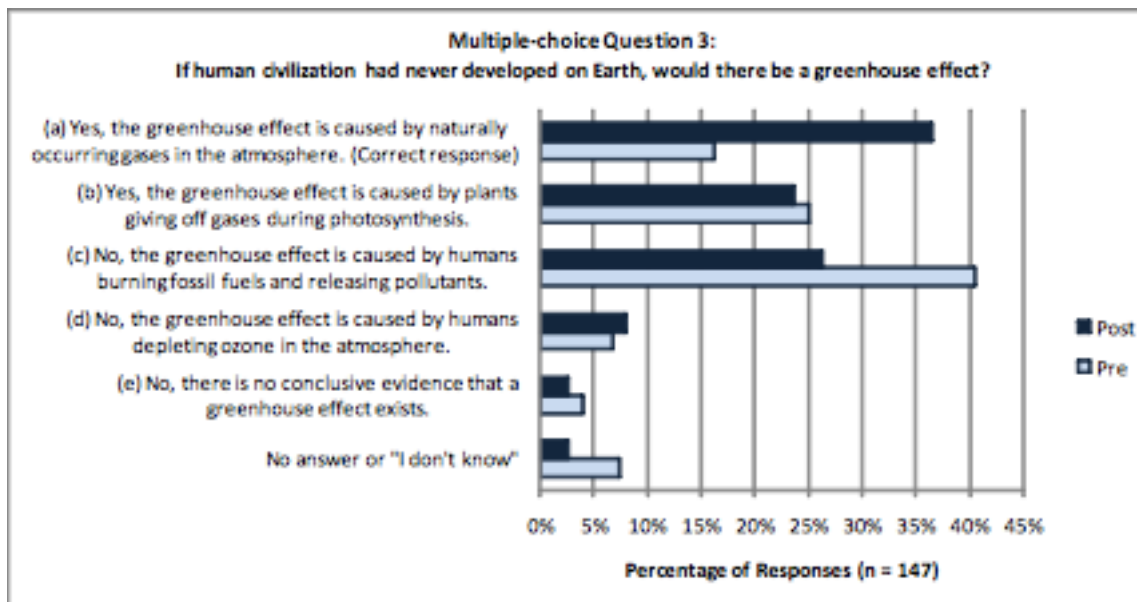
### Changes in teacher practices

MST students Lisa Schultz and Mindi Kvaal Andersen had the opportunity to observe teachers implementing the materials used in this project, which was a very valuable aspect in their preparation as teachers. Observations and verbal and written comments from teachers pointed toward changes in practice. Teachers reported that they had:

- learned the importance of integrating concepts within math and science;
- became familiar with misconceptions students may have (about content and about the process of science);
- found resources for information for their classrooms;
- considered ways of incorporating what they learned at the workshop into the classroom;
- become proficient in the "use of the Carbon 14 cycle to introduce climate change";
- examined patterns of local climate change;
- used charts, graphs and data to relate science and mathematics concepts;
- recognized the value in awarding time for student reflection.

**E. Inquiry-based Dynamic Earth Application of Supercomputing (IDEAS).** This NSF ITEST project, run by faculty from the UMaine Department of Electrical and Computer Engineering and the Climate Change Institute, was part of the 2008 Summer Academy and subsequent activities involving teachers and students are ongoing. The conference led to more involvement by RiSE Center faculty and students to assess student learning related to computer models introduced in the project. As activities were implemented in the classroom, MST students Lisa Schultz and Katie Priest worked with teachers to evaluate students' learning about the greenhouse effect and earth's seasons using computer simulation models. The following chart describes pre- and post- test student responses, indicating a gain in correct understanding of the greenhouse effect after using a computer model to explore this phenomenon.

### Student Assessment Data – Representative Chart



### Changes in teacher practices

Project facilitators received this communication from an IDEAS teacher during 2009-2010:

“It's not often that we get a chance to reflect on our teaching or be recognized by our peers and administration for what we do with students. I have the honor and privilege of being nominated by the staff and administration of Hermon Middle School as a Maine teacher of the Year for 2011. I see this as a reflection of the learning and lessons that I have taken from both the C2C workshops and the IDEAS work. Both have brought new ideas and lessons into the classroom that would not have been there if not for the work that you both have done to expose me to great resources and rekindle the teaching flame that, for an almost 22 year veteran, is starting to burn lower. I don't know how far I will get in the process, but please realize that each step is because of teachers, like yourselves, that have shown me what excellent teaching is and presented me with the tools to make a difference in science education in Hermon. After my lessons on Computer modeling today, I really thought I needed to share.”

### Description of the role pre-service teachers played and what they learned

MST student Lisa Schultz conducted her thesis research of how students' understanding of the greenhouse effect changes after working with a NetLogo-modified model. She learned how to analyze pre- and post- concept maps, free-response, and multiple choice questions. She compared how these different types of assessments worked for honors students and students in the regular academic track. She also looked for differences by gender in her data, but did not see any. Her work provided extensive analysis of data, investigations of available computer models, and analysis of features in those models that enhanced student learning.

For more details about this study, please see:

<http://www.umaine.edu/center/directory/mst-graduates/lisa-schultz/>

MST student Katie Priest is studying aspects of student learning about the seasons related to technology use from this project for her thesis research.

## **6. Facilitate the growth of university-school networks that connect faculty and STEM and education researchers with current and future middle and high school science and mathematics educators (*i.e.*, *vertical partnerships*).**

**A. Astrobiology Curriculum Pilot Evaluation.** At the 2008 conference, Susan McKay, Professor of Physics and RiSE Center Director, discussed with Anita Bernhardt, Maine Science and Technology Specialist in the Department of Education, an upcoming pilot of an astrobiology curriculum in ten schools. Both agreed that there should be an evaluation of student learning and changes in students' aspirations along with this introduction of the new curriculum. They pursued funding from the Maine Space Grant Consortium and the National Astrobiology Institute for this study, which pre- and post-tested participating students in the pilot and a group of control students. Content questions used in the evaluation were aligned with 8<sup>th</sup> and 9<sup>th</sup> grade Maine performance indicators and national standards and were included in the interdisciplinary Astrobiology curriculum. The questions, many from released state, national or international tests, were reviewed by an experienced group of science teachers. Attitudes towards science

class and STEM careers were also measured, with a total of 273 students participating. Analyses, done by MST student Elizabeth Burroughs as part of her thesis, showed no significant differences between astrobiology and control students in either the science content or the attitude post-test data. There were also no significant differences between the two groups in learning gains or attitude movement between pre-test and post-test. There was no evidence indicating that the astrobiology curriculum worked better (or worse) than traditional curricula for either gender or for students who are economically disadvantaged, as indicated by receiving free or subsidized school lunch. This type of detailed study, which also looked for correlations between students' performance with either curriculum and their Maine Educational Assessment scores, provides a model for evaluation of future curriculum pilots. Besides bringing Dr. McKay and Ms. Bernhardt together to discuss this study, the Conference also provided additional knowledge and helpful discussions with others about how to do this evaluation most rigorously. The full report on this study will be posted on the RiSE Center website later this summer. ([www.umaine.edu/center/](http://www.umaine.edu/center/))

**B. Expansion of University-school collaboratives post-conference.** The Conference and Summer Academy facilitated the growth of University-school networks. During the two-year period following the conference, five collaboratives, serving as professional learning communities, met: Middle School Science and Mathematics Teachers Collaborative, 9<sup>th</sup> Grade Science Teachers Collaborative, the Penobscot Bay STEM Teachers Working Group, the High School Physics Teachers Collaborative, and the Mathematics Cross Tier Teaching Teams. Although the groups differ in scope, independence, and goals, each supports the development of a culture of evidence about effective instruction in STEM and has goals of improving student achievement and aspirations and broadening participation in these fields. Four of these groups received some support through an educational outreach grant administered by RiSE Center Assistant Director Amie Gellen from Maine EPSCoR through NSF award #EPS-0554545, the Forest Bioproducts Research Initiative, which supplemented funding from this award. These collaboratives linked STEM teachers, STEM and STEM education faculty, graduate students, and postdoctoral research associates and focused on topics generally suggested by the teachers. Specific common curriculum and assessment projects conducted by the 9<sup>th</sup> Grade Science Teachers Collaborative and the Middle School Science and Mathematics Teachers Collaborative follow in items C and D.

Collaboratives built on project successes by furthering awareness of research-supported best practices in STEM teaching, helping teachers learn how to implement these practices, and strengthening forums for educators to share experiences, network with colleagues, and work together to implement and assess practices that research indicates are most beneficial to student learning and aspirations in these fields. Practices that broaden participation in STEM fields, including collaborative learning, inclusion of relevant applications to engage diverse groups, and constructive classroom environments were emphasized. Over 100 teachers, 60 pre-service teachers and graduate students, and 25 STEM and education faculty have participate in these networks, reaching over 6000 middle and high school students. Historically, about 60% of program participants are women. Early in the project, these forums provided venues for sharing outcomes from the Summer Academy classroom pilots. As the project developed, discussions were based more upon use of common materials and assessments.

The MST students played a key role in the collaboratives, and the collaboratives provided valuable educational experiences for them. Typically part of the MST student's assistantship support was for analyzing data for the teachers and seeking research-based curriculum materials on particular topics. Their work between meetings raised the level of the collaboratives, providing analysis to guide further improvements in teaching practice. One completed MST thesis and four theses in progress have research questions related to work in the collaboratives or other professional development activities linked to the 2008 Conference and Summer Academy.

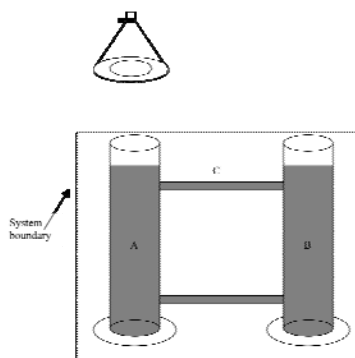
### **C. Ninth Grade Science Teachers Collaborative use of a common unit and assessments.**

This group of seven teachers represents six high schools in central Maine, most within the Penobscot River Educational Partnership, a long-time collaborator with the RiSE Center involved in the planning and proposals for this and previous conferences. This group of teachers serves approximately 400 students from households with a wide range of incomes. Students are predominantly Caucasian, but also include a significant Native American population.

This collaborative was established and organized by the participating teachers, who identified two primary goals: (1) the improvement of teachers' collective and individual understanding of core scientific concepts; and (2) the creation (or adaptation), implementation, and assessment of common instructional units. The core concept that became the focus of this group is energy transfer through systems, with the system of interest being the Earth's oceans. During the first year following the Conference, this group met to gauge the variety of curricula in the region, to learn the pedagogical approaches of others, to identify common challenges, to deepen understanding of content, and to envision a defensible and essential 9<sup>th</sup> grade science experience. Throughout, the collaborative referred to published national guiding documents, such as Ready, Set, Science, a guidebook of recent science teaching and learning research published by the National Academies Press. As they grappled with content, they invited STEM and STEM education faculty as guests to their meetings.

Once the collaborative decided upon the focus for their work and committed to using common materials and assessments, they submitted a brief proposal detailing their plans and budget to Dr. Susan McKay, who was able to provide the funds that they needed for materials and teacher stipends through this award as a follow-up to the 2008 Conference. From this group, six teachers collected student responses to an online pre- and post-instruction test that included questions about a system that replicated one studied in their classrooms, a configuration of tubes and columns of water, with a light either on or off above one column as illustrated below. Students had the opportunity, as part of their instruction on this topic, to make observations and build explanations for their observations using a set-up similar to the one pictured.





Data and results, summarized in the table below, were analyzed by MST students and showed significant normalized gains for characterizing most aspects of this system, although some students still had difficulty understanding the (lack of) motion of the water with the light off. Teachers discussed the common incorrect answers from their students, and also the difficulties that students had connecting this model system with actual ocean currents. This group plans to re-teach this unit next year, after discussing ways to help students make the necessary connections to energy transfer in the Earth's oceans.

Questions (offered in five-response, multiple choice format)	Percent Normalized Gain (%)
1: With the light OFF, which part of the system would be gaining the most energy?	58
2: With the light still OFF, which part of the system would be losing the most energy?	46
3: With the light still OFF, which of the following would best describe the motion of the water in Tube C?	26
4: How would the system respond if the light was turned ON?	68
5: Imagine that the light is ON and that it has been ON for a while. Which of the following now best describes the motion of the water in Tube C?	65

The percentage of normalized gain was found by dividing the percentage of actual gain by the percentage of maximum gain possible. In addition to the five multiple choice questions summarized above, the group also used free response items to probe student thinking in more depth. A poster describing this study was presented at the RiSE Center's June 2010 Conference, and a very constructive discussion ensued during the Open Space Session of that conference, suggesting other assessments such as the Energy Concept Inventory that could be helpful in this project. There was also considerable discussion of the vocabulary needed to describe this type of system: equilibrium, steady state, driven system, non-equilibrium – all good terms for students to understand better.

This group also presented their work to the Penobscot River Educational Partnership: Professional Development Network’s curriculum coordinators’ group. That group identified this work as a model to be encouraged for teachers in other subjects and at other grade levels.

MST students involved in this study worked with the teachers to find resources that could be used, set up the pre- and post-tests on Survey Monkey, and analyzed and presented the data to the teachers. One of the MST students, Mary Jean Jones, co-taught the unit as part of her student teaching internship. Involvement with this group of teachers through this process has provided an unusual and valuable educational opportunity for these pre-service teachers.

**D. Development and implementation of engineering units for middle school students as part of the Forest Bioproducts Research Initiative.** This project was part of the work of the middle school science and mathematics teachers collaborative, which involved three MST students; five lead middle school teachers; RiSE Center Assistant Director Amie Gellen, a former practicing civil engineer and mathematics educator; David J. Neivandt, Associate Professor of Chemical and Biological Engineering, and Darrell Donahue, Professor of Chemical and Biological Engineering at the University of Maine. Lead teachers Patricia Bernhardt, Judy Campbell, Elizabeth Haynes, Kelley Littlefield, and Tracy Vassiliev piloted four units at three middle schools. The units were: (1) wood composites inquiry science lab; (2) tree management; (3) creation of a tree brochure; and (4) microbial pie, and were created by Tracy Vassiliev through three NSF Research Experience for Teachers supplements to an NSF Research Experiences for Undergraduates grant (EEC-06 48793 “Explore it! Building the Next Generation of Bio-Refinery Researchers”). For each unit, content assessments were administered pre- and post-instruction.

Students’ views regarding science and scientists were also assessed before and after each activity. Students were asked to pick from ten adjectives to describe a scientist. Seven of these qualities saw significant growth: creative, hard working, makes mistakes, observant, works with others, uses mathematics, and continues to learn. Curious, persistent, and open-minded all saw positive but non-significant change. Below is one example of a content assessment for the microbial pie activity, which was implemented in two schools with approximately 200 students participating. Over half of these students qualify for free or reduced-price lunch.

Student Assessment Data – Representative Chart

**Microbial Pie:** significance: +/- 15 students

*What is a zone of inhibition?*

<b>Choice</b>	<b>Change (count)</b>
An area of growth	-26
An area of mixed organisms	-29
An area of no growth	75

An area of only one organism	-10
I don't know / blank	-10

This question shows a strong increase in the correct answer; before instruction the results to this question were divided, while after instruction student responses were focused on the correct response. Smaller, but still significant, improvements were seen in other questions that required more depth of knowledge. Further information about this work at the middle school level is available on the RiSE Center website: [www.umaine.edu/center/](http://www.umaine.edu/center/).

**E. Focus on STEM careers for girls.** Briana Haynes, a mathematics teacher at the Belfast Area High School in Belfast, Maine, and a Summer Academy and Mathematics Cross-Tier Teaching Team participant has partnered with the RiSE Center on a grant proposal to the Maine Girls Collaborative Project. Discussions regarding this proposal began at the Conference. The project, which received funding, provides opportunities for 9<sup>th</sup> grade girls to interact with women in STEM fields with the goal of generating interest in STEM careers and increasing the number of girls in higher level mathematics and science classes at Belfast Area High School. At the start of this project, only one of the 80 girls in the senior class was taking the upper level mathematics class and only eight of the 80 senior girls plan on entering STEM fields when they begin college, so some intervention is extremely necessary. The senior class has approximately 125 students. Amie Gellen, RiSE Center Assistant Director, is collaborating with Ms. Haynes on this project.

**F. Penobscot Bay STEM Teachers Working Group initiated by Conference and Summer Academy participants.** Professor Molly Schaufli, RiSE Center and UMaine Climate Change Institute faculty member, and co-instructor for the Summer Academy workshop “Classroom Inquiry into Climate Using Computer Models and Linked Laptops” became inspired by Conference keynote speaker Ron Berger, Field Director of the Northeast Region of Expeditionary Learning Schools Outward Bound when he talked about community-based research projects. As follow-up to her Summer Academy involvement, she worked with a group of four teachers who started to monitor long-term temperature at their schools using automatic data-loggers. This group of teachers met two times after the Summer Academy to continue to develop skills working with data and develop evidence to answer questions related to temperature. Six new teachers subsequently joined the group. They posted their temperature data on a common Moodle site, so that all ten schools involved could exchange data freely. This group also met at the 2009 NQLB conference to share results and discuss examples of student-generated research questions. Interest in working with data remained high among these teachers, and was part of the impetus for the formation of the Penobscot Bay STEM Teachers Working Group, which is co-facilitated by Elizabeth Haynes, a mathematics teacher at Troy Howard Middle School in Belfast, ME and a Lead Teacher in the Middle School Science and Mathematics Teachers Collaborative. This new group has been meeting over the past year to explore

- current STEM topics relevant to community and global change;
- how the group might collaborate to make STEM learning relevant to community and personally meaningful to students;
- how STEM curricula might be vertically aligned and incorporate relevant themes such as issues facing Penobscot Bay communities and environments, energy use, or others, so

students build interest, knowledge, and skills in STEM subjects and their applications in local communities; and

- funding options for investigations, student research projects, and support to work to align STEM curriculum vertically and across STEM disciplines.

This group brings together educators from RSU 20, the University of Maine Hutchinson Center, Waldo County Technical Center, United Technologies Center, the Penobscot Marine Museum, Bucksport and Deer Isle-Stonington schools. During the past year, participants have already become part of several submitted or funded collaborative grant proposals aligned with their interests.

**7. Increase the number of pre-service and practicing teachers involved in the critical evaluation of curriculum materials for science and mathematics teaching and learning through research-based methods of assessing student achievements in science and mathematics.**

The Conference and Summer Academy provided necessary background, motivation, and initiation for many teachers required for them to use research-based methods to evaluate curriculum materials. The following are the titles of the talks and workshops at the Conference that specifically addressed research-based assessment strategies:

- Assessment and Improvement of Problem Solving
- What Were They Thinking? Linking National Standards, Research on Learning, and Formative Assessment
- Research From a World Class Ecosystem Study Promotes Environmental Literacy for Teachers: How Do We Measure the Impact?
- Are You Really Teaching if No One is Learning? How Interactive-Lecturing Can Be Used to Measure Improved Student Learning

After the 2008 Conference and Summer Academy, the collaboratives and other professional development projects continued this emphasis on assessment, with teachers using data to inform their teaching practice, building a culture of evidence. Discussion of assessments continued at the 2009 NQLB conference and the RiSE Center website is being expanded to include an exchange of information on assessment tools. Most valuable in meeting this goal, though, has been the collaborations of MST students and teachers, with the students doing much of the data collection and putting it into forms that teachers can interpret and discuss. Most teachers do not have the time to process the data, and many do not have the skills. MST students, though, are involved in discipline-based education research and can bring these skills to the project. This approach enables teachers to guide modifications by data about their own classes and those of their peers, which is inherently very interesting to them and improves their own pedagogical content knowledge.

**8. Create a pioneering, research informed model that utilizes collaborative teams of STEM researchers, future and practicing STEM teachers, and STEM education researchers to bring cutting-edge STEM content into middle, secondary, and post-secondary classrooms.**

This conference and summer academy, the collaborations, follow-up events and projects that have resulted contain essential pieces for a pioneering, research informed model that uses collaborative teams. Horizontal and vertical partnerships have been formed or strengthened. STEM teachers at the middle and high school levels have become an increasingly important part of the education of future teachers and, at the same time, University faculty and future teachers have provided valuable professional development for STEM teachers, often based upon what is going on in their classrooms. The links with University faculty have become an important resource for teachers as they reflect upon their practice individually and as a community, and work to employ research-based practices. Research questions to improve STEM teaching and learning are arising from the middle and secondary level teacher collaboratives as well as from University faculty, leading to partnered explorations. MST students have played an important part in the success of this project, by constructing web resources, collecting and analyzing data, locating or developing appropriate assessments, and searching for research-based units in content areas requested by teachers.

An essential ingredient in any successful model, though, is follow-up, and that follow-up must contain a strong assessment component in order to document impacts and guide future related efforts. The involvement of STEM educators in developing common assessments led to not only better measurement of outcomes, but also to a clearer statement of the desired outcomes of the units prior to implementation. Thus this project illustrates how a Conference and Summer Academy, with follow-up, can strengthen existing projects, lead to new partnerships, build a shared culture of evidence, and instill a common framework of knowledge for project participants.

It is the exciting connections described above that led the RiSE Center faculty and teachers in 42 Maine schools to propose working together in the Maine Physical Sciences Curriculum Partnership, submitted in August of 2009 and recently funded by the National Science Foundation. The conferences and collaboratives described above, and those held previously, provided the groundwork and trust leading to this large, five-year Partnership. This model is a powerful one for improving STEM education for all students, achieving vertical alignment of curriculum, and using data and collaborations to inform and improve practice. The Conference and Summer Academy, as well as other interactions across these communities, have kept participants focused on ways to achieve these goals.