



MAINE CENTER FOR RESEARCH IN STEM EDUCATION

ANNUAL REPORT

July 1, 2011 – June 30, 2012

CONTENTS

- Listing of Center Faculty and Staff
- Mission
- Research Overview and Highlights from FY12
- Student and Faculty Awards and Honors
- Items Relevant for Return on Investment
- Goals for the Coming Year
- Opportunities, Challenges and Solutions for FY13
- Long-term Priorities
- New and Continuing Funded Research
- Graduate Degrees Awarded
- Publications
- MST Courses Offered
- K-12 Placements and Teacher Sabbatical Participants
- Maine Map Showing Placements and School Locations of Sabbatical Teachers

Prepared by Susan R. McKay, Center Director and Professor of Physics

**LISTING OF FACULTY AND STAFF
MAINE CENTER FOR RESEARCH IN STEM EDUCATION
(RiSE Center)**

Erika Allison

Maine Physical Sciences Partnership Project Operations Director

Francois G. Amar

Associate Professor and Chair, Department of Chemistry

Shirly Avargil

Maine Physical Sciences Partnership Postdoctoral Research and Teaching
Associate

Jason Baker

Maine Physical Sciences Partnership Resource Coordinator

David J. Batuski

Professor and Chair, Department of Physics and Astronomy

Mitchell R. Bruce

Associate Professor of Chemistry

Elizabeth Burroughs

Interim Project Coordinator, Maine Physical Sciences Partnership, and
Interim RiSE Center Assistant Director

Patricia L. Byard

Administrative Assistant I (shared with the Department of Physics and
Astronomy through August 31, 2011)

Daniel Capps

Assistant Professor of Science Education

Krista Capps

Postdoctoral Research and Teaching Associate (September - December,
2011)

Erik daSilva

Interim Project Coordinator, Maine Physical Sciences Partnership

Frank Dudish

Lecturer in Physics and Center Research Associate

Brian Frank

Postdoctoral Research and Teaching Associate (through July 31, 2011)

Robert D. Franzosa

Professor of Mathematics and Statistics

Christopher Gerbi

Assistant Professor of Earth Sciences

LISTING OF RiSE CENTER FACULTY AND STAFF (cont.)

Kirk A. Maasch

Professor of Earth Sciences and Climate Change Institute

Susan R. McKay

Director, RiSE Center, and Professor of Physics

Joanna Meyer

Maine Physical Sciences Partnership Resource Coordinator

Edie Miles

Maine Physical Sciences Partnership On-line Community and Data Manager

Stephen A. Norton

Professor Emeritus of Geological Sciences and Climate Change Institute

Eric A. Pandiscio

Associate Professor of Mathematics Education

Leisa S. Preble

Secretary (shared with the Department of Physics and Astronomy)

Tracy Richardson

Financial and Personnel Manager

Molly Schaufler

Research Assistant Professor (adjunct) with the Climate Change Institute

Jonathan Shemwell

Assistant Professor of Science Education and Cooperating Assistant

Professor of Physics

Michelle Smith

Assistant Professor of Biological Sciences

Natasha Speer

Assistant Professor of Mathematics Education

Medea Steinman

Maine Physical Sciences Partnership Placement and Professional Development

Coordinator

MacKenzie Stetzer

Assistant Professor of Physics

John R. Thompson

Associate Professor of Physics and Cooperating Associate Professor of
Education

Michael C. Wittmann

Associate Professor of Physics and Cooperating Associate Professor of
Education

**Mission of the Maine Center for Research in STEM Education:
*To advance the research and practice of teaching and learning
in science, technology, engineering and mathematics (STEM).***

RISE CENTER RESEARCH OVERVIEW AND HIGHLIGHTS 2011-2012

Research Overview

RiSE Center faculty members, with their postdocs, students and other collaborators, have continued to investigate teaching and learning of science and mathematics at grades 6-16+. The research of the Maine Physical Sciences Partnership (MainePSP) has led to new strengths in teacher and student learning in physical sciences in grades 6-9 and significant investigations into teacher preparation and practice.

One area of common interest among several faculty members is ***the knowledge needed by teachers, including content knowledge, pedagogical content knowledge, and knowledge for assessment***. Research on this topic is essential for effective teacher preparation and professional development. **Natasha Speer** received a grant from the Spencer Foundation to continue her work on mathematicians' knowledge for teaching, focusing at the postsecondary level. **Francois Amar, Mitchell Bruce and Jon Shemwell** have been working with MainePSP postdoctoral research and teaching associate **Shirly Avargil** and MST student **Laura Millay** to investigate teachers' knowledge for assessment in the middle grades. **Michael Wittmann** and physics doctoral candidate **Benedikt Harrer** are analyzing video of middle school teachers to better understand teacher knowledge of student thinking about energy and how it influences their practice. **Francois Amar, Mitchell Bruce, Mac Stetzer, and John Thompson** are working with MST student **Dan Laverty** to investigate teacher knowledge of student ideas related to density and force and motion at the middle school level. **Dan Capps** has continued work with the national Fossil Finders program, investigating teacher learning and teacher change as teachers participate in an authentic paleontological investigation.

Complementing these studies of teacher knowledge are investigations into student thinking in middle and high school grades. **Molly Schaffler** and her MST advisees **Kara Soule, Kathryn Priest, and Mary Jean Jones** are studying student thinking about key concepts related to climate change, cause of seasons, and data analysis at the middle and high school levels. **Michael Wittmann** and MST student **Levi Lucy** are studying teacher and student ideas about energy. MST student **Dan Laverty** and collaborating faculty listed above are also investigating student ideas of density and force and motion in the middle grades.

Numerous RiSE Center research projects focus on student learning in University courses. **Francois Amar, Mitchell Bruce, Jon Shemwell, and Michael Wittmann** have all been involved in studies of gesture analysis to better understand student cognition and coordinate depictive and linguistic experiences in science classes. MST students **Evan Chase, Virginia Flood, and Savannah Lodge-Scharff** are also part of the research team for these studies. **Mac**

Stetzer is investigating student learning of analog electronics in introductory and upper division laboratory courses in physics. Upper level laboratories are part of almost all undergraduate physics curricula but are only beginning to be studied. **Molly Schaufler**, working with MST student **Milissa Knox**, is investigating undergraduate students' perceptions of cell structure and function. **Jon Shemwell and Mac Stetzer**, working with physics Ph.D. student Jayson Nissen, are studying students' affective experience in introductory physics courses. **Shirly Avargil, Francois Amar, and Mitchell Bruce** are building analogous reasoning opportunities into introductory chemistry laboratories and studying their impacts on student learning. **Michelle Smith** is collaborating with other faculty members from the School of Biology and Ecology to study student learning at the introductory level (BIO100) and also in an upper level genetics course (BIO350). In particular, she is interested in student conceptual difficulties in genetics and in using clickers (personal response systems) to enhance student engagement and learning through discussion. She is working with **Francois Amar, Mitchell Bruce** and **Barbara Stewart** to conduct similar research using clickers in introductory chemistry courses. **Natasha Speer** worked with recent MST graduate **Allison Dorko** to investigate students' understanding of the concepts of area and volume in calculus. **Speer's** research, done in collaboration with MST students **Rob Blaisdell, Sarah Rizzo, Shawn Firouzian, Adi Conlogue, and Marie Strause**, also investigates student knowledge or teacher understanding of student knowledge of key concepts in calculus, college algebra, and recursion. **John Thompson**, working with MST student and physics doctoral candidate **Rabindra Bajracharya**, is investigating student understanding of definite integrals using graphical representations. **Thompson** is also investigating upper division teaching of specific physics concepts within the fields of thermodynamics and statistical mechanics, working with Ph.D. student **Jessica Clark**. In related work, **Francois Amar** and MST student **Jason Bakelaar** are studying student understanding of entropy and free energy changes. **Jon Shemwell** and collaborators are investigating the value of inductive models of instruction for science learning. Their studies focus on undergraduate learning of challenging physics concepts, and find better learning from inductive models than from hypothetico-deductive processes.

With the release of the national Next Generation Science Standards (NGSS) in early 2013 and their anticipated adoption by the state of Maine, an important and timely area of research is how teachers interpret the scientific practices and use them in their classrooms. Also important is research into the supports that are most essential for teachers as they make the transition to NGSS. **Shirly Avargil, Dan Capps, Jon Shemwell, and Bill Zoellick** (from SERC Institute) have formed the Teacher Experiences Project within the MainePSP. This group has analyzed teacher journals and interviewed teachers who are shifting to more research-supported, student-centered practices through the MainePSP to understand the difficulties that they have encountered and the places where teachers and students would benefit from additional support to teachers. This research is essential to the MainePSP, and is also of high national importance in

anticipation of the adoption of NGSS by a large number of states during the coming year. **Dan Capps** and his MST advisee **Ashley Young** are investigating current use of scientific practices by teachers in K-12.

MST student **Kendra Michaud** is collaborating with **Dan Capps** and **Michelle Smith** and leadership at the Challenger Learning Center of Maine to collect and analyze data from middle school classes who participate in Challenger missions. Clickers are being used to collect the data to increase response rate and make it easier for participants to respond. This information will be used to improve the mission experience and better understand student learning from it.

Highlights from 2011-2012

- The RiSE Center welcomed four outstanding new tenure-track faculty members at the beginning of the 2011-2012 academic year: Dan Capps (College of Education and Human Development), Jon Shemwell (College of Education and Human Development), Michelle Smith (School of Biology and Ecology), and Mac Stetzer (Department of Physics and Astronomy). These new faculty have initiated new collaborations with each other and across campus. They have also demonstrated strong leadership skills in the context of the Maine Physical Sciences Partnership (MainePSP).
- The RiSE Center moved into its own space in York Complex, Building #1. This space houses the Center staff, and provides three small shared offices for the fourteen faculty who are part of the Center and the sixteen Master of Science in Teaching students supported by grants and needing office space. As a first space for RiSE personnel, this is a major step. However, there is not enough space for the MainePSP research team and for graduate students supported by other RiSE grants. Plans are in the works for a renovation of Estabrooke Hall, which will provide additional space for RiSE faculty, staff, and students. The benefits of having all RiSE members in the same building with places to collaborate and congregate, and offices for those who do not have offices elsewhere on campus, are huge.
- The Maine Physical Sciences Partnership (MainePSP), which involves most RiSE Center faculty members and numerous MST students, as well as 48 schools in Maine, accomplished the goals of Year II of their \$12.3 million grant funded by the National Science Foundation's Math Science Partnership Program. This grant established MainePSP, targeting the teaching and learning of physical sciences in grades 6-9 and the preparation of science teachers at the University of Maine. This proposal, entitled "Maine Physical Sciences Curriculum Partnership: Research and Infrastructure for Ongoing Educational Improvement", was awarded effective July 1, 2010, and recently the annual report from Year II was accepted, releasing full funding for the next two years. The project includes RiSE Center director **Susan McKay** as PI, and RiSE Center faculty members **Mitchell Bruce**, **John Thompson**, and **Michael Wittmann** as co-PIs, along with Owen Maurais, Executive Director of the Penobscot River Educational Partnership: Professional Development

Network. Senior personnel who are playing an important role in the Partnership are RiSE Center faculty members **Francois Amar, Dan Capps, Chris Gerbi, Jon Shemwell, Michelle Smith, Natasha Speer,** and **Mac Stetzer**; Susan Smith, Executive Director of the Down East Educational Partnership; John McDonald, Assistant Superintendent of Regional School Unit #20 (Belfast and Searsport area); Susie Valaitis, Associate Director of the Institute for Broadening Participation; and Bill Zoellick, Chief Financial Officer and Director of Education Research at the SERC Institute. Besides SERC Institute and the Institute for Broadening Participation, other supporting partners on this grant include the Maine Department of Education (Anita Bernhardt and Jeff Mao), and the Maine Mathematics and Science Alliance.

- Highlights from the year's MainePSP campus-based initiatives include: (1) a successful competition for Faculty Incentive Grants (led by **Natasha Speer**), to provide more active learning, student centered pedagogy in campus STEM courses, especially those taken by pre-service teachers. Grants were awarded to faculty in Biology, Chemistry, Earth Sciences, Marine Sciences, and Physics and Astronomy. These faculty will be including Maine Learning Assistants, undergraduates facilitating group work, in their courses and assessing the learning outcomes from the changes in their pedagogy. **Mac Stetzer** developed and taught a seminar for Maine Learning Assistants, preparing them for this type of course involvement; (2) a summer undergraduate research experience program for four University of Maine undergraduates majoring in STEM or STEM education subjects, led by **Mitchell Bruce**; (3) professional development for graduate teaching assistants in STEM, led by **Natasha Speer, John Thompson,** and **Mitchell Bruce**; (4) the University Classroom Observation Program, led by **Michelle Smith** and **Mac Stetzer**, in which teachers spent three days observing STEM courses at the University, using a common observation protocol. These observations provide baseline information about STEM teaching and learning at the University; and (5) a workshop for STEM faculty to provide professional development in preparing the Broader Impacts section of grant proposals to include meaningful research collaborations between K-12 students and teachers and STEM researchers, led by **Michelle Smith** and Bill Zoellick.
- Major accomplishments of the MainePSP during the past year in its work with grades 6-9 partnering districts include: (1) implementation of common, task-force-recommended instructional resources by 24 middle school science teachers, led by **Francois Amar** and **Michael Wittmann**; (2) selection of common 9th grade instructional resources to be implemented in 2012-2013 via a task force led by **Dan Capps** and **Mac Stetzer**; (3) professional development for first cohort of MainePSP teachers, including Summer Academy, led by **Dan Capps, Mac Stetzer,** and **Michael Wittmann**; collaboratives (led by **Michael Wittmann**), cohort meetings (led by **Francois Amar** and **Michael Wittmann**), and Teacher-in-Residence opportunities (led by **Francois Amar** and **Susan McKay**); observations and journal analysis by faculty, postdocs, and graduate students to better understand how the PSP impacts classroom practice and the areas in which teachers need additional

supports (led by **Shirly Avargil, Dan Capps, Jon Shemwell, and Bill Zoellick**); development of a working on-line community for all project participants, including MainePSP teachers (led by **Edie Miles** and Bill Zoellick); a Teaching Partner Program pairing pre-service teachers, with professional development in the use of PSP-selected instructional resources, with PSP teachers in their classrooms (led by **Erika Allison**); and support from Resource Coordinators **Jason Baker** and **Joanna Meyer** to provide materials needed for hands-on instructional.

- RiSE Center faculty members had twenty new projects funded during the past year for a total of **\$1.65 million** (some of these projects include multiple year funding). These grants provide support for graduate students, postdocs, and faculty summer salary, as well as some research equipment and facilities. This total does not include the continuing grants previously funded.
- With funding from the Maine Technology Asset Fund, RiSE Center Director **Susan McKay** and Physics faculty member **Sam Hess** have worked with University of Maine Facilities Management to create two offices and an image processing laboratory from unused space in Bennett Hall. The Image Processing Laboratory, now completed and fully equipped, is an invaluable research tool for high speed processing of interview and classroom video. This project also includes a new elevator to improve equipment transport and handicap accessibility within the building, which is planned for completion during the coming year.
- RiSE Center faculty, staff, and students produced 26 accepted or published peer-reviewed papers, two book chapters and one book during the year. Faculty, postdocs, and students gave over 110 research presentations and invited colloquia during the year.
- The MST program has expanded its impact on Maine schools, with 24 students or graduates teaching full-time in the public schools (see map and table included) and three student teachers spending the spring semester in classroom internships. As part of the Center's collaboration with the Jackson Laboratory (JAX), one sabbatical teacher and four Master of Science in Teaching students spent the spring 2012 semester as research interns at JAX and developed research-based curricula, which were implemented in local classrooms, with assistance from experienced mentor teachers. In this way, the program is bringing current research and the concepts underlying it into science and mathematics classes. This project receives funding from the Howard Hughes Medical Institute and the Lloyd G. Balfour Foundation and, this year, received a renewal from the Arthur Vining Davis Foundation. Additional funds for future years have been awarded from the Hearst Foundation and Jane's Trust.
- The RiSE Center hosted its sixth biennial conference "Integrating STEM Education Research into Teaching: Knowledge of Student Ideas" on June 20th-22nd at the University of Maine, which attracted over 140 participants. This conference brought together future teachers, other graduate students and postdoctoral research associates, STEM education researchers, and middle and high school science and mathematics teachers.

- **Molly Schaffler** conducted over 20 data literacy workshops with middle and high school science and mathematics teachers in Hancock, Waldo and Penobscot Counties. Working with Bill Zoellick of SERC Institute, she has incorporated Project-Based Inquiry Science activities and data sets from the MainePSP into these professional development opportunities for teachers.

STUDENT AND FACULTY AWARDS AND HONORS

- **Elizabeth Burroughs** was selected as the Outstanding MST Graduate in the Generalist Option for 2012. She has completed the requirements for initial certification in secondary life sciences and mathematics and has accepted a position teaching mathematics at Ellsworth High School beginning fall of 2012. Her thesis was advised by Professor Susan McKay.
- **Allison Dorko** was selected as the Outstanding MST Graduate in the Mathematics Concentration for 2012. She will be beginning a doctoral program in mathematics education at Oregon State University in the fall of 2012. Her thesis was advised by Professor Natasha Speer.
- **Rabindra Bajracharya** was selected as the Outstanding MST graduate in the Physics Concentration for 2012. His thesis is advised by Professor John Thompson.
- **Chris Gerbi** received a prestigious National Science Foundation Career Award: Identifying Dominant Controls on Strain Localization in the Lower Crust, which also includes a significant education component.
- **Mac Stetzer** was invited to co-present (with Lillian McDermott, U. of Washington) a workshop for new Physics and Astronomy Faculty held in College Park, MD, entitled "Research in physics education: A resource for improving student learning."
- **John Thompson** was elected to chair the Physics Education Research Topical Group of the American Association of Physics Teachers.
- **Mitchell Bruce** served as a Grant Review Board member of the Northeast Region Board of the American Chemical Society.
- **Dan Capps** served as a reviewer for the Presidential Awards for Excellence in Mathematics and Science Teaching for the state of Maine.
- **Eric Pandiscio** serves on the editorial review board of the Journal for Research in Rural Education.
- **Michael Wittmann** served as the lead organizer for the conference Foundations and Frontiers of Physics Education Research 2011, held in Bar Harbor, Maine.
- **Susan McKay** was appointed to the Governor's STEM Council and serves on the higher education subcommittee of that group.
- **Molly Schaffler** serves as Vice President of the Belfast Bay Watershed Coalition and Secretary of the Josselyn Botanical Society.
- **Jon Shemwell** served on the Item Review Committee for the Maine Science Assessment.
- **Michelle Smith** has been selected to co-lead the Howard Hughes Medical

Institute's educational initiative called Course Source, which will provide peer-reviewed educational materials to instructors. She will be working specifically on the genetics education portion of the project.

- **Dan Capps** was selected to co-chair the National Association for Research in Science Teaching Graduate and Early Career Scholars Group.
- **Francois Amar** serves on the American Chemical Society's Exams Institute Committee, which writes National General Chemistry examinations.
- **Michael Wittmann** serves on the editorial board for Physical Review Special Topics – Physics Education Research.
- **Natasha Speer** is Chair of the editorial board of the Journal for Research in Mathematics Education Research and serves as coordinator of the Special Interest Group for Research in Undergraduate Mathematics Education of the Mathematical Association of America.
- **Kate McCann Hayes**, an MST student who graduated in August, 2009, holds a prestigious Knowles Science Teaching Foundation Fellowship. She is teaching physics at Bangor High School. Kate is a Maine native who completed her undergraduate degree in Biomedical Physics at Northeastern University and graduated as valedictorian of her class there. Through the Knowles Science Teaching Foundation, she was awarded a grant to establish a high school physics teachers collaborative in the Bangor area during 2011-2012.
- **Susan McKay** was invited to serve on the Maine Next Generation Science Standards Leadership Team.
- **John Thompson** was invited to serve on the Selection Committee for the Knowles Science Teaching Fellows.

ITEMS RELEVANT FOR RETURN ON INVESTMENT

Total new grants and contracts funded in FY2012: \$ 1.65 million
(This total does not include continuing projects in which funding was granted as a single award.)

Peer-reviewed papers or conference proceedings accepted or published: 26
Presentations at national and international meetings and invited colloquia: ~112.

For FY12, the RiSE Center received ~\$43,100 in MEIF funding. **Return on investment: ~38 times.** Impressive as this return rate is, it is substantially lower than last year's return, since none of the funding from the \$12.3 million MainePSP is included as new awards.

The MEIF funds make a huge difference in the RiSE Center's ability to support personnel. They support, in part, the Center's postdoctoral research associates and graduate students conducting research. This budget line enables the RiSE Center to provide continuing appointments as some grants end and new ones begin. Without these personnel, the research productivity of the RiSE Center would have been much lower. In particular, it would not have been possible for the RiSE Center to have prepared the \$12.3 million Math-Science Partnership proposal funded by NSF without the MEIF support.

The Master of Science in Teaching Program is supported in part through E&G funding. This funding is allocated to support student teaching assistantships and costs associated with faculty teaching courses in the program, rather than research activities.

There are no University faculty members with salary lines through the RiSE Center funded by MEIF. Beginning in the fall of 2011, three new faculty members (Capps, Smith, and Stetzer) started their appointments with salary lines supported by the Maine Physical Sciences Partnership grant from the National Science Foundation. All other Center faculty members are supported by appointments through their home departments.

Additional measures of success for the Maine Center for Research in STEM Education:

Estimated number of K-12 students who had an MST graduate, sabbatical participant, or current MST student as a teacher in 2011-2012: more than 2,500 (figuring conservatively with approximately 80 students per teacher; most of these students are in Maine)

Total number of pre- and in-service teachers participating in Center conferences, collaboratives, and other outreach programs in 2010-2011: approximately 150.

GOALS FOR THE COMING YEAR

- Collaborate with the College of Education and Human Development (COEHD) and the STEM departments to develop a proposal for an interdisciplinary Ph.D. program in science and mathematics teaching and learning. Pursue other joint projects in teacher preparation and the teaching and learning of STEM K-16+ with these groups. With a new dean and two new science education faculty members in COEHD, this is a great time to work together to further strengthen STEM education in Maine and STEM education research at the University of Maine.
- Acquire suitable space for RiSE faculty, staff and students by working with Facilities Management, the architects, and other planned occupants to complete the renovations of Estabrooke Hall as quickly as possible, while still maintaining the high quality of the project.
- Continue to build research strength and attract external funding. The RiSE Center is well positioned to meet this goal with its strong senior faculty, its four new faculty members and the new research initiatives launched as part of the Maine Physical Sciences Partnership (MainePSP).
- Continue to provide mentoring and support for the four new faculty members and new postdoctoral research and teaching associates in the RiSE Center. Help them to meet their career goals while at the same time contributing productively to the research and teaching work of the Center and the work of the MainePSP.
- Continue to attract top quality students to the MST program. The MST Program is becoming increasingly selective, with the MainePSP attracting more applicants than in previous years. RiSE faculty have decided to increase enrollment from 25 to 30 students, due to the increased advising capacity of new faculty hired. Some of this added capacity is being reserved for the formation of a new interdisciplinary Ph.D. program in Science and Mathematics Teaching and Learning, which is under discussion.

OPPORTUNITIES, CHALLENGES, AND SOLUTIONS FOR FY13

OPPORTUNITIES:

1. The Center is unusual in its level of quality research collaboration among discipline departments and the College of Education and Human Development. With so much concern about STEM education in the United States, the time is right to grow strength in this research area at the University of Maine. We have an excellent start and are nationally competitive for grants and graduate students. In order to be in a position to take full advantage of increased federal funding in these areas and expand the Center's disciplines to include biological sciences, marine sciences, and engineering, additional faculty members are needed. The three new faculty hired through the Maine Physical Sciences Partnership (MainePSP) and a new hire in science education in the College of Education and Human Development have provided an outstanding cohort of four faculty members to support the Center's work. In this first year, this cohort has already contributed greatly to the MainePSP and to other RiSE research. In addition to the research and teaching expertise that they bring, all have shown strong leadership capabilities and teamwork skills.
2. The release of the Next Generation Science Standards early next year and Maine's planned adoption of these standards provide a positive roadmap to substantially improve science teaching and learning in K-12 in Maine. These standards interweave science practices and content in specific ways, qualitatively different from the Maine Learning Results. To support teachers making this transition in their teaching, the University needs to modify its science teacher preparation and professional development. These changes have already begun as part of the MainePSP, guided by the Common Core Framework for Science.
3. The MainePSP provides superb opportunities for the RiSE Center and the University of Maine in the areas of STEM teacher preparation and modification of STEM courses to include student-centered, research-supported pedagogy, and data-guided modifications. The research that is part of this partnership will truly make the University a leader in science and mathematics teacher preparation, and create an infrastructure for ongoing improvement in STEM education. This grant has provided substantial national and state recognition and visibility, giving opportunities for an increased voice in state and national work and additional collaborations.
4. The RiSE Center is poised to collaborate in meeting the demand for a Ph.D. Program in Science and Mathematics Teaching and Learning. Graduates from the MST program and practicing teachers frequently inquire about the future availability of such a program. This program is crucial in order to retain and maximize the research productivity of the four new RiSE faculty. This type of offering would meet a need for the capacity in Maine to sustain and expand the work of the MainePSP, including continual data-guided improvement of science and mathematics education.

5. The MainePSP is using an innovative multi-district/University partnership model to bring research-supported instructional materials and teacher professional development to Maine science classrooms. This model has the potential to expand regionally and lead to a sustainable infrastructure that will build upon the work of the initial grant. This partnership has started something that appears to be very effective and, with proper planning and advancement work, the opportunities to have a large, statewide, and perhaps regional, impact are substantial.

CHALLENGES AND SOLUTIONS:

1. Urgent need for space for the Maine Physical Sciences Partnership that supports the interdisciplinary work of the project. The Maine PSP moved its staff into the renovated space in York Complex, Building #1 in October of 2011. Unfortunately there is not enough space for the researchers involved in the project, including graduate students, postdocs, and faculty. While faculty all have offices in their academic homes, it would be helpful for those leading the research and implementation pieces of the project to have some shared office space near the staff and students with whom they need to interact frequently. Graduate students are currently sharing offices exceeding double capacity. A feasibility study is underway for Estabrooke renovations. If both the first and second floors can be done, this renovation would enable all RiSE members to have at least shared office space in one location. Estabrooke also provides needed storage for the extensive materials and supplies used in science teaching grades 6-9 as part of the MainePSP. We are working with the architects, Facilities Management, and the other planned occupants of Estabrooke to move this project forward as quickly as possible. However, as the MainePSP enters Year III, and continues to grow in terms of the number of people involved in research and implementation activities, this space is crucial and urgently needed. Renovations for this space must move forward very rapidly, without sacrificing the quality of the space, to support collaborative research within the RiSE Center.

2. Need for additional mathematics education faculty. With its four new science education hires, the University of Maine is well positioned to conduct research on and influence the preparation of teachers for implementation of the Next Generation Science Standards. Similarly, though, the Common Core Standards for Mathematics have been adopted in Maine and mathematics teachers are trying to adjust their teaching to align with them. The best way to serve Maine students and teachers well through this transition in mathematics is by collaborative district/University work, similar to that underway in the MainePSP. However, the University has only two mathematics education faculty members, Professors Eric Pandiscio and Natasha Speer. When the MST program was established, there were three mathematics education faculty. We have had to reduce the number of mathematics concentrators in the MST at a

time when more preparation for mathematics teachers is needed. It will not be possible to offer mathematics in the interdisciplinary Ph.D. program under discussion without more mathematics education faculty. Hiring one additional mathematics education faculty has been discussed for 2014-2015 as part of the Department of Mathematics and Statistics' plan. It is crucial that this plan be enacted, and it would be beneficial to add one more beyond this person if at all possible. Mathematics education faculty would strengthen the research competitiveness within the RiSE Center and improve the teacher preparation at all levels in mathematics and science on campus.

LONG-TERM PRIORITIES

- ***Space and visibility.*** We have need for a place where research collaborators, teachers in residence, and other visitors can work productively as part of our intellectual community. Facilities for student interviews, data analysis, student offices, and classroom video recordings are also needed. We hope that this problem will be solved, at least in the short-term, through space promised for the Maine Physical Sciences Partnership. Having space on campus will enhance visibility. RiSE faculty members are also working with RiSE Advisory Board members on strategies to build the center's visibility off campus.
- ***Growth of our high quality research center.*** We need to keep adding excellent faculty and postdoctoral research associates to strengthen research in new areas and build collaborations across disciplines. The Maine Physical Sciences Partnership (MainePSP) grant has provided three faculty positions and three postdoctoral research associate positions, which have given the RiSE Center a wonderful opportunity for growth.
- ***Establishment of an interdisciplinary Ph.D. Program in Mathematics and Science Teaching and Learning.*** The RiSE Center is working with the College of Education and Human Development and the STEM departments to develop a plan for this program, including planning realistically for resources to sustain such a program. Interested faculty members have begun drafting by-laws for a "field", whose members would lead this program, and course requirements for the program have been drafted.
- ***Ongoing development and improvement of the MST program.*** The MST Program is a niche program at the University and attracts excellent future science and mathematics teachers to Maine. Expansion of the areas of science teaching taught in the program to include chemistry, biology, marine sciences, and engineering education is a priority. Possible introduction of a middle school science concentration, coordinated with the MainePSP, would also be very beneficial and help sustain the work of the initial MainePSP grant.

NEWLY FUNDED RESEARCH PROJECTS

(Only investigators and co-investigators who are RISE Center members are listed.)

Funding Source	Project Title	Principal Investigator	Co-Investigators	Sponsor Total
National Science Foundation through Island Institute	Energy for ME	M. Schaffler		\$21,281
Spencer Foundation	Mathematicians' Knowledge for Teaching	N. Speer		\$39,975
National Science Foundation	Integrated Analytical-Computational Analysis of Microstructural Influences		Christopher Gerbi	\$298,171
Howard Hughes Medical Institute through Jackson Laboratory	Biomedical Research Experiences for Students and Teachers 11-12	S. McKay		\$87,793
National Science Foundation through Seattle Pacific University	Processes of Learning About Energy Dynamics	M. Wittmann		\$14,950
US Department of Energy	Thermochemical Conversion of Woody Biomass to Fuels and Chemicals		F. Amar	\$620,000
Webber Oil Foundation	Support for Integrating Clicker Technology in the Middle School Classroom	M. Smith		\$1,500
University of Maine CETA	Making Things Click in UMaine Biology Classes		M. Smith	\$824

Howard Hughes Medical Institute through Jackson Laboratory	Biomedical Research Experiences for Students and Teachers Yr 5	S. McKay		\$65,500
Provost funds for STEM	Support for collaboration between the RiSE Center and the Challenger Learning Center	S. McKay, D. Capps		\$14,000
University of Maine Unified Course Fees	Request for Departmental set of clickers		M.Smith	\$3,099
Arthur Vining Davis Foundation through Jackson Laboratory	Mastering Science: Biomedical Research Experiences for Teachers and Students	S. McKay		\$100,000
US Dept. of Education through Schoodic Education and Research Center Institute	Acadia Learning Phase II Yr 2		M. Schaffler	\$23,419
Hearst Foundation through Jackson Laboratory	Mastering Science: Biomedical Research Experiences for Teachers and Students	S. McKay		\$100,000
US Dept of Education through ME Dept of Education	Extended Data Literacy		M. Schaffler	\$30,146
University of Maine Learning Assistant Program	Proposal for the Modification of BIO350	M.Smith		\$3,376
Provost funds for STEM	Research Fellows for the Governor's STEM Council	S. McKay		\$12,500
National Science Foundation	CAREER: Identifying Dominant Controls on Strain Localization in the Lower Crust	C. Gerbi		\$125,000

Jane's Trust through Jackson Laboratory	Mastering Science: Biomedical Research Experiences for Teachers and Students	S. McKay		\$80,000
Maine Community Foundation	Gateway to Science: a pilot early college program for mid-coast high school students		M.Schauffler	\$8,108

Total FY Awarded: \$1.65 million.

CONTINUING FUNDED RESEARCH PROJECTS

(Only investigators and co-investigators who are RiSE Center members are listed.)

Funding Source	Project Title	Principal Investigator	Co-Investigators and Sr. Personnel	Amount
National Science Foundation	Maine Physical Sciences Curriculum Partnership: Research and Infrastructure National Science Foundation	S. McKay	F. Amar M. Bruce N. Speer J. Thompson M. Wittmann	\$12.3 million
San Diego State University Foundation (NSF)	Using Gesture Analysis to Explore Embodied Cognition in Chemistry	F. Amar	M. Bruce M. Wittmann	\$5,000
Lloyd G. Balfour Foundation	Mastering Science: Biomedical Research Experiences for Students and Teachers	S. McKay	M. Schauffler	\$270,276
San Diego State University Foundation (National Science Foundation)	Investigating Mathematical Knowledge Using Physicsless Physics Questions	J. Thompson		\$5,000
National Science Foundation	Collaborative Research: A Conference to Promote the Integration of Research on Undergraduate Mathematics, Physics, and Chemistry Education		J. Thompson	

National Science Foundation	Collaborative Research: Research and Curriculum Development in Thermal Physics		J. Thompson	\$337,214
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MASTER OF SCIENCE IN TEACHING DEGREES AWARDED 2011-2012

Name	Degree	Thesis Title	Advisor
Elizabeth Burroughs	MST	The Astrobiology Project: Effects on Students' Science Aspirations and Achievement, and an Analysis of Self-Handicapping Behavior	S. McKay
Katie Clegg	MST	Assessing Middle and High School Students' Conceptual Understanding about Photosynthesis	M. Schauffler
Allison Dorko	MST	Calculus Students' Understanding of Area and Volume in Non-Calculus Contexts	N. Speer

Publications

BOOK

Hauk, S., **Speer**, N., Kung, D. & Tsay, J. (2012). *Videocases for novice college mathematics instructors*. Washington, DC: American Mathematical Society.

BOOK CHAPTER

Furtak, E.M., Shavelson, R. J., **Shemwell, J.T.** & Figueroa, M. (2012). To teach or not to teach through inquiry. In S.M. Carver, & J. Shrager (Eds.), *The journey from child to scientist* (pp. 227-244). Washington, DC: American Psychological Association.

McDermott, L.C., Heron, P.R.L., Shaffer, P.S., & **Stetzer, M.R.** (2011). Improving the preparation of K-12 teachers through physics education research. In D.E. Meltzer and P.S. Shaffer (Eds.), *Teacher Education in Physics: Research, Curriculum, and Practice* (pp 147-151). American Physical Society. Reprinted from *American Journal of Physics* 74, 763 (2006).

Thompson, J.R., Christensen, W.M., & Wittmann, M.C. (2011). Preparing future teachers to anticipate student difficulties in physics in a graduate-level course in physics, pedagogy, and education research. In D.E. Meltzer and P.S. Shaffer (Eds.), *Teacher Education in Physics: Research, Curriculum, and Practice* (pp. 91-102). American Physical Society. Reprinted from *Physical Review Special Topics Physics Education Research* 7 (2008).

ABSTRACTS, ARTICLES, and PROCEEDINGS (University of Maine faculty and students bolded)

Bajracharya, R.R., Wemyss, T.M., & Thompson, J.R. (2012). Student interpretation of the signs of definite integrals using graphical representations. In C. Singh, N.S. Rebello, & P. Engelhardt (Eds.), 2011 Physics Education Research Conference. *AIP Conference Proceedings* 1413, 111-114.

Capps, D.K. (2012, in press). A simple lesson illustrating inquiry-based teaching. *Science Scope*.

Capps, D.K., Crawford, B.A., & Conostas, M.A. (2012). A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education* 23(3), 291-318.

Christensen, W.M. & **Thompson, J. R.** (2012, in press). Investigating graphical representations of slope and derivative without a physics context. *Physical Review Special Topics: Physics Education Research*.

Frieman, B.M., **Gerbi, C.**, & Johnson, S.E. (2012). The effect of microstructure and rheological heterogeneity on kinematics and bulk strength in porphyroblastic schists. *Structural Geology and Tectonics Forum*.

Frieman, B.M., Johnson, S.E., & **Gerbi, C.** (2012). Rheological heterogeneity, strain partitioning, shear stress coupling, and kinematics in porphyroblastic schists. *Geological Society of America Abstracts with Programs* 44(2), 106.

Frieman, B., Johnson, S.E., & **Gerbi, C.** (2011). Microstructural and electron backscatter diffraction evidence for porphyroblast rotation during non-coaxial flow. *Geological Society of America Abstracts with Programs*.

Gerbi, C., & Culshaw, N.G. (2011). Strain-related weakening in deep orogenic shear zones: what factors to consider? *Eos Transactions AGU, Fall Meeting Supplement*.

Gerbi, C. (2012). Evaluating the utility of a phase distribution parameter in calculating the bulk viscous strength of two-phase composites. *Journal of Structural Geology* 39, 224-236.

- Gerbi, C., Koons, P.O.,** Marsh, J.H., & Culshaw, N.G. (2012). Impact of shear zone distribution in the middle to lower crust, *Structural Geology and Tectonics Forum*.
- Hawkins, J.M., Frank, B.W., Thompson, J.R., Wittmann, M.C., & Wemyss, T.M.** (2012). Probing student understanding with alternative questioning strategies. In Singh, C., Rebello, N.S., & Engelhardt, P. (Eds.) 2011 Physics Education Research Conference. *AIP Conference Proceedings* 1413, 207-210.
- Hewage, J.W., Rupika, W.L., & **Amar, F.G.** (2012, in press). Structure, dynamic and energetic of mixed transition metal clusters A computational study of mixed clusters of silver and nickel. *European Physical Journal D*.
- Johnson, S.E., Vel, S.S., **Gerbi, C.**, Cook, A.C., Song, W.J., & Okaya, D. (2011). Evaluating the effects of shear zone development on seismic anisotropy in deep cratonic crust: natural examples and computational methods. *Geological Society of America Abstracts with Programs*.
- Kryjevskaja, M., **Stetzer, M.R.**, & Heron, P.R.L. (2012). Student understanding of wave behavior at a boundary: The relationships among wavelength, propagation speed, and frequency, *American Journal of Physics* 80, 339-347.
- Kung, D. & **Speer, N** (2011). Do they really get it? Evaluating evidence of student understanding of power series. PRIMUS
- Mako, C.A., Markley, M, & **Gerbi, C.** (2012). Heterogeneous deformation of gabbroic rocks in the Central Metasedimentary belt boundary thrust zone, Grenville Province, Canada. *Geological Society of America Abstracts with Programs* 44(2), 100.
- Marsh, J.H., **Gerbi, C.**, Culshaw, N.G., Wooden, J.L., & Clark, C. (2012). New in-situ zircon ages from the southern Parry Sound Domain, Grenville Province, Ontario, Canada: Constraints on the timing of metamorphism, dike emplacement, and shearing along the Twelve Mile Bay shear zone. *Precambrian Research* 192, 142-165.
- Marsh, J.H., Grew, E.S., **Gerbi, C.**, Yates, M.G., & Culshaw, N.G. (2012). The petrogenesis of the garnet menzerite-(Y), end member $Y_2CaMg_2Si_3O_{12}$, and its bearing on the Y+HREE budget in granulite-facies rocks in the Parry Sound Domain, Grenville Province, Ontario. *Canadian Mineralogist* 53, 73-99.
- Naus-Thijssen, F.M., Goupee, A., Johnson, S.E., Vel, S., & **Gerbi, C.** (2011). The influence of crenulation cleavage development on the bulk elastic properties and seismic wave velocities of phyllosilicate-rich rocks. *Earth and Planetary Science Letters* 311, 212-224.
- Nuhiji, E, **Amar, F.G.**, Wang, H., Byrne, N., Nguyen, T-L., & Lin, T. (2011). Whispering gallery mode emission generated in tunable quantum dot doped glycerol/water and ionic liquid/water microdroplets formed on a superhydrophobic coating. *Journal of Materials Chemistry* 21(29), 10823-10828.
- Price, N., Johnson, S.E., **Gerbi, C.**, & Koons, P.O. (2011). Structure of a shear zone at the base of the seismogenic zone, Norumbega fault system, Maine; Potential for comparison with upper-crustal fault structure. *Eos Transactions AGU Fall Meeting Supplement*.

- Price, N.A., Johnson, S.E., & **Gerbi, C.** (2011). Using heterogeneous quartz CPO data to interpret the deformation history of a shear zone at the base of the seismogenic zone. *Geological Society of America Abstracts with Programs*.
- Price, N.A., Johnson, S.E., & **Gerbi, C.** (2012). The structure of a shear zone at the base of the seismogenic zone, Norumbega fault system, Maine. *Structural Geology and Tectonics Forum*.
- Shulman, D.J., **Gerbi, C.**, & Culshaw, N.G. (2012). Causes of meter-scale strain localization at the margin of the Grenville Front and Central Gneiss belt, Ontario, Canada. *Geological Society of America Abstracts with Program* 44(2), 99.
- Semsar, K., Knight, J.K., Birol, G., & **Smith, M.K.** (2011). The Colorado Learning Attitudes about Science Survey (CLASS) for use in Biology. *CBE - Life Science Education* 10(3), 268-278.
- Price, N.A., Johnson, S.E., **Gerbi, C.**, & West, D.P. Jr. (2012). Identifying deformed pseudotachylyte and its influence on the strength and evolution of a crustal shear zone at the base of the seismogenic zone. *Tectonophysics* 518, 63-83.
- Smith, M.K.** (2012). A fishy way to discuss multiple genes affecting the same trait. *PLoS Biology* 10(3).
- Smith, M.K.** & Knight, J.K. (2012). Using the genetics concept assessment to document persistent conceptual difficulties in undergraduate genetics courses. *Genetics* 191, 21-32.
- Smith, M.K.**, Thomas, K.E., & Dunham, M. (In press, 2012). In-class incentives that encourage students to take concepts assessments seriously. *Journal of Science College Teaching*.
- Thompson, J.R.**, Manogue, C.A., Roundy, D.J., & **Mountcastle, D.B.** (2012). Representations of partial derivatives in thermodynamics. In Singh, C., Rebello, N.S., & Engelhardt, P. (Eds), 2011 Physics Education Research Conference, *AIP Conference Proceedings* 1413, 85-88.
- Wagner, J.F., Manogue, C.A., & **Thompson, J.R.** (2012). Representation issues: Using mathematics in upper-division physics. In Singh, C., Rebello, N.S., & Engelhardt, P. (Eds), 2011 Physics Education Research Conference, *AIP Conference Proceedings* 1413, 89-92.
- Wemyss, T.M.**, **Bajracharya, R.R.**, **Thompson, J.R.**, & Wagner, J.F. (2011). Student understanding of integration in the context and notation of thermodynamics: Concepts, representations, and transfer. In Brown, S., Larsen, S., Marrongelle, K., & Oehrtman, M. (Eds.), Proceedings of the 14th Annual Conference on Research in Undergraduate Mathematics Education. *Mathematical Association of America*.
- Zoellick, B., Nelson, S.J., & **Schauffler, M.** (In press, 2012). Participatory science and participatory education: Bringing both views into focus. *Frontiers in Ecology and the Environment*.

MEDIA / OTHER

Michelle Smith contributed to an education supplement about the Model Encyclopedia of DNA Elements (modENCODE) that will be published in *Science*.

This website will be used to help students and teachers explore the significance of two classic model organisms in genetics: the fruit fly and the round worm. Students also investigate how genes are activated, transcribed, and translated, and learn about international scientific collaborations. Smith co-authored the following pages: “*C. elegans as a model organism*,” “*Apoptosis*,” “*What do worm cells, the space between my fingers, and cancer have in common?*” “*Aging - that worm looks fantastic for its age!*” and “*RNA interference - pick a gene, make a mutant!*” Accepted, 2012.

MST Courses Offered – 2011-2012

Semester	Title	Professor	Enrollment
Summer 2011	SMT 699 – Graduate Thesis	Susan McKay	11
Fall 2011	SMT 502 – Integrated Approaches in Physics Education I	Michael Wittmann	5
	SMT 504 – Integrated Approaches in Earth Sciences Education I	Molly Schaffler	3
	SMT 505 – Integrated Approaches in Mathematics Education I	Natasha Speer	9
	SMT 588 – Seminar in Science and Mathematics Education Research	Michael Wittmann	9
	SMT 699 – Graduate Thesis	Susan McKay	18
Spring 2012	SMT 500 – Educational Psychology with Applications to Science and Mathematics Teaching and Learning	Daniel Capps	10
	SMT 506 – Integrated Approaches in Mathematics Education II	Eric Pandiscio	5
	SMT 507 – Research-related Curriculum Development in Science and Mathematics	Molly Schaffler and Michelle Smith	5
	SMT 589 – Graduate Seminar for MainePSP Teaching Partners	Mitchell Bruce	6
	SMT 590 – Seminar for Teaching Interns	Susan McKay	3
	SMT 591 – Secondary Student Teaching	Susan McKay	3
	SMT 598 – Special Topics in Science and Mathematics	Susan McKay	5

	Education: Research Internship at the Jackson Laboratory		
	SMT 699 – Graduate Thesis	Susan McKay	13

**GRADUATE AND 2012 MST STUDENT TEACHER PLACEMENTS
AND TEACHER SABBATICAL PARTICIPANTS**

Name	Position	School Name & Town
Abbey, Karen (2008 Graduate)	Mathematics teacher	Parish Hill Middle High School Chaplin, CT
Alley, Lynn (JAX Teacher Intern 2006)	Science teacher	Jonesport Beals High School Jonesport, ME
Burroughs, Elizabeth (MST Student)	Mathematics student teacher	John Bapst Memorial High School Bangor, ME
Clegg, Katie (MST Student)	Science teacher	Nute High School Milton, NH
Dorko, Allison (MST Student)	Mathematics student teacher	Orono High School Orono, ME
Friant, Denise (2008 JAX Teacher Intern)	Science teacher	Bath Middle School Bath, ME
Hutchinson, Maggie (2011 Graduate)	Mathematics teacher	The Denver Street School Lakewood, CO
Jones, MaryJean (MST Student)	Science teacher	Bancroft School (Middle School) Worcester, MA
Knight, Kathleen (2005 Graduate)	Mathematics teacher	George Stevens Academy Blue Hill, ME
LaRoche, R. Bradford (JAX Teacher Intern 2009)	Science teacher	Camden-Rockport Middle School Camden, ME
Leland, Matthew (2006 Graduate)	Mathematics teacher	Lincoln Academy Newcastle, ME
Lowe, Rachael (MST Student)	Mathematics teacher	George Stevens Academy Blue Hill, ME
McCann Hayes, Kate (2009 Graduate)	Science teacher	Bangor High School Bangor, ME
McGann, Deborah (JAX Teacher Intern 2007)	Science Teacher	Maine School of Science and Mathematics Limestone, ME
McIntyre, Zachary (2007 Graduate)	Mathematics teacher	Chelmsford High School Chelmsford, MA
McOsker, Megan (2009 Graduate)	Science teacher	Connors Emerson School Bar Harbor, ME
Miniutti, Danielle (2009 Graduate)	Science teacher	Noble High School North Berwick, ME
Mitchell, Nitisha (MST Student)	Science teacher	Bonny Eagle Middle School Buxton, ME
Murphy, Michael (2005 Graduate)	Technology and mathematics teacher	John Bapst Memorial High School Bangor, ME
Nelson, David (2006 Graduate)	Science teacher	Interlakes High School Meredith, NH
O'Brien, Michael (2005 Graduate)	Science teacher	Kennebunk High School Kennebunk, ME
Owen, Jeff (2003 Graduate)	Science teacher	Orono High School Orono, ME
Pratt, Jon	Science teacher	Foxcroft Academy

(2006 Graduate)	and academic dean	Dover-Foxcroft, ME
(Priest) Glidden, Katie (MST Student)	Science teacher	Penquis Valley Middle School Lincoln, ME
Rappaport, Elliot (2007 Graduate)	Science teacher	Semester at Sea Woods Hole, MA
Rieffler, Jennifer (2007 Teacher JAX Intern)	Science Teacher	Mount Desert Island High School Bar Harbor, ME
Schultz, Lisa (2009 Graduate)	Science teacher	Old Town High School Old Town, ME
Shanholtzer, Jennifer (2009 Teacher JAX Intern)	Science teacher	Mount Desert Island High School Bar Harbor, ME
Shanklin, Joanna (2011 JAX Teacher Intern)	Science teacher	Old Town High School Old Town, ME
Snyder, Karen (2005 Graduate)	Mathematics teacher	John Bapst Memorial High School Bangor Maine
Soule, Kara (MST Student)	Student teacher	Belfast Area High School Belfast, ME
Southworth, Margaret (2007 JAX Teacher Intern)	Science Teacher	Troy Howard Middle School Belfast, ME
Spaulding, Emily Allen (2012 JAX Teacher Intern)	Science teacher	Bangor Christian School Bangor, ME
Stahley, John (2011 Graduate)	Mathematics teacher	Mascoma Valley Regional High School Canaan, NH
Zukowski, Adam (2008 Graduate)	Mathematics teacher	Gray-New Gloucester H.S. Gray, ME

Center Students, MST Graduates and Sabbatical Teachers in the State of Maine 2012

