Maine Center for Research in STEM Education
(RiSE Center)
Annual Report
July 1, 2017 – June 30, 2018

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Appendices

Executive Summary

The Maine Center for Research in STEM Education (RiSE Center), with its twenty faculty members and over thirty graduate students in the Master of Science in Teaching (MST) Program, has had an outstanding year of research productivity, with twenty refereed journal articles and conference proceedings published or accepted for publication and over 120 research presentations at conferences and other venues. Graduate and undergraduate students are integral to the center's research and, in the past year, six Master's theses, one doctoral thesis in discipline-based education research, and 27 honors theses and senior capstone research projects were mentored by RiSE faculty members. Six MST degrees were awarded through the RiSE Center. In addition, RiSE faculty are Principal Investigator or Co-Principal Investigator on eight new and twenty-four continuing external grants, totaling over $25 million.

The RiSE Center has continued to take important steps to support and enhance its grant-funded partnerships with elementary, middle and secondary teachers as grant support for the Maine Physical Sciences Partnership (from the National Science Foundation) and the Maine Elementary Sciences Partnership (from the Maine Department of Education) have ended. To sustain these valuable partnerships, involving over 1000 Maine science and mathematics teachers and impacting over 25,000 students, these two partnerships have merged to form the Maine STEM Partnership at the RiSE Center. This new partnership also includes the Faculty Course Modification Incentive Grant – Maine Learning Assistant (FIG – MLA) Program which, in the past year, involved 28 University of Maine faculty in science, technology, engineering, and mathematics, the STEM disciplines, and expanded to 34 course offerings with total enrollment of over 4,000 students. Thus, the Maine STEM Partnership at the RiSE Center continues as a state-wide improvement community for STEM teaching and learning over the grade span PK-16+. During the past year, funding to support and expand the work of this partnership came from grants, partnering school districts and over $200,000 in private donations. Leadership in the RiSE Center has taken a more active role in seeking philanthropic support for the Center's work and pursuing Maine Department of Education commitments to continue this statewide STEM education improvement initiative.

During this year, the prestigious NSF Teaching Fellowship Program, designed to support new science and mathematics teachers from the MST Program as they begin their careers teaching in rural high-need Maine districts, continued with seven of the fellows teaching in high-need districts. Fifteen of the twenty-two fellowship positions have been awarded to date and we anticipate that the remainder will be selected within the coming year. Fellows are supported in their transition from student to teacher by a pool of leading science and mathematics mentor teachers, who are connected with them to provide guidance in all aspects of their classroom practice and their new professional role.

The RiSE Center, now seventeen years old, held two major strategic planning retreats, to consider the center's successes, revisit its vision, and identify areas for targeted growth and improvement. The first retreat involved the seven RiSE professional staff members and the director, and focused on themes within the RiSE mission to be targeted in the next three years, objectives, strategies, and action steps. (Faculty had held a similar retreat in the prior year.) The second retreat brought together RiSE faculty and staff to establish shared priorities and plans. A major outcome was to affirm the strength and value of both basic and applied discipline-based education research as the foundation of RiSE Center activities.

I. Overview

Overview. The Maine Center for Research in STEM Education (RiSE Center) is an interdisciplinary research center organized to conduct research, graduate education, and professional learning experiences for educators, and to build community partnerships focused on improving the research and research-based practice of STEM education at all levels of instruction. Members of the RiSE Center include faculty, staff, and graduate students engaged in education research across multiple STEM departments and the College of Education at the University of Maine. RiSE faculty, staff, students, and collaborators contribute to knowledge of teaching and learning across STEM subject areas, with significant national and international contributions in Biology, Chemistry, Ecology and Environmental Sciences, Earth and Climate Sciences, Education, Marine Sciences, Mathematics, and Physics. The RiSE Center provides education and professional learning experiences for emerging educators through undergraduate, graduate and postdoctoral opportunities, including teaching and research assistantships, a Master of Science in Teaching degree with a teacher certification option, and an interdisciplinary STEM Education PhD program. RiSE faculty and staff run all aspects of the University of Maine Faculty Course Modification Incentive Grant – Maine Learning Assistant Program (FIG – MLA), designed to improve teaching and learning at the undergraduate level in STEM, through a community of faculty working to implement research-supported practices in their courses. The RiSE Center also facilitates community partnerships with PreK-12 schools and school districts, teachers, university faculty, and other organizational partners in Maine and beyond to improve STEM education and teacher preparation through research-supported practices.

Mission. To advance the research and practice of teaching and learning in science, technology, engineering, and mathematics – the STEM disciplines.

Vision and Strategic Plan. The RiSE Center was founded as an interdisciplinary research center bringing together a research community focused on investigations of teaching and learning in science and mathematics. This group of researchers has developed a strong national and international reputation, as evidenced by over $23.9 million in external grants and contracts continuing or newly funded during the past year, and contributes basic knowledge in discipline-based education research to the field. It also provides applications of this knowledge in professional learning experiences for STEM educators PK-12 and at the University of Maine. A guiding part of the vision is to build a culture of evidence, using research findings to inform improvements in science and mathematics teaching and learning. Investigations conducted by RiSE faculty members and their collaborators continue to improve understanding of student reasoning, lead to evidence-guided development of instructional materials, identify knowledge required by educators for teaching, and shed light on strategies for teacher preparation and growth.

A major part of the RiSE Center's original strategic plan was to develop and sustain the MST Program, a content-rich, research-based opportunity for graduate study for recent graduates or career changers in STEM seeking preparation and certification for secondary science or mathematics teaching, for experienced teachers desiring to return to school for full or part-time study, and for those interested in studying, at the Master's level, teaching and learning in STEM. The MST Program, initially offered in 2003, has developed into a nationally recognized model, attracting applicants from across the United States and internationally, and has grown from its

original size of 15 students to a current enrollment of 31 students, 23 full-time and 8 part-time. Coupled with the MST program has been the enhancement of introductory courses in science and mathematics, with some of these courses serving as laboratories for MST thesis research or as preparation sites for MST students as future educators.

Another part of the vision of the RiSE Center has been the development of strong, symbiotic relationships between RiSE, the University's STEM Departments and College of Education and Human Development, and PreK-12 partners. The development of these partnerships has been strongly enhanced by over $18 million in external funding from the National Science Foundation and the Maine Department of Education during the last eight years.

With these accomplishments to build upon, the RiSE Center is embarking upon development of a new strategic plan, guided by UMaine's strategic plan and the current vision of faculty and professional staff members within the center. Faculty and professional staff members have provided input to this process through interviews and surveys, and groups have met for two working retreats during the past year. A summary of this dynamic plan is provided in Appendix H.

Administration and Staffing Structure. The RiSE Center is led by founding director Professor Susan McKay, supported by an Executive Committee that meets approximately monthly. RiSE professional staff meet approximately weekly to coordinate their work and regular faculty meetings are held approximately monthly for discussion of issues related to the faculty as a whole. There are short-term and standing committees, typically involving both faculty and staff, that design and coordinate much of the RiSE Center's work. Decisions related to the MST Program (admissions, application of policies, etc.) are made through a three-faculty interdisciplinary program committee chaired by the director. The Maine STEM Partnership at the RiSE Center is run by a 15-person leadership team that meets monthly and includes faculty, staff, teachers, and administrators involved in this evidence-guided STEM education improvement community. The only staff member currently fully base-budgeted in the RiSE Center is the financial and personnel manager. A base-budgeted assistant director position and a base-budgeted research and evaluation coordinator position are crucial in order to meet the basic needs of the center and ensure compliance with MST Program accreditation, IRB, FERPA and requirements for data storage and data management. Strategies to obtain ongoing base-budget funding of these positions are under discussion with the Vice President for Research (VPR). Additional professional staff positions are externally funded to coordinate grant- or school-funded programs, and the RiSE office is staffed by work study students, who also assist with events run by RiSE. The NSF Teaching Fellowship Program Coordinator is supported by a cost-share commitment made by the VPR. In total, RiSE currently has seven professional staff and twenty faculty members.

II. Serving Maine

Community Engagement. The Maine STEM Partnership at the RiSE Center is a prime example of community engagement. PreK-12 members of this partnership work with RiSE faculty and staff to set priorities for professional learning, select high quality instructional resources through a task force evaluation process, and develop a shared vision and plan for science and

mathematics educational improvement in Maine. Members of this community gathered at Point Lookout in Northport, ME in the fall of 2017 for the annual Maine STEM Partnership summit to share their work and develop plans for the coming year. This event is so valued by community members that a lottery system was implemented in order to choose participants, filling the facility to capacity. During the past year, this community has impacted over 550 teachers with 270 professional learning opportunities and over 850 hours of high-quality sessions, reaching 173 schools and 117 Maine school districts. Over 20,000 Maine students, PreK-12, had a teacher during the last year who participated in this community. The Maine STEM Partnership also includes twenty-eight STEM faculty who have received incentive grants to bring research-based practices into their courses and 130 Maine Learning Assistants who have been part of these course improvements.

Economic and Workforce Development. The RiSE Center contributes to Maine's economic and workforce development through its improvements in STEM education at both the PreK-12 and postsecondary levels. STEM taught well not only builds disciplinary content and practice knowledge, but also supports the development of essential workplace skills, such as oral and written communication, problem solving, and teamwork. During the RiSE Center's June 2018 conference, a focus was research-guided ways to support the development of these professional skills while teaching STEM. This conference included a panel discussion that brought together teachers with representatives of four Maine-based businesses. By providing a highly regarded research center in STEM Education, the RiSE Center contributes to Maine's reputation as a place that cares about excellence in education, particularly in STEM disciplines, which is important for attracting new businesses. Its STEM teacher preparation and professional learning experiences lead to improvements in teaching and learning in these disciplines. (Please see Appendices F and G.) The RiSE Center uses Maine sites for its annual summit (107 participants), annual conference (116 participants), and (new this year!) postsecondary teaching symposium (103 participants representing 18 colleges and universities). These events require catering, lodging, and hosting of out-of-state presenters in our communities, thus supporting the local economy.

Collaborations with UMaine System Campuses. The RiSE Center has used Research Reinvestment Funds to build strong connections with other University of Maine System (UMS) campuses. Associate Professor Michelle Smith received seed grant funding for "Workforce Development: Helping UMaine Faculty Develop Classroom Activities that Prepare Students for Skills Needed in Maine's Science Careers", involving biology faculty from all seven UMS campuses, as well as the Jackson Laboratory, James W. Sewall Company, and Oceanswide. Professor and RiSE Director Susan McKay is part of "Revolutionizing Computing Across the University of Maine System", led by Professor Harlan Onsrud and co-led by Professor Constance Holden (UMA), a project that involves faculty teaching computing skills at all UMS campuses. Associate Professor Janet Fairman leads a planning grant "Building a Collaborative Partnership to Support K-12 Professional Development in Maine", with collaborators from USM and UMF. In a separate collaboration, Assistant Professor Anita Stewart McCafferty and Professor Jeff Beaudry (USM) have worked with RiSE faculty and staff to develop and implement a professional development series on formative assessment in science.

Collaborations with Other Outside Institutes/Organizations. The RiSE Center works closely with Bill Zoellick, Director of Education Research at the Schoodic Institute at Acadia National Park on research related to challenges faced by new teachers, development of teacher leadership, and evaluation of impacts of RiSE professional learning experiences. Teachers from the Maine STEM Partnership, RiSE faculty and staff, and Leigh Peake, Chief Education Officer at the Gulf

of Maine Research Institute, have worked on the development of a Maine middle level student research journal, which published its first issue this spring. This initiative is led by Castine middle-school science teacher Bill McWeeny, part of the Maine STEM Partnership teacher leadership coalition. RiSE faculty are PIs or coPIs on new or continuing collaborative research grants involving partners at other institutions.

III. Financial Sustainability

E&G Support; Salary and Operating Support. The MST Program and faculty salaries and benefits for joint appointments receive support through E&G funding to the MST budget ($189,844). This funding is allocated for expenses associated with running a 30-student graduate program, including faculty compensation to teach some of the MST courses, as well as some compensation to the Department of Physics and Astronomy to support their teaching needs, as partial compensation for Professor Susan McKay's time as center director and teacher for SMT590 and SMT591. Currently all other RiSE faculty members except Associate Professor Natasha Speer receive full salary through their home departments. Dr. Speer is joint appointed in the Department of Mathematics and Statistics and the RiSE Center, and the MST budget includes part of her salary and benefits. The RiSE Center also receives, through successful competition in the Maine Academic Prominence Initiative (MAPI), $32,899 annually, which is used to provide bridge support for staff, postdoctoral research associates and graduate students doing research. MAPI funds also provide small writing grants for MST graduates and their advisors who submit papers to refereed journals based upon MST thesis research.

MEIF Support. The RiSE Center receives $56,396 in MEIF funding to support its research mission. Most of this revenue goes toward the salary of the financial and personnel manager, the only base-budgeted staff member in the RiSE Center. Remaining funds are used for research and evaluation coordination, bridging students and postdoctoral research associates between grants, and running the RiSE Center colloquium series.

Research Funding; Submitted and Awarded. In the past year, the RiSE Center submitted 23 new proposals for a total of $20,665,831. Eleven new awards were funded for a total of $1,584,641, and 29 awards were continued (typically after annual report review), with total award values of over $25 million (new and continuing). Details are provided in Appendix C.

Brief Overview of Major New Award. With eleven new awards contributing to the RiSE Center's success this year, it is not possible to even briefly summarize each major award within the space provided. Here we summarize one new award to Associate Professor MacKenzie Stetzer. Additional information about other new awards will be provided upon request. This NSF award investigates the development of reasoning and critical thinking skills, which is possibly the most important outcome of college physics instruction, as these abilities extend to all STEM disciplines. They are integral to many non-STEM professions as well. However, research has shown that students who demonstrate correct conceptual understanding and reasoning on one task often fail to use the same knowledge and skills on related tasks. Observed inconsistencies can be accounted for by dual-process theories of reasoning. These theories assert that human cognition relies on two thinking processes. The first heuristic process is fast, intuitive, and automatic. The second analytic process is slow, effortful, and deliberate. Students get incorrect answers when their analytical process fails to reject an incorrect intuitive response. This project will develop classroom activities that give students opportunities to slow down, examine intuitively appealing responses, and recognize instances of biased reasoning. Becoming aware of

one's own thinking paths and reasoning approaches is a critical step toward more expert-like reasoning in physics and beyond. This five-year collaborative project will integrate findings and models from cognitive science into research-based curriculum development efforts in physics to maximize their efficacy by improving student reasoning skills. The project will first develop and document instructional interventions that improve student reasoning. Secondly, it will identify specific mechanisms by which such interventions help students reason productively. Thirdly, the project will establish a framework for curriculum development explicitly aligned with dual-process theories of reasoning. Central to the project will be the development of a portfolio of illustrative examples of research-based instructional materials (along with instructor resources) that attend explicitly to the dual nature of human thinking. The materials will adapt or supplement existing interventions and thus improve their impact. In addition, this project will help researchers gain greater insight into: (1) the reasoning approaches employed by novice physics learners, (2) the factors and circumstances contributing to intuitive student ideas, and (3) strategies by which students mediate their intuitive thinking. Finally, the project will establish a comprehensive framework for developing or enhancing instructional materials that draw upon dual-process theories of reasoning.

Return on Investment. For FY18, the RiSE Center's new awards totaled $1,584,641, considering the return on MEIF investment in the center provides a **return on investment of 28 times**. (One could argue that the costs of supporting a graduate program, including teaching and director buyout, should not be included in this calculation, since these costs are generally born by the academic departments rather than the research centers. The RiSE Center is somewhat unusual in that it runs such a large graduate program.) This return on investment does not count the continuing grant revenue or the value of improving Maine STEM education and STEM workforce through professional development to educators PK-16+.

Revenue Centers. Most RiSE external funding comes from the National Science Foundation, with significant amounts also coming from the Maine Department of Education, U.S. Department of the Interior, U.S. Department of Energy, U.S. Department of Commerce, and private foundations, such as the Perloff Family Foundation, which has donated 11 3D printers to the RiSE Materials Warehouse.

Private Giving/Alumni Cultivation. This RiSE Center has received $216,000 in private donations during the past year to support its work, a record amount for the center. The center continues to (re)connect with alumni from the MST Program, with many alumni involved in RiSE professional development, assisting in MST courses, and mentoring new graduates. Since the program is only fifteen years old, we do not yet have an extensive alumni base for donations.

Initiatives to Increase Efficiency. During the past year, we have continued using work study students to staff the RiSE Center office and assist with preparations for professional development, colloquia, and other center events. We were fortunate to be able to hire excellent students who quickly learned the job and did excellent work, saving the RiSE Center over $15,000 while providing these students with valuable work experience. This savings, combined with other efficiencies, has enabled us to support a full-time financial and personnel manager. We plan to continue this staffing model through the coming year, provided that qualified students can be found.

IV. Culture of Excellence

Faculty and Staff Achievements. RiSE faculty members hold leadership positions in professional organizations and are invited participants at many conferences. Their expertise is recognized through national and international collaborations and RiSE research positively impacts the teaching of STEM locally and nationally. For example: **Francois Amar** collaborated on a Servant Heart Research Collaborative project involving computer based test taking practice for high-stakes tests in Sierra Leone. **David Batuski** continued modification of AST 109 to a "flipped classroom" model though a Faculty Course Modification Incentive Grant and began introducing elements of this model to PHY 455. **Mitchell Bruce** was elected to the American Chemical Society (ACS) Committee on Committees, charged with overseeing all committees of the ACS. **Justin Dimmel** presented his work investigating intersections of virtual reality and education at the 13th International Conference on Technology in Mathematics Teaching in Lyon, France. **Janet Fairman** conducted studies and briefings for the Maine Legislature's Joint Standing Committee on Education and Cultural Affairs to inform policies on education topics. **Robert Franzosa** worked on co-authoring the 4th edition of Rogawski's Calculus book with colleague Colin Adams of Williams College. **Christopher Gerbi's** research made measurements of ice microstructure that are the first in the world of their kind. **Elizabeth Hufnagel** modified all science methods courses (both elementary and secondary) offered by the College of Education, to include teaching clinics that enhance partnerships with local schools. **Sara Lindsay** mentored students in identifying nearly 6000 individual invertebrates while conducting research into the diversity of marine invertebrate macrofauna found associated with oyster farms on several rivers in Maine. **Susan McKay** was an invited participant in the NSF 2017 Noyce Summit on Stimulating Research in Preservice Education of STEM Teachers in High-Need Schools. She also serves as an appointed member of the Maine Governor's STEM Council. **Sarah Nelson** coordinated the Dragonfly Mercury Project, which has expanded to include over 94 national parks and involved over 4000 citizen scientists to date. **Asli Sezen-Barrie** was nominated for an outstanding early career award by the National Association for Research in Science Teaching (NARST) and was recognized for outstanding service to the National Science Teachers Association (NSTA) conference in Baltimore. **MacKenzie Stetzer** was awarded a grant by the National Science Foundation to pursue developing research-based physics curriculum, building on his ground-breaking research into student reasoning and metacognition **John Thompson** co-organized the "Transforming Research in Undergraduate STEM Education" (TRUSE) conference and the Physics Education Research Conference in July 2017. **Eric Pandiscio** worked in collaboration with administration of the Bangor School Department to create and teach a new graduate course combining mathematics content, pedagogy, and assessment. **Franziska Peterson** designed a content immersion workshop for K-12 teachers and conducted mathematics professional development workshops with teachers throughout the year through the Maine STEM Partnership. **Molly Schauffler** brought research-based STEM teaching practices to Tuva, a popular online platform that is designed for teaching data literacy. **Natasha Speer** received the award for Best Paper through the Research in Undergraduate Mathematics Education (RUME) conference. **Michael Wittmann** was asked to serve on the Board of Trustees for the Knowles Teacher Initiative. He has also received over 1400 citations of his research, including over 650 in the past 5 years.

RiSE professional staff also contributed in very significant ways to the accomplishments of the RiSE Center and its culture of evidence. **Elizabeth Byerssmall** and **Marina Van der Eb** collaborated with Maine teachers to deliver six state and national workshops and presentations

highlighting groundbreaking work being conducted by the Maine STEM Partnership in teacher leadership and professional learning opportunities for assessment. **Laura Millay** co-authored a Maine Policy Review article focused on teacher leadership that drew from data collection and analysis that she has conducted over the past several years. **Elizabeth Muncey** coordinated instructional resources for over 90 classrooms, managing hundreds of sets of hands-on science materials to support inquiry-based instruction. **Maureen Raynes** shepherded the successful close, within 60 days, of over $14 million in grant funding with the end of the Maine Physical Sciences Curriculum Partnership and its supplemental funding. **Deborah Shulman** developed a website for the Maine STEM Partnership, helping to connect over 1000 educators around the state to professional learning opportunities and resources. **Erin Vinson** organized the first RiSE Center Teaching Symposium, bringing 103 participants together for professional learning sessions focused on engaging students through evidence-based teaching strategies.

Research and Scholarship Summary. RiSE Center faculty have published or had accepted for publication 20 refereed journal articles or conference proceedings and four technical reports as listed in Appendix B. They gave 25 invited presentations and 95 contributed presentations at conferences and departmental colloquia.

Curricular Innovations/Integration with UMaine Education Mission. RiSE Center faculty and staff run the Faculty Course Modification Incentive Grant – Maine Learning Assistant (FIG – MLA) Program, which brings research-supported practices into STEM classrooms and laboratories and evaluates their impacts on students. The evaluation component brings together FIG faculty, RiSE faculty, and MST students to measure the outcomes of the course modifications and use this information to guide further improvements. During the past year, 28 FIG faculty participated in this community, impacting 34 courses in 10 STEM departments across three UMaine colleges. The total enrollment of FIG-MLA courses was over 4,000 students and 130 semester-long undergraduate positions were part of the Maine Learning Assistant Program.

V. Student Engagement, Student Success

Undergraduate Student Research, Scholarship or Creative Activities. In the summer of 2017, the RiSE Center offered summer undergraduate research opportunities to four undergraduates. These undergraduates, who are interested in teaching careers, complete an undergraduate research project, capstone, or honor's thesis as an outgrowth of their summer work. Through these opportunities, provided as part of the NSF-funded Undergraduate STEM Education Professionals (USEP) Program, the undergraduates also work with teachers on evidence-guided improvements of curriculum, instruction, and assessments and have the opportunity to observe STEM classes at the PK-12 and University level.

Undergraduate Student Awards. RiSE faculty member Justin Dimmel obtained two competitive fellowships for undergraduates working in his research laboratory: Nathan Gazey received a Maine Space Grant Consortium Summer Research Fellowship (2017) and Joseph Haney received a CUGR Summer Fellowship for his research on locomotion within an immersive rendered environment.

Graduate Student Research, Scholarship or Creative Achievement. The MST Program requires a research thesis in teaching and learning related to STEM for all graduates. With 23 full-time and 8 part-time MST students, graduate student research is a large part of the RiSE Center's work. Student names are bolded in the publications and presentations listings in Appendices B and C, showing the involvement of these students, many of whom are future teachers, in research. The RiSE Center offers small writing grants to support these graduates to prepare and submit their thesis research to refereed journals, as a strategy to encourage publication of their work.

Graduate Student Awards. Ken Akiha (profiled below) and Adam Rogers were co-recipients of the Outstanding Graduate from the MST Program Award this year. Adam is completing his thesis in the summer of 2018 and will begin a position in education research in the fall. Before entering the MST Program, he worked as a Maine Learning Assistant and, during his graduate studies, he was a data analyst for the RiSE Center. He earned his undergraduate degree from the University of Maine in Earth and Climate Sciences.

Retention and Graduation Numbers, Initiatives. Data from the FIG-MLA Program suggests that first-year undergraduate students who take two or more FIG-MLA courses are more likely to be retained than those who did not. This trend persists for both STEM and non-STEM majors. We are continuing to monitor this data as additional faculty join the program and more students are impacted. (See Appendix F.)

Degrees Granted. Six MST students graduated during the past year: Ken Akiha (Advisor: Michelle Smith), Maura Foley (Advisor: Jon Shemwell), Ethan Geheb (Advisor: Jon Shemwell), Graham Hummel-Hall (Advisor: Chris Gerbi), Derek LaBarron (Advisor: Jon Shemwell), and Savannah Lodge-Scharff (Advisor: Jon Shemwell). One of these graduates has accepted a teaching position in Maine and is an NSF Teaching Fellows (Akiha), three have accepted teaching positions out of state, one is continuing on in a STEM education doctoral program, and one May graduate is still seeking a teaching position.

Highlighted Student Profile. We choose to highlight Ken Akiha, selected as one of this year's Outstanding Graduates from the MST Program. Ken came to the MST Program with an undergraduate degree in biology from Bowdoin College. His thesis research, advised by Associate Professor Michelle Smith in the School of Biology and Ecology, focused on the types of instructional shifts that students experience moving through our public education system from middle school through university level. His research measured the types of pedagogical strategies used at each grade band, with particular attention to active learning. Ken has published and presented this research, which is fundamental to supporting students across critical transitions, at national and local conferences. He is a science teacher at Old Town High School and has been selected as an NSF Teaching Fellow, an appointment that he will hold for five years, as he further develops his science teaching and leadership skills. In his teaching position, he has already begun to develop his leadership abilities in the area of computer science education through training programs offered by code.org.

VI. Preserving – Restoring Infrastructure N/A

VII. Summary of Anticipated Challenges

(1) The RiSE Center has built, with grant support, an excellent reputation for high quality research and research-guided, community-based professional learning experiences for educators.

It has also expanded its MST Program and has launched, with the College of Education and Human Development, a STEM Education Ph.D. Program. While these expansions have occurred, the base budget for the MST Program has been reduced and MEIF support remains flat. An organization of this size needs appropriate fulltime, base-budgeted staff support to do its work. It puts stress on the organization to be so understaffed in these crucial, ongoing areas of need. The center needs a full-time assistant director to support all aspects of the center's daily operations, including documentation for accreditation of the MST Program, grant proposal preparation, conferences and events, and reporting on grants and contracts. A research and evaluation coordinator is also required in order to ensure compliance with research involving human subjects and FERPA regulations, as well as data management, including security and access. Currently the only base-budgeted RiSE staff member is the financial and personnel manager, also essential for a center of this size with so many grants, graduate student appointments, materials purchases, and teacher stipend payments.

(2) During the last seven years, the RiSE Center has benefited from substantial graduate student and staff support from the Maine Physical Sciences Partnership (MainePSP), an NSF Math Science Partnership (MSP) Program award the Maine Elementary Sciences Partnership (MaineESP), which the MainePSP seeded. The federal MSP program has been discontinued, and the $14 million MainePSP award, along with supplements and extensions, ended in August, 2017. Federal agencies have not announced another initiative in STEM education of this magnitude, and it is difficult to obtain the multiple smaller grants that would be required to replace this stable, longer term funding. Yet, there is a strong desire to sustain and expand the work and community formed through this grant and the projects that it has seeded. The University of Maine administration has institutionalized and supported the FIG – MLA Program, initially established through this grant. It is more challenging to piece together sustainable funding for the PreK-12 work, in spite of data showing how beneficial it has been to Maine students and the willingness of the school partners to pay the costs of materials rentals for hands-on science and part of the costs of ongoing teacher professional development. School district and philanthropic support have provided bridge funding until ongoing sources can be found, but stable, continuing funding, most likely from multiple sources, is needed to ensure that Maine students continue to receive the benefits of these high quality STEM education programs.

(3) From our school partners and the Maine Department of Education, there is increased demand for comprehensive mathematics teacher professional development, similar in scope to that provided for science through the MaineESP and MainePSP. The model developed and the lessons learned from these partnerships could be applied in mathematics, but the University of Maine (and the UMS) do not have enough faculty in mathematics education to undertake this type of large scale project. Additional mathematics education faculty with expertise in PreK-12 are needed in order to support teachers to provide high quality mathematics education to all Maine students.

VIII. Summary of New Initiatives

As an outgrowth of the RiSE Center strategic planning this year, there is a firm commitment by faculty to increase the center's research productivity and visibility and, among many faculty, to develop more collaborative research projects across disciplines, taking advantage of the

interdisciplinarity of the RiSE Center. The RiSE Research Group, which meets weekly, has grown to a gathering of typically 10-20 researchers, and provides informal feedback and input for student and faculty research projects. Further, RiSE faculty are working increasingly with those from other campuses within the UMS, leading to collaborative proposals and shared educational and professional learning practices. A variant of the FIG – MLA Program has expanded to the University of Southern Maine and expansion to other campuses is underway, recognizing the effectiveness of this program to improve retention and encourage the use of research-supported practices in STEM teaching.

During the past year, the Leadership Team of the NSF Teaching Fellowship Program selected the first fifteen fellows (of a total of twenty-two fellows funded). This program is designed to recruit, prepare and retain new science and mathematics teachers from the MST Program for high-need rural Maine school districts. To date, fellows have been placed in Brewer High School (1), Gray-New Gloucester High School (1), Ellsworth High School (1), Hermon High School (1), and Old Town High School (3). A pool of leading experienced teachers, with disciplinary and grade-band expertise to match those of the fellows, has also been selected and will be expanded as more fellows are selected. This community, a partnership of RiSE faculty and staff and new and experienced teachers, will be able to have a substantial positive impact on STEM education in rural Maine during the six years of this grant. The grant supports work by leading teachers and ongoing targeted professional learning and supports for the fellows. It also funds research being led by Bill Zoellick, Director of Education Research at the Schoodic Institute at Acadia National Park, to better understand the challenges faced by these new teachers, the development of teacher leadership in this community, and the types of support that are most effective during the induction phase of a teacher's career, particularly in a rural, high-need school. This knowledge will guide future teacher preparation and professional support for teachers in rural areas, both in Maine and nationally.

Through the Maine Physical Sciences Partnership and the Maine Elementary Sciences Partnership, the RiSE Center has developed a scalable model for state-wide professional learning for teachers that leads to improved outcomes for students. (See, for example, Appendix G.) This model is currently being discussed as a strategy to help every student succeed in science and mathematics. Although this statewide expansion would require considerable investment and collaboration across the state, it has the potential to make Maine a national leader in STEM education. Further, the approach applied to the STEM disciplines could be adapted to other areas of study, strengthening PreK-12 education through statewide partnership. RiSE faculty have submitted two proposals building upon this model for integration of computer science with mathematics (PreK-8) and with science (grades 6-8). Offering strong computer science education to Maine students is essential in order to prepare them for career opportunities of the 21st century.

Appendix A

LISTING OF RiSE CENTER FACULTY AND STAFF
2017 – 2018

Francois G. Amar
Professor, Department of Chemistry and Dean, Honors College
David J. Batuski
Professor, Department of Physics and Astronomy
Mitchell R. Bruce
Professor of Chemistry
Elizabeth Byerssmall
NSF Teaching Fellowship Program Coordinator
Justin Dimmel
Assistant Professor of Mathematics Education and Instructional Technology
Robert D. Franzosa
Professor of Mathematics and Statistics
Christopher Gerbi
Professor of Earth and Climate Sciences
Janet Fairman
Associate Research Professor of Education
Elizabeth Hufnagel
Assistant Professor of Science Education
Sara Lindsay
Associate Professor, School of Marine Sciences
Hayley Leonard
RiSE Undergraduate Assistant
Susan R. McKay
Director, RiSE Center, and Professor of Physics
Laura Millay
RiSE Research and Evaluation Coordinator
Elizabeth Muncey
RiSE Professional Development and Resource Coordinator
Sarah Nelson
Associate Research Professor, Senator George J. Mitchell Center, and Associate Research Professor in Watershed Biogeochemistry, School of Forest Resources
Eric A. Pandiscio
Associate Professor of Mathematics Education
Franziska Peterson
Assistant Professor of Mathematics Education

Maureen Raynes
RiSE Financial and Personnel Manager
Molly Schauffler
Research Assistant Professor (adjunct), School of Earth and Climate Sciences and Climate Change Institute
Deborah Shulman
RiSE Professional Development and Resource Coordinator
Michelle Smith
Associate Professor of Biological Sciences, C. Ann Merrifield Professor in Life Science Education, and Cooperating Associate Professor of STEM Education
Natasha Speer
Associate Professor of Mathematics Education
MacKenzie Stetzer
Associate Professor of Physics and Cooperating Associate Professor of STEM Education
John R. Thompson
Professor and Chair of Physics and Astronomy and Cooperating Professor of STEM Education
Anna Tyrina
RiSE Undergraduate Assistant
Marina Van der Eb
Maine STEM Partnership Coordinator
Erin Vinson
RiSE Campus Programs Coordinator
Michael C. Wittmann
Professor of Physics and Cooperating Professor of STEM Education

Appendix B

Publications

RiSE Faculty, Postdocs, Graduate Students, and Staff are in bold.

Akiha, K., Brigham, E., Couch, B., **Lewin, J**., Stains, M., **Stetzer, M**., . . . **Smith, M.** (2018, January 22). What Types of Instructional Shifts Do Students Experience? Investigating Active Learning in Science, Technology, Engineering, and Math Classes across Key Transition Points from Middle School to the University Level. Retrieved from https://doi.org/10.3389/feduc.2017.00068

Amar, F., & Ladenheim, M. (2018). The Research Collaborative: A New Framework for Undergraduate Research. *Minerva*.

Amar, F., Bellefleur, A., Cox, C., & Ladenheim, M. (Eds.). (2018, March 7). Minerva. *15*, 1-56.

Amar, F. (n.d.). Honors Education at the University of Maine, 1935-2017. In *A History of the University of Maine, 1965-2015* (pp. 1-42). Orono, Maine: University of Maine Press.

Bock, C., & Dimmel, J.K. (2017). Explorations of volume in a gesture-based virtual mathematics laboratory. In E. Galindo & J. Newton, (Eds.), Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (pp. 371-374) Indianapolis, IN: Hoosier Association of Mathematics Teacher Educators.

Bragdon, D., **Pandiscio, E.**, & **Speer, N**. (n.d.). University Students' Graph Interpretation and Comprehension Abilities. *Investigations in Mathematics Learning*.

Case, J., & **Speer, N.** (n.d.). Calculus Students' Deductive Reasoning and Strategies When Working with Abstract Propositions and Calculus Theorems. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*.

Dimmel, J.K., & Bock, C. (2017). HandWaver: A Gesture-Based Virtual Mathematical Making Environment. In G. Aldon & J. Trgalová (Eds.), Proceedings of the 13th international conference on technology in mathematics teaching (pp. 323 – 330). Lyon, France: École Normale Supérieure de Lyon.

Dimmel, J.K., & Bock, C.G. (accepted for publication). Dynamic mathematical figures with immersive spatial displays: The case of HandWaver. To appear in G. Aldon and J. Trgalova (eds.), Selected papers of the 13th international conference on technology in mathematics teaching. Berlin: Springer

Dimmel, J.K., & Herbst, P.G. (2017). Secondary mathematics teachers attitudes' toward alternative communication practices when doing proofs in geometry. Teaching and Teacher Education, 68, 151 – 160.

Dimmel, J., & **Pandiscio, E.** (2017). *Proceedings of the 39th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. Indianapolis, USA: Hoosier Association of Mathematics Teacher Educators.

Fairman, J., & Mette, I. (2018). *Exploring innovative models for school leadership in Maine* (Tech.). University of Maine.

Fairman, J., & Seymour, M. (2018). *Study of a regional approach for delivering special education programs and services* (Tech.). University of Maine.

Fairman, J., Johnson, A., Mette, I., Wickerd, G., & LaBrie, S. (2018). *A review of standardized testing practices and perceptions in Maine* (Tech.). University of Maine.

Flanagan Pritz, C., & **Nelson, S**. (2017). Collecting Data on Charismatic Mini-Fauna: Public Participation and the Dragonfly Mercury Project. *Maine Policy Review, 26.2*, 50-54.

Franzosa, R., & Vieira, E. (2017). Transition matrix theory. *Transactions of the American Mathematical Society, 369*(11), 7737-7764.

Gavin, A., **Nelson, S**., Klemmer, A., Fernandez, I., Strock, K., & McDowell, W. (n.d.). Acidification and climate linkages to increased dissolved organic carbon in high elevation lakes. *Water Resources Research*.

Gehertz, J., **Speer, N**., & Ellis Hagman, J. (2018). *Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education,*.

Gette, C., Kryjevskaia, M., **Stetzer, M**., & Heron, P. (2018, March 13). Probing student reasoning approaches through the lens of dual-process theories: A case study in buoyancy. Retrieved from https://doi.org/10.1103/PhysRevPhysEducRes.14.010113

Ishimoto, M., Davenport, G., & **Wittmann, M**. (2017). Use of item response curves of the Force and Motion Conceptual Evaluation to compare Japanese and American students' views on force and motion. *Physical Review Physics Education Research, 13*(2), 020135.

Johnson, S., Song, W., Vel, S., & **Gerbi, C**. (n.d.). Quartz α↔β phase transition drives damage and reaction in continental crust. *Nature*.

Hufnagel, E., Kelly, G., & Henderson, J. (2018). How the environment is positioned in the Next Generation Science Standards : A critical discourse analysis. Environmental Education Research, 24, 731-753.

Kryjevskaia, M., Gette, C., Grosz, N., **Stetzer, M**., & Boudreaux, A. (n.d.). Investigating student reasoning with the Cognitive Reflection Test. *Physical Review Physics Education Research*.

McKay, S., Millay, L., Allison, E., Byerssmall, E., Wittmann, M., Flores, M., . . . **Smith, M.** (n.d.). Investing in Leadership Capacity to Advance Professional Growth and Improve Student Outcomes: A Model from STEM Education. *Maine Policy Review*.

Melosh, B., Rowe, C., **Gerbi, C**., Smit, L., & Macey, P. (n.d.). Seismic cycle feedbacks in a mid-crustal shear zone. *Journal of Structural Geology*.

Miner, K., **Gerbi, C**., Campbell, S., Liljedahl, A., Anderson, T., Perkins, B., . . . Kreutz, K. (n.d.). Organochlorine pollutants within a polythermal glacier in the Interior Eastern Alaska Range. *Environmental Science and Technology*.

Nelson, S., Capone, S., Dukett, J., & Houck, N. (2017). *Lake Site Assessments: US EPA TIME-Adirondack Lakes* (Tech.).

Patel, K., MacRae, J., Ohno, T., **Nelson, S**., & Fernandez, I. (n.d.). Winter thaw events alter soil and microbial C and N dynamics: A laboratory study. *Pedobiologia*.

Patel, K., **Nelson, S**., Spencer, C., & Fernandez, I. (2018). Soil temperature record for the Bear Brook Watershed in Maine. *PANGAEA*.

Patel, K., **Nelson, S**., Spencer, C., & Fernandez, I. (n.d.). Fifteen-year record of soil temperature for the Bear Brook Watershed in Maine. *Scientific Data*.

Patel, K., Tatariw, C., MacRae, J., Ohno, T., **Nelson, S**., & Fernandez, I. (n.d.). Soil C and N responses to snow removal and concrete frost in a coniferous Maine forest. *Canadian Journal of Soil Science, 98*.

Rice, L., **Lindsay, S**., & Rawson, P. (n.d.). Genetic homogeneity among geographically distant populations of the blister worm, Polydora websteri. *Aquaculture Environment Interactions*.

Schermerhorn, B., & **Thompson, J**. (2018, March 6). *Students' determination of differential area elements in upper-division physics*. Retrieved from doi:10.1119/perc.2017.pr.084

Schermerhorn, B., & **Thompson, J**. (n.d.). Physics students' construction and checking of differential volume elements in an unconventional spherical coordinate system. *Physical Review Physics Education Research*.

Schermerhorn, B., & **Thompson, J.** (n.d.). Physics students' construction of differential length vectors in an unconventional spherical coordinate system. *Physical Review Physics Education Research*.

Sezen-Barrie, A. (2018). Utilizing Professional Vision in Supporting Preservice Teachers' Learning About Contextualized Scientific Practices. *Science & Education*.

Soranno, P., **Nelson, S**., & 79 others, .. (2017). LAGOS-NE: A multi-scaled geospatial and temporal database of lake ecological context and water quality for thousands of U.S. lakes. *GigaScience*.

Speer, N., **Millay, L**., & **Vinson, E**. (2018). *Proceedings of the 21st Annual Conference on Research in Undergraduate Mathematics Education*.

Stapleton, M., & **Sezen-Barrie, A**. (2017, November 1). A Scientist, Teacher Educator and Teacher Collaborative: Innovative Professional Learning Design focused on Climate Change and Lessons Learned from K-12 Classrooms. Retrieved from http://innovations.theaste.org/a-scientist-teacher-educator-and-teacher-collaborative-innovative-professional-learning-design-focused-on-climate-change-and-lessons-learned-from-k-12-classrooms/

Tabachnick, E., Colesworthy, P., & Wittmann, M. (2018). *Physics Education Research Conference Proceedings 2017* (pp. 384-387). Compadre.

Van De Bogart, K., & **Stetzer, M**. (n.d.). Investigating student understanding of bipolar junction transistor circuits. *Physical Review Physics Education Research*.

Van De Bogart, K., Dounas-Frazer, D., Lewandowski, H., & **Stetzer, M.** (2017, September 12). Investigating the role of socially mediated metacognition during collaborative troubleshooting of electric circuits. Retrieved from https://doi.org/10.1103/PhysRevPhysEducRes.13.020116

Watkins, T., Miller-Rushing, A., & **Nelson, S.** (2018). Science in Places of Grandeur: Communication and Engagement in National Parks. *Integrative and Comparative Biology*.

Weatherbee, R., & **Lindsay, S**. (n.d.). Designing a curriculum-aligned assessment of cumulative learning about marine primary production to improve an undergraduate marine sciences program. *Journal of Microbiology and Biology Education*.

Wittmann, M. (2018). Research in the Resources Framework: Changing environments, consistent exploration. In *Reviews in Physics Education Research* (Vol. 2). PER Central.

Wittmann, M., Rogers, A., Alvarado, C., Medina, J., & **Millay, L.** (2018). *Physics Education Research Conference Proceedings 2017* (pp. 440-443). Compadre.

Appendix C

Grants and Contracts: New Grants Awarded to RiSE Faculty, FY18

Name/Role	% Resp	Title	Funding Agency	Award Amount	Award Date
Bruce, Mitchell R. (PI)	50	The Synthesis of X-Ray Quality Crystals for Use in Introductory Chemistry	American Chemical Society	$5,000	5/2/18
Dimmel, Justin (PI)	100	Geometer's Planetarium	National Aeronautics and Space Administration	$10,000	9/28/17
Fairman, Janet (PI)	100	Maine Education Policy Research Institute (MEPRI) FY18	Maine State Legislature through University of Southern Maine	$125,000	7/1/17
Gerbi, Christopher (PI)	50	Collaborative research: Computational methods supporting joint seismic and radar inversion for ice fabric and temperature in streaming flow Year 2	National Science Foundation	$97,274	9/19/17
Lindsay, Sara (PI)	100	Developing a curriculum-aligned assessment of student learning in marine sciences: essential groundwork	University of Maine Office of Assessment mini-grant	$1,000	1/1/18
Nelson, Sarah (PI)	100	Linking freshwater mercury concentrations in parks to risk factors and bio-sentinels: a national-scale research and citizen science partnership	US Dept of the Interior	$20,000	7/14/17
Sezen-Barrie, Asli (PI)	100	MADE CLEAR (Maryland Delaware Climate Change Education and Assessment Research)	National Science Foundation through University of Maryland	$8,000	4/5/18
Smith, Michelle K and Stetzer, MacKenzie (PI/coPI)	60/30	Collaborative Research: Promoting instructional change in introductory STEM courses through Faculty Learning Comm.	National Science Foundation	$154,910	8/21/2017

Smith, Michelle K (PI)	100	CourseSource: Developing, Disseminating, and Understanding the Usefulness of Resources for Evidence-based Undergraduate Biology Teaching	National Science Foundation	$274,708	8/30/17
Speer, Natasha (PI)	100	Improving the Preparation of Graduate Students to Teach Undergraduate Mathematic	National Science Foundation through Mathematical Association of America	$25,510	11/1/17
Stetzer, MacKenzie (PI)	100	Collaborative Research: Establishing a new model for research-based curriculum development in physics aligned with dual-process theories of reasoning	National Science Foundation	$863,239	6/22/18
Total				**$1,584,641**	

Grants and Contracts: Continuing Grants Awarded to RiSE Faculty, FY18

PI	CoPI	Title	Funding Agency	Award Amount
Amar, Francois		Comparative Functional Genomics INBRE in Maine (Honors College)	US Dept of Health & Human Services through Mount Desert Island Biological Lab	$105,035
	Amar, Francois	Thermochemical Conversion of Woody Biomass to Fuels and Chemicals	US Dept of Energy	$1,889,988
Bruce, Mitchell		Fostering Connections between Macroscopic, Submicroscopic, and Representational Levels Using Analogical Reasoning in the Chemistry Lab	National Science Foundation	$275,284
Fairman, Janet		Math4ME	US Dept of Education through ME Dept of Education	$48,284
	Fairman, Janet	CRE-State Personnel Development Grant (CRE-SPDG)	US Dept of Education through Office of Special Programs	$141,607
Gerbi, Christopher		Collaborative research: Computational methods supporting joint seismic and radar inversion for ice fabric and temperature in streaming flow Year 2	National Science Foundation	$97,274
	Gerbi, Christopher	Collaborative Research: Developing an Antarctic Tephra Database for Interdisciplinary Paleoclimate Research (AntT)	National Science Foundation	$365,095
Gerbi, Christopher		Collaborative Research: Influence of natural ice microstructure on rheology in general shear: in-situ studies in the Alaska Range	National Science Foundation	$518,673
Gerbi, Christopher		CAREER: Identifying the Dominant Controls on Strain Localization in the Lower Crust	National Science Foundation	$220,864

	Gerbi, Christopher	Origin and vertical extent of damage zones around continental strike-slip faults	National Science Foundation	$282,951
McKay, Susan	Mitchell Bruce, Michael Wittmann, John Thompson	Maine Physical Sciences Curriculum Partnership: Research and Infrastructure for Ongoing Educational Improvement	National Science Foundation	$12,347,771
McKay, Susan	Mitchell Bruce, Michael Wittmann	MainePSP Supplement: Strengthening Recruitment and Preparation of Pre-Service STEM Teachers Using the MainePSP Community and Infrastructure	National Science Foundation	$2,060,084
McKay, Susan	Michelle Smith, Jon Shemwell, MacKenzie Stetzer	Building Rural STEM Educator Capacity through Partnership	National Science Foundation	$299,997
McKay, Susan	MacKenzie Stetzer, Michelle Smith, Eric Pandiscio	A Model NSF Teaching Fellowship Program to Improve STEM Teacher Recruitment, Preparation, Professional Development, and Retention in Rural High-Need Schools	National Science Foundation	$1,950,034
Nelson, Sarah		(Seed Grant) Maine's Changing Winter: focus on natural resources, ecology, and the economy	US Dept of the Interior	$5,000
Nelson, Sarah		Adirondack Long Term Monitoring	US Environmental Protection Agency through Adirondack Lakes Survey Corporation	$8,714
Nelson, Sarah		EPA IAG for Clean Air Act trends research, 2015-2016	US Environmental Protection Agency through University of New Hampshire	$80,918
	Nelson, Sarah	RAPID: Experimental Recovery at the Bear Brook Watershed in Maine	National Science Foundation	$49,720

Nelson, Sarah		Technical Assistance: GLKN Monitoring Larval Dragonflies for Mercury	US Dept of the Interior	$30,000
Nelson, Sarah		The Future of Four Seasons in Maine	US Dept of Commerce	$125,000
Nelson, Sarah		UMaine Research Reinvestment Fund: Graduate student support to continue UM's lead role in the Dragonfly Mercury Project across US National Parks	UMaine RRF	
Smith, Michelle K.		Collaborative Research: Expanding a National Network for Automated Analysis of Constructed Response Assessments to Reveal Student Thinking in STEM Yr 5	National Science Foundation	$42,704
Smith, Michelle K.	Stetzer, MacKenzie, McKay, Susan	Catalyzing Institutional Change Through Synergistic Observation and Professional Development Programs	National Science Foundation	$249,851
	Speer, Natasha	Improving the Preparation of Graduate Students to Teach Undergraduate Mathematics	National Science Foundation	$1,029,299
Stetzer, MacKenzie		Collaborative Research: Examining the development of student reasoning skills through scaffolded physics instruction	National Science Foundation	$169,806
Thompson, John	Stetzer, MacKenzie	Research on learning and teaching at the physics-engineering interface: thermodynamics and electronics	National Science Foundation	$599,999
Thompson, John		Collaborative Research: Research on learning and teaching at the physics-mathematics interface	National Science Foundation	$197,647
	Thompson, John	Continuing the Conversation in DBER: The Transforming Research in Undergraduate STEM Education (TRUSE) Conference Transforming Research in Undergraduate STEM Education	National Science Foundation	$37,342
Wittmann, Michael		Collaborative Research: Assessing, Validating and Developing Content Knowledge for Teaching Energy	National Science Foundation	$280,532
Total				**$23,509,473**

GRANTS AND CONTRACTS: PROPOSALS SUBMITTED BY RiSE FACULTY AND PENDING OR NOT FUNDED, FY18

Name/Role	Title	Funding Agency	Award Amount	Submission Date
Amar, Francois (PI)	Comparative Functional Genomics INBRE in Maine	US Dept of Health & Human Services through Mount Desert Island Biological Lab	$960,279	3/16/18
Bruce, Mitchell (CoPI)	Acquisition of a 500 MHz NMR Spectrometer with Improved Sensitivity and Accessibility to Benefit Research and Education at Umaine	National Science Foundation	$798,100	2/5/18
Dimmel, Justin (CoPI)	A remote multimodal learning environment to increase graphical information access for blind and visually impaired students	National Science Foundation	$749,371	1/8/18
Dimmel, Justin (PI)	How do students reason about large-scale figures? A comparison study	Spencer Foundation	$49,914	4/30/18
Dimmel, Justin (PI)	Transforming mathematics education with an immersive, gesture-based digital learning platform	National Science Foundation	$726,524	1/8/18
Gerbi, Christopher	Developing numerical environments for geoscience investigations	University of Maine	$8,000	2/6/18
Gerbi, Christopher (PI)	Promoting development of the cross-disciplinary Center for Numerical Modeling and Simulation	University of Maine	$31,000	1/16/18
Lindsay, Sara (CoPI)	Cultivating and Sustaining Change -- A Study of Pedagogical, Departmental and Institutional Best	National Science Foundation	$1,137,591	12/8/17

	Practices in STEM Higher Education (with Thomas Jack and others, through Dartmouth College))			
McKay, Susan (PI), Pandiscio, Eric (CoPI), Peterson, Franziska (CoPI), Fairman, Janet (CoPI)	Maine Elementary and Middle-Level Mathematics Partnership: Coordinated Community-Based Professional Learning for Teachers to Strengthen Students' Problem Solving Abilities	National Science Foundation	$4,885,634	5/17/18
McKay, Susan (PI), Bruce, Mitchell CoPI, Hufnagel, Beth (CoPI)	Building Rural Students' Disciplinary Engagement in STEM: A Researcher - Practitioner Partnership	National Science Foundation	$3,000,000	11/14/17
Nelson, Sarah (PI)	EPA IAG for Clean Air Act trends research, 2017-2018 (Determining the effectiveness of the Clean Air Act and Amendments on the recovery of surface water	US Dept of the Interior through University of New Hampshire	$399,233	10/20/17
Nelson, Sarah (PI)	Appalachian National Scenic Trail Natural Resource Condition Assessment Statement of Interest	US Dept of the Interior	$0	2/2/18
Nelson, Sarah (PI)	Does timing sampling matter? Spatial and temporal variation in life histories and mercury concentrations of a burrowing larval dragonfly, Cordulegaster spp.	US Dept of the Interior	$13,684	10/27/17
Nelson, Sarah (PI)	Dragonfly Mercury Project addition of Wild & Scenic River sites	US Dept of the Interior	$0	6/1/18
Nelson, Sarah (PI)	Linking freshwater mercury concentrations in parks to risk factors and bio-sentinels: a	US Dept of the Interior	$43,247	5/10/18

	national-scale research and citizen science partnership +$			
Nelson, Sarah (CoPI)	NRT: Enhancing conservation science and practice: An interdisciplinary program	National Science Foundation	$2,998,314	2/5/18
Sezen-Barrie, Asli (CoPI)	Assessing the Impact and Scalability of a Cognitive Apprenticeship model for Culturally Responsive Teaching in STEM	National Science Foundation	$299,567	11/13/17
Sezen-Barrie, Asli (CoPI)	Collaborative Research: NSF INCLUDES Alliance: Partnerships to Practice (P2P): Building Inclusive STEM Education and Workforce Development through Partnered-Participatory Learning	National Science Foundation	$1,495,133	4/4/18
Speer, Natasha (PI)	SEMINAL project in calculus	National Science Foundation through Association of Public & Land-Grant University	$99,191	10/10/17
Speer, Natasha (CoPI), Stetzer, MacKenzie (CoPI), Lindsay, Sara (CoPI)	The Community-based Undergraduate Success Program	Howard Hughes Medical Institute	$1,000,000	10/6/17

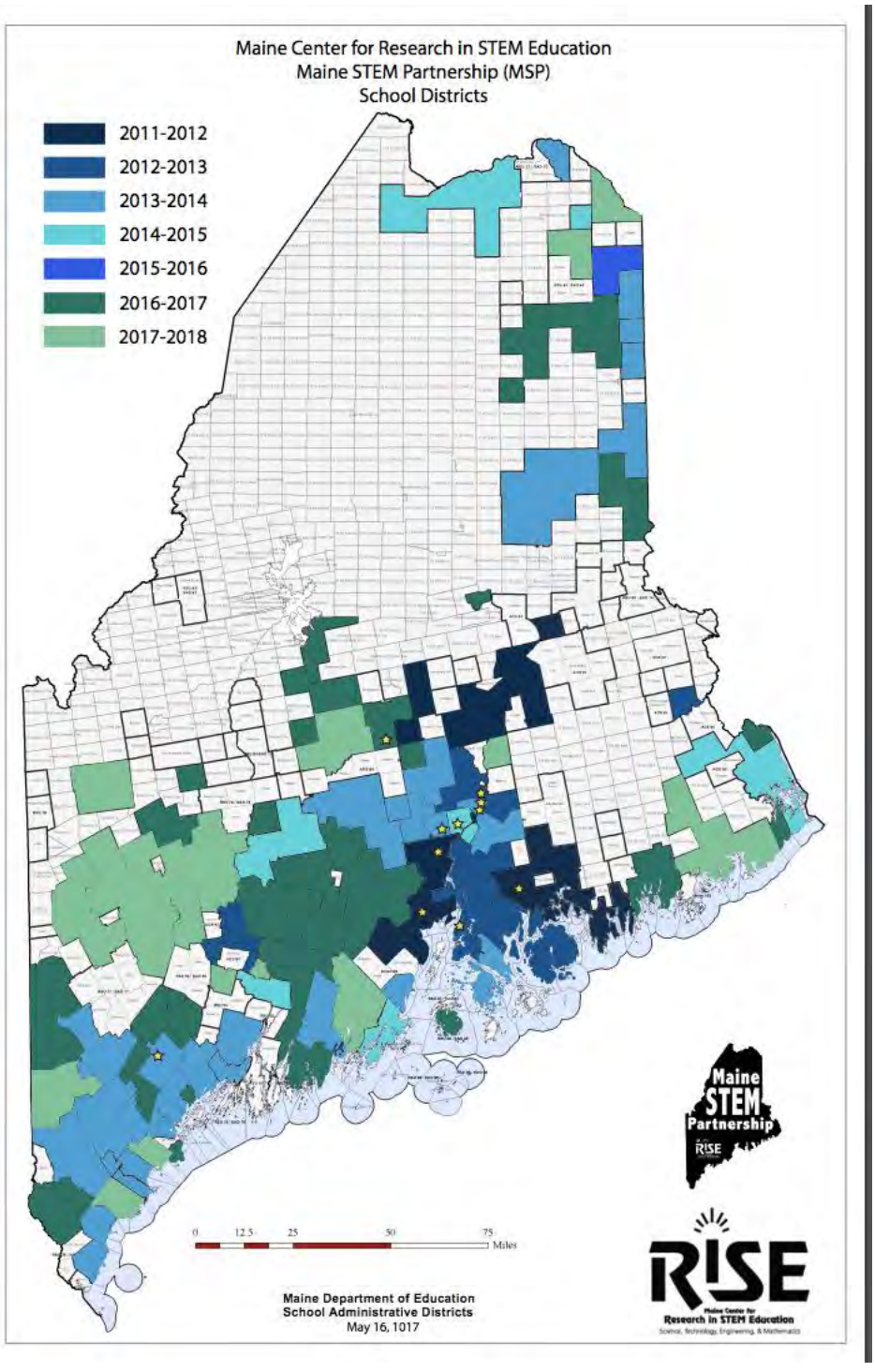
Thompson, John (PI)	Collaborative Research: Beyond procedures: a research-based approach to teaching mathematical methods in physics	National Science Foundation	$473,390	10/24/17
Thompson, John (PI)	Collaborative Research: Replicating and Diffusing RUME Results in Physics Education Research and Practice	National Science Foundation	$297,659	12/12/17
Wittmann, Michael (PI) and Peterson, Franziska (CoPI)	Improving the Interdisciplinary Identity of Middle School Science and Mathematics Teachers	National Science Foundation	$1,200,000	9/5/17
Total			**$20,665,831**	

Appendix D

Courses Offered by the RiSE Center 2017 – 2018

Semester	Title	Professor	Enrollment
Summer 2017	SMT 699 Graduate Thesis/ Research	Susan McKay	13 with 15 credit hours
Fall 2017	SMT 504 Integrated Approaches in Earth Sciences Education II	Molly Schauffler	8
Fall 2017	SMT 588 Seminar in Science and Mathematics Education Research	Natasha Speer	5
Fall 2017	SMT 699 Graduate Thesis/ Research	Susan McKay	17 with 54 credit hours
Fall 2017	INT 492 Maine Learning Assistant Pedagogy Seminar	MacKenzie Stetzer	46
Spring 2018	SMT 500 Educational Psychology with Applications to Science and Mathematics Teaching and Learning	Asli Sezen-Barrie	6
Spring 2018	SMT 506 Integrated Approaches in Mathematics Education II	Justin Dimmel	5
Spring 2018	SMT 590 Seminar for Teaching Interns	Susan McKay	7
Spring 2018	SMT 591 Secondary Student Teaching	Susan McKay	7
Spring 2018	SMT 599 Graduate Thesis/ Research	Susan McKay	13 with 43 credit hours
Spring 2018	INT 492 Maine Learning Assistant Pedagogy Seminar	MacKenzie Stetzer (assisted by Erin Vinson)	23
Summer 2018	SMT 598 Special Topics in Science and Mathematics Education: Using 3D Printers to Enhance Science Learning in the Middle and High School Grades	Susan McKay (assisted by Marina Van der Eb)	3
Summer 2018	SMT 699 Graduate Thesis/ Research	Susan McKay	9 with 11 credit hours

Appendix E


Maine Center for Research in STEM Education
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Maine STEM Partnership
RISE
Research in STEM Education

Appendix F

Selected Outcomes of the FIG-MLA Program

- The FIG-MLA Program grew in 2016-17 to involve 103 Maine Learning Assistants and 24 faculty in modifying 22 STEM courses across 10 departments, with total enrollment of 4,275 students.
- 78% of incoming STEM majors take one or more FIG-MLA courses during their first year of enrollment at the University of Maine
- Students who take 2 or more FIG-MLA courses during their freshman year are significantly more likely to be retained into their second year at University of Maine, than students who take 0 or 1 FIG-MLA courses.

Departments and Courses Added to FIG-MLA Program by Year		
2012-2013	School of Biology & Ecology Physics & Astronomy School of Marine Sciences Earth Sciences	BIO 100, BIO 350, ERS 201, PHY 121/122, SMS 300
2013-2014	Chemistry Electrical & Computer Engineering Mathematics & Statistics	CHY 121/122, ECE 342, MAT 122, MAT 126, PHY 441, SMS 422

2014-2015	Chemical & Biological Engineering Computer Sciences Molecular & Cellular Biology	BMB 155, CHE 386, COS 250, MAT 126*
2015-2016	No new departments added	BIO 465, BIO 480, CHE 350, MAT 103, PHY 121/122*
2016-2017	Food Science Ecology & Environmental Science	AST 109, BIO 100*, BIO 307, CHY 121/122*, CHY 251, CHY 472, EES 100, ERS 151, FSN 330, MAT 122*, PHY 121/122*, SMS 201
2017-2018	Civil & Environmental Engineering Mechanical Engineering	BIO 200, BMB 322, CIE 331, ERS 102, MAT 116, MAT 122*, MAT 127, MET 320

*some courses are repeated above either because a different instructor was awarded a FIG-MLA grant or same instructor was awarded another FIG-MLA grant

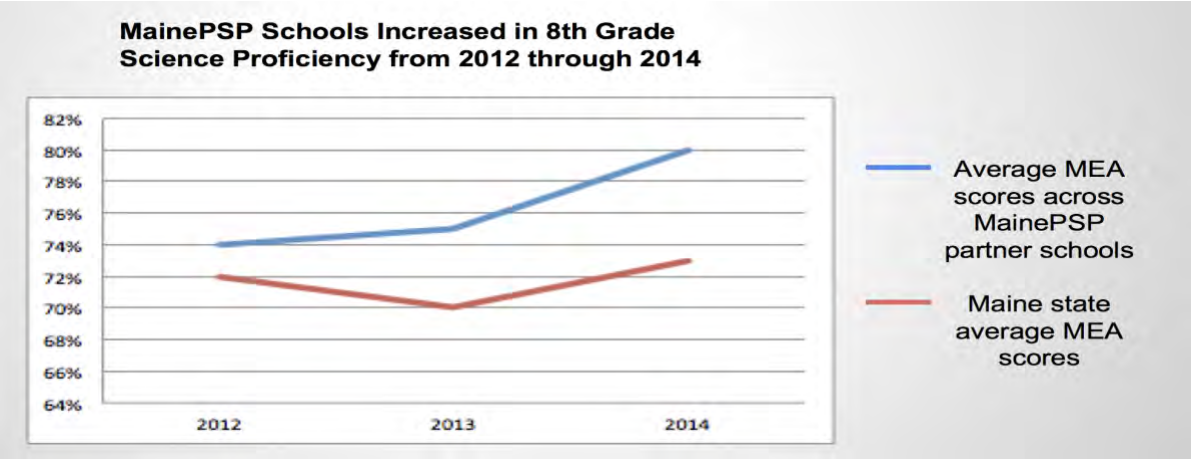
Appendix G

Selected Outcomes of Partnership Work at the Elementary and Middle Levels

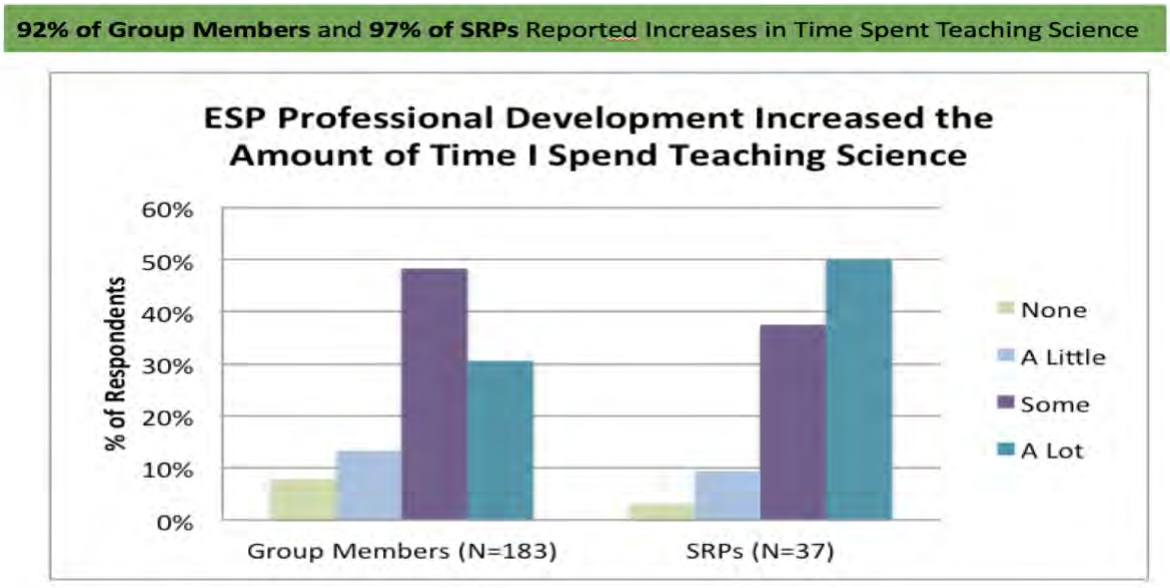
In 2016-17, the RiSE Center provided over 11,000 hours of professional development and a research and evidence-based professional community to over 700 teachers of Maine students in grades K-12. This programming impacted more than 25,000 Maine students during this instructional year.

Significant outcomes for Maine students include:

- Improved proficiency on MEA achievement testing for middle school students in the Maine Physical Sciences Partnership

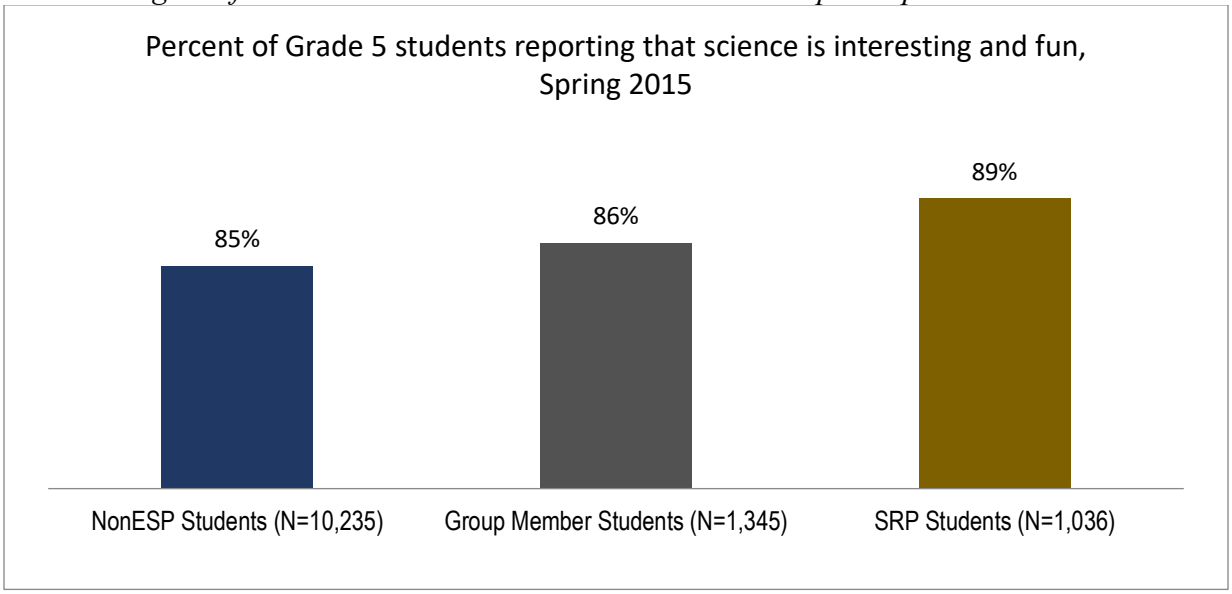


- Increased science instruction for K-5 students in the Maine Elementary Sciences Partnership, *Note: This outcome was reported by Science Resource Partners (SRPs) and their Group Members, and was independently reported by the impacted students.*



- Improved attitudes toward STEM and STEM careers for students in participating classrooms

Grade 5 students in Maine Elementary Sciences Partnership Classrooms (Group Member Students and Science Resource Partner or SRP Students) were more likely to agree that "science is interesting and fun" than students in classrooms that did not participate.



Appendix H

Summary of RiSE Center Strategic Planning for 2017-2018

The RiSE Center has identified four strategic themes that reflect key areas for us to build on current strengths in order to further our mission and vision. These themes were identified through a strategic planning process involving the 20 STEM faculty across multiple departments who are members of the RiSE Center and the Center's 7 professional staff.

Within the next five years, the RiSE Center seeks to grow to be a nationally and internationally recognized research center tied to the University of Maine's signature area of STEM Education and Education Research. Through exemplary Discipline Based Education Research (DBER) and interdisciplinary education research across STEM departments, the RiSE Center will contribute key insights to knowledge of teaching and learning in STEM disciplines. At the same time, the RiSE Center will continue to provide evidence-based professional development and resources to STEM educators, supporting students at all levels of instruction and preparing pre-service teachers and education researchers through the Master of Science in Teaching and STEM Education PhD programs.

Excellence in STEM education research

Last year, the RiSE Center had an outstanding year of research productivity, with twenty-nine refereed journal articles and conference proceedings published and over ninety research presentations at conferences and other venues. In addition, six Master's theses, one doctoral thesis in discipline-based education research, and six honors theses and senior capstone research projects were completed mentored by RiSE faculty members. RiSE faculty are Principal Investigator or Co-Principal Investigator on eight new and twenty-four continuing external grants, totaling over $25 million, and three internal Research Reinvestment Fund grants seeding collaborations with other University of Maine System (UMS) campuses. In order to realize our five-year vision and continue developing capacity for research, we need to (1) add a base-budgeted research and evaluation coordinator (2) strengthen the existing STEM Education PhD program with some resources to jump-start admissions and productivity and (3) add a base-budgeted Assistant Director position.

Excellence in interdisciplinary collaboration

Interdisciplinary collaborations in the RiSE Center take place through grant proposals, graduate student thesis committees, and an interdisciplinary research group. RiSE faculty collaborate extensively across STEM departments in order to plan for and implement the Master of Science in Teaching program and the STEM Education PhD program. RiSE faculty from across STEM departments collaborate with staff to plan an annual interdisciplinary conference and a successful ongoing campus-wide STEM education improvement effort - the Faculty Course Modification Incentive Grant and Maine Learning Assistants (FIG-MLA) program. Faculty, staff, and graduate students collaborate to support professional development for STEM educators across the state and year-round, through the Maine STEM

Partnership. The RiSE Center's major grants (over $18 million in grant funding within the past 8 years) have built upon and furthered these collaborations.

The RiSE Center currently involves 20 STEM and education faculty from nine colleges and departments, including Physics and Astronomy, Biology and Ecology, Marine Sciences, Forestry, Environmental Sciences, Chemistry, Mathematics and Statistics, College of Education, and Earth and Climate Sciences. In addition, 32 full or part-time MST students, 5 Physics Education Research PhD students and 2 STEM Education PhD students participate in Discipline Based Education Research (DBER), including DBER that crosses multiple disciplines.

Moving forward, the RiSE Center proposes to develop a model for how to foster and build on interdisciplinary collaborations to promote STEM Education Research and the integration of STEM Education Research with the practice of STEM teaching at all levels of instruction, including preK through graduate instruction. The Assistant Director, research coordinator, and PhD students would play an integral role in developing these collaborations.

Excellence in professional learning experiences for STEM professionals at all levels of instruction

The RiSE Center currently facilitates professional learning for STEM professionals at the University and across the state through the Maine STEM Partnership, a partnership of STEM educators and researchers working to improve STEM education through research-supported practices at all levels. The Center also prepares pre-service teachers and STEM education researchers through the Master of Science in Teaching (MST) program, the STEM education research PhD program, and the NSF Teaching Fellowship program.

Within this theme, objectives are to increase the reach and accessibility of our programming, strengthen and increase external partnerships, increase and expand high-quality programming for educators at all levels, and strengthen pre-service teacher preparation. The Assistant Director, research coordinator, and PhD students would add needed capacity for developing evidence-based programming and conducting research to support innovation.

Excellence in communication about our work

In the coming year, the RiSE Center will work to increase awareness about our work and impacts through an increased focus on communications. The Assistant Director would play a key role in enhancing communication within the Center, across the University of Maine, and with our diverse partners. In addition, the Assistant Director would collaborate with communications and marketing personnel at the University of Maine in order to build the national reputation of the Center and the University.

Appendix I

Table of Faculty Appointments

Unit Name: RiSE Center

Faculty Name	Center Faculty Title	Academic Unit	MOU*	Initial Appoint Date
Francois G. Amar	Professor, Department of Chemistry and Dean, Honors College	Honors		
David J. Batuski	Professor and Chair, Department of Physics and Astronomy	PHY		
Mitchell R. Bruce	Associate Professor of Chemistry	CHY		
Justin Dimmel	Assistant Professor of Mathematics Education and Instructional Technology	STL		
Robert D. Franzosa	Professor of Mathematics and Statistics	MAT		
Christopher Gerbi	Associate Professor of Earth and Climate Sciences	ECS		
Janet Fairman	Associate Research Professor of Education	STL		
Elizabeth Hufnagel	Assistant Professor of Science Education	STL		
Sara Lindsay	Associate Professor, School of Marine Sciences	SMS		
Susan R. McKay	Director, RiSE Center, and Professor of Physics	PHY		
Sarah Nelson	Associate Research Professor, Senator George J. Mitchell Center, and Associate Research Professor in Watershed Biogeochemistry, School of Forest Resources	EES		
Eric A. Pandiscio	Associate Professor of Mathematics Education	STL		
Franziska Peterson	Assistant Professor of Mathematics Education	MAT		
Molly Schauffler	Research Assistant Professor (adjunct), School of Earth and Climate Sciences and Climate Change Institute	ECS		
Asli Sezen-Barrie	Assistant Professor of Curriculum, Assessment and Instruction	STL		
Michelle Smith	Associate Professor of Biological Sciences, C. Ann Merrifield Professor in Life	SBE		

	Science Education, and Cooperating Associate Professor of STEM Education			
Natasha Speer	Associate Professor of Mathematics Education	MAT	X	9/1/2017
MacKenzie Stetzer	Assistant Professor of Physics and Cooperating Assistant Professor of STEM Education	PHY		
John R. Thompson	Professor of Physics and Cooperating Professor of STEM Education	PHY		
Michael C. Wittmann	Professor of Physics and Cooperating Professor of STEM Education	PHY		

*Enter X if a MOU exists for the faculty member and submit the MOU with your report.