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Investing in Teachers' Leadership Capacity: A Model from STEM Education

Susan R. McKay
Principal Investigator; University of Maine, Orono, susan.mckay@maine.edu

Laura Millay
University of Maine, laura.millay@maine.edu

Erika Allison

Elizabeth Byerssmall
University of Maine, elizabeth.byerssmall@maine.edu

Michael C. Wittmann
University of Maine, mwittmann@maine.edu

See next page for additional authors

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Authors

Susan R. McKay, Laura Millay, Erika Allison, Elizabeth Byerssmall, Michael C. Wittmann, Mickie Flores, Jim Fratini, Bob Kumpa, Cynthia Lambert, Eric A. Pandiscio, and Michelle K. Smith

Investing in Teachers' Leadership Capacity:

A Model from STEM Education

by Susan R. McKay, Laura A. Millay, Erika Allison, Elizabeth ByersSmall, Michael C. Wittmann, Mickie Flores, Jim Fratini, Bob Kumpa, Cynthia Lambert, Laura Matthews, Eric Pandiscio, and Michelle K. Smith

Abstract

Teachers play a key role in the quality of education provided to students. The Maine Center for Research in STEM Education (RiSE Center) at the University of Maine has worked with partners to design, implement, and evaluate several programs in the past eight years to provide professional learning opportunities and support for Maine's STEM teachers, leading to significant impacts for teachers and students across the state. A strategic investment in developing teacher leadership capacity played a key role in expanding the initial partnership to include teachers and school districts across the state. With support from education researchers and staff at the RiSE Center, STEM teachers have taken on roles as leaders of professional learning opportunities for peers and as decision makers in a statewide professional community for improving STEM education. This article describes the structures that have fostered teacher leadership and how those structures emerged through partnership and collaboration, the ways in which teacher leadership has amplified the resources we have been able to provide to STEM teachers across the state, and the outcomes for Maine students.

OVERVIEW

The Maine Center for Research in STEM Education (RiSE Center) at the University of Maine has developed a statewide partnership to improve the quality of science, technology, engineering, and mathematics (STEM) education for all Maine students using research-supported practices. Education research has shown that the teacher is a primary factor in the quality of education provided to students—second only to the quality of educational leadership in the school (Leithwood et al. 2004). In an environment of changing standards, teachers need ongoing professional learning opportunities to keep up with changes in recommendations and expectations. Further, in our rural state, STEM teachers often teach multiple subject areas including ones that are outside their fields of expertise (Millay 2018).

The RiSE Center has been conducting professional learning programs for STEM teachers since 2010, funded primarily by over $18 million in National Science Foundation (NSF) funds. The initial focus was on the selection of high-quality instructional materials for middle school and ninth grade physical and earth sciences and on the implementation of a professional learning program to support teachers in using those materials in the classroom. From 2013 to 2016, Maine Department of Education funding supported an expansion of RiSE Center professional development from middle and high school science teachers to elementary school teachers. Additional funding from NSF supported involvement of high school science and mathematics teachers and increased supports for preservice science and mathematics teacher preparation. These partnerships had profound impacts on STEM outcomes for Maine students in elementary, middle, and high school as well as in undergraduate education and preservice teacher preparation at the University of Maine. Furthermore, this work has been disseminated to a national and international community of educators and education researchers (Alvarado et al. 2016; Barth-Cohen et al. 2016; Shemwell, Avargil, and Capps 2015; Wittmann, Alvarado, and Millay 2017). Even though the major grant funding has concluded, school districts and the University of Maine continue to support a statewide community to improve STEM education, the Maine STEM Partnership at the RiSE Center, comprised of teachers, university faculty, education researchers, administrators, and preservice teachers.

In our work over the past eight years, many members of our community have emerged as leaders and have collectively advanced development of a vibrant, multifaceted professional community that is strengthened by diverse expertise. Diversifying leadership has played a strategic role in supporting innovation, expansion, and sustainability in our work. A full description of this development is beyond the scope of this paper; here, we focus primarily on the development of our teacher leadership programs to show how increased opportunities for teacher leadership led to growth and sustainability in our programming. We seek to describe (1) structures that have fostered teacher leadership and how those structures emerged through partnership and collaboration, (2) ways in which teacher leadership has amplified the resources we have been able to provide to STEM teachers across the state, and (3) outcomes for Maine students.

Education researchers and policy experts regularly advocate for development of teacher leadership capacity to achieve multiple goals. One model of teacher leadership involves preparing teachers to take on administrative roles or to enable them to better support school administrators in implementing programs (Mette, Fairman, and Terzi 2017). In this model, leadership roles are conferred within a hierarchical structure. A second model of teacher leadership focuses on increasing teachers' capacities as facilitators of learning and as advocates for education within their schools, districts, and larger communities (Childs-Bowen, Moller, and Scrivner 2000). The RiSE Center focuses on this second model in part because our initial focus was on developing a professional community in which teachers, faculty, and administrators all have a significant voice as decision makers in matters related to curriculum, instruction, assessment, and professional learning. Calling on teachers to contribute significantly to these types of decisions collectively leads teachers to feel empowered and encourages a leadership model in which veteran teachers support the teachers who are new to our projects. The new participants include preservice teachers who are students in the University of Maine's Master of Science in Teaching (MST) Program and undergraduate College of Education and Human Development programs.

Importantly, development of teacher leadership in the RiSE Center community has been supported through the leadership of others in our professional community, including faculty, staff, and graduate students. Part of our model of distributed leadership is that teacher leaders are members of teams that are comprised of other professionals who bring additional expertise and experiences. This distributed-leadership model is a key element contributing to success in our programs.

IMPACTS ON STEM EDUCATION IN MAINE

The work of the RiSE Center has had far-reaching impacts on Maine's PK–12 STEM teachers and students over the past eight years. Although attributing outcomes to inputs is challenging in education research, we have found evidence of growth, some of which is documented in our program evaluations (Inverness Research 2016a; Zoellick and Millay 2016). Here, we highlight a few examples that showcase the impacts of teacher leadership.

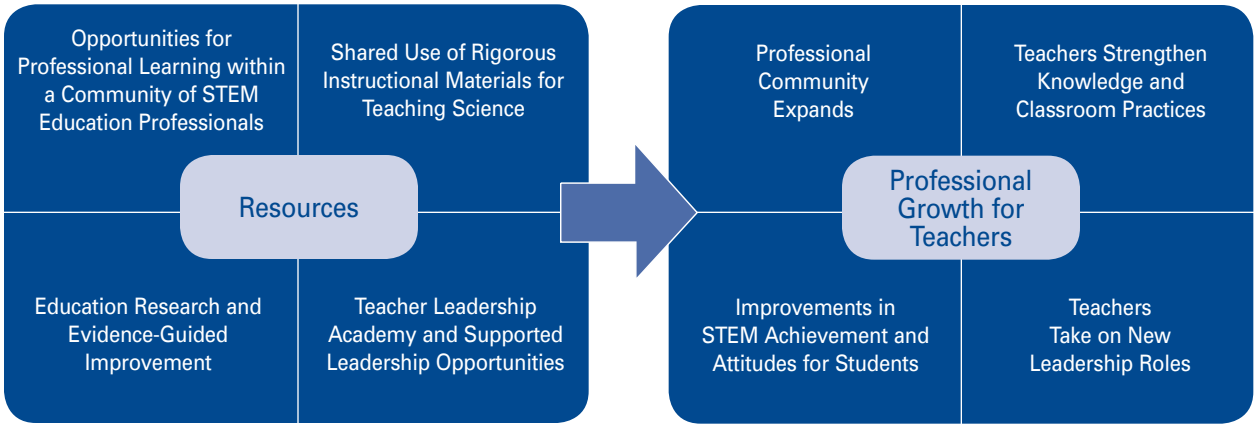
Maine Physical Sciences Partnership

Our first major project, the Maine Physical Sciences Partnership (MainePSP, 2010–2017) was funded by NSF and invested $14.4 million in improving STEM education in Maine. Initially, the project used many of these resources toward impacts in grades 6–9 instruction in the physical sciences, recognizing how critical the transition from middle school to high school is for many students. The development of STEM teacher leadership was initiated and initially funded by the MainePSP. In addition, the MainePSP's professional community and models for professional learning have been refined and carried forward.

Figure 1 shows resources of the MainePSP (left side) that led to changes in PK–12 STEM education across the state (right side). Significant resources of the MainePSP included a variety of targeted professional learning opportunities supported by grant funding, including staff and faculty salaries, stipends for teacher participants, support for meetings and events, and rigorous instructional resources for classrooms. Grant funds were invested in ways that built a vibrant professional community focused on evidence-based improvement of STEM education. This community values the diverse expertise brought by education researchers, faculty, teachers, project staff, and preservice teachers.

The impacts to teachers of this professional experience included gains in content knowledge and pedagogical content knowledge (Shulman 1986), improvements in confidence for teaching STEM, increased collaboration with colleagues, growth as

FIGURE 1: **Resources Invested by the MainePSP and Their Impacts**



leaders, and changes in classroom practices (Inverness Research 2016a). Measurable impacts to students included strengthened achievement and attitudes toward STEM. For example, student achievement on the eighth grade Maine Educational Assessment (MEA) for Science improved in schools that collaborated with the RiSE Center through the MainePSP (see Figure 2). In addition, interest in science careers increased for middle school students receiving two years of vertically aligned physical sciences instruction through the MainePSP. Notably, 12 percent more students expressed interest in a science career at the end of middle school compared to at the start, even though interest in science careers typically decreases through the middle school years (Osborne, Simon, and Collins 2003). As indicated in Figure 1, these changes can be attributed to a multipronged effort and a significant investment of resources from multiple sources.

The MainePSP fostered teacher leadership through a variety of strategic decisions and formal structures designed to involve teachers in making improvements to STEM education. Notably, a formal program has provided opportunities for 62 teachers to develop and practice leadership skills. Research and evaluation of this program revealed that participating teachers have taken on leadership roles that extend beyond their classrooms. Research conducted by Zoellick (for further discussion see Zoellick et al., this issue) describes some of these roles and provides case studies of the transformation of teachers through the leadership program. As one teacher stated,

> *I didn't see myself as a leader going in and they helped me see the skills I have to be a leader and how I can put those skills to use. It's given me the confidence to say the things I might not have said before and to meet with people and have important conversations in a productive way.* (Inverness Research 2016b: 5)

Maine Elementary Sciences Partnership

Teacher leaders expanded the capacity of the professional community facilitated by the RiSE Center. Some of these teacher leaders took on key roles in the

FIGURE 2: **Percentage of Students Meeting/Exceeding Proficiency on the Grade 8 MEA for Science, RiSE Partner Schools Compared to NonPartner Schools, 2009–2014**

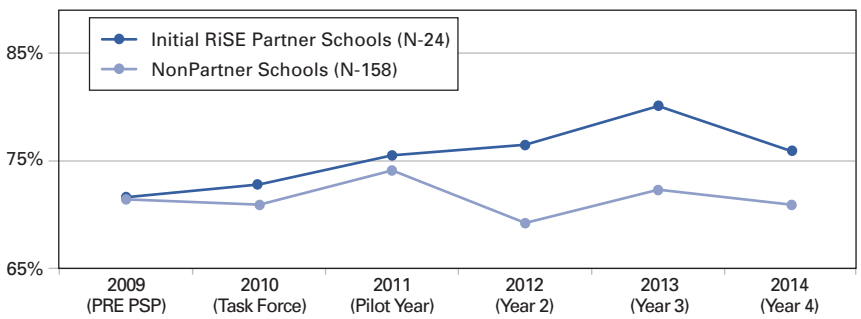
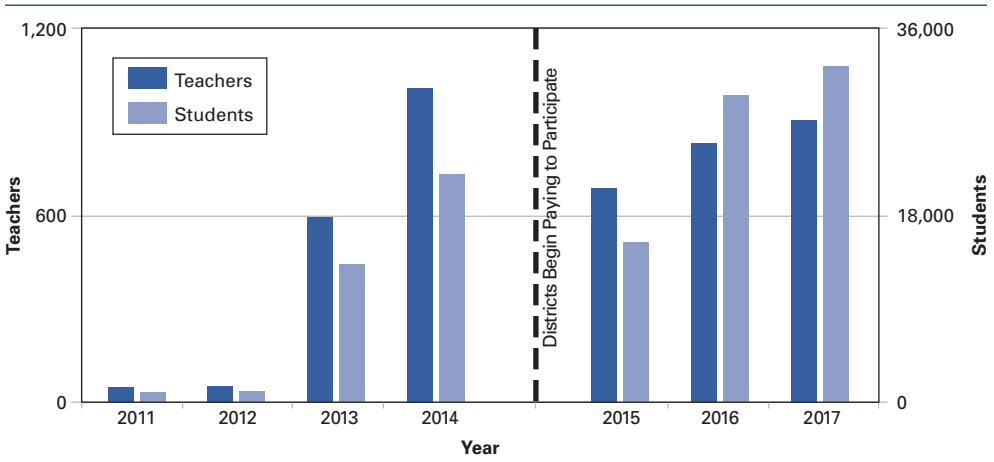


FIGURE 3: **Teachers Participating in RiSE STEM Professional Development and PK–12 Students Affected, 2011–2017**



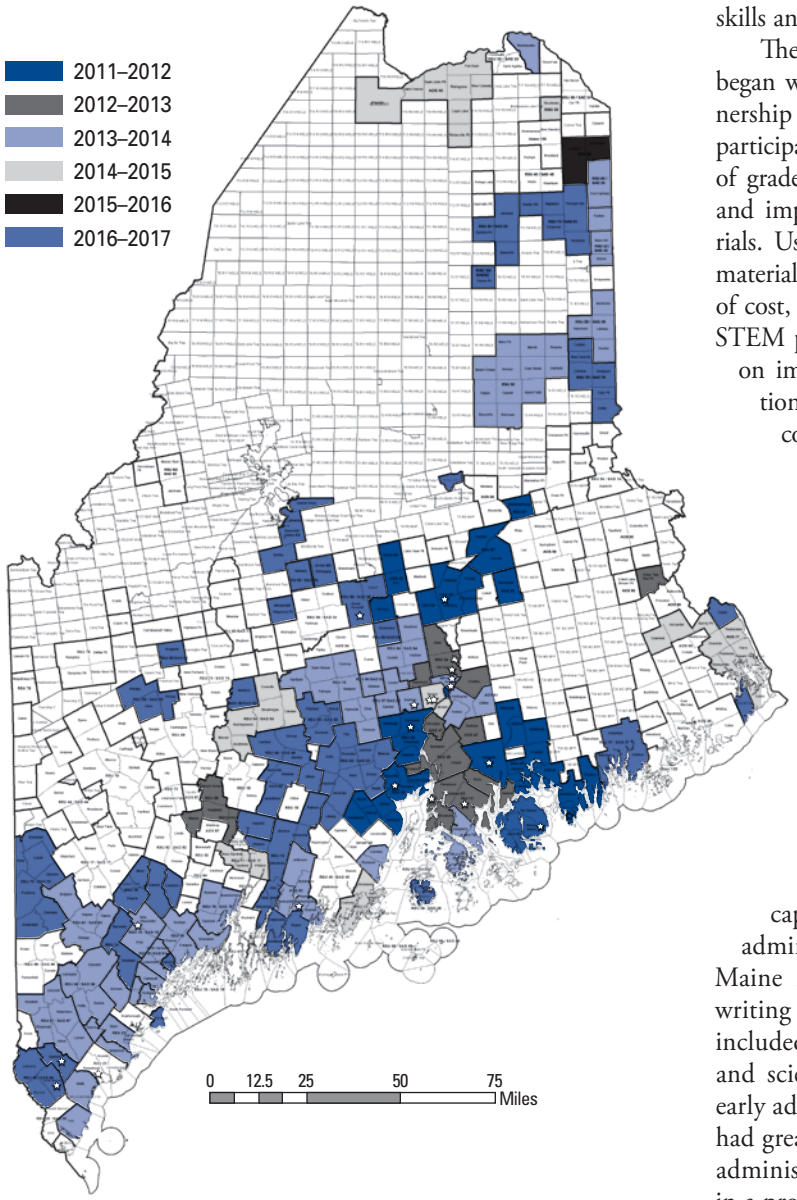
subsequent major grant-funded project of the RiSE Center, the Maine Elementary Sciences Partnership (MaineESP, 2013–2016), funded by $1.7 million from the Maine Department of Education. To maximize project resources, the MaineESP provided direct learning opportunities facilitated by faculty, staff, and teachers to a group of 147 elementary school teachers. These 147 teachers were then supported in developing study groups that provided professional learning opportunities to 1,285 teachers across the state. This distributed leadership model affected between 10,500 and 18,500 students each year of the project, at a cost of less than $42 per student per year. Maine currently spends an average of $11,330 per student per year for education (MDOE 2015).

Maine STEM Partnership

The RiSE Center further refined this highly cost-effective model in 2016 when the major grant funding for the work ended and the MainePSP and MaineESP communities were combined to form the Maine STEM Partnership. In the current model for some of the RiSE Center's professional learning communities, a group of 12 teacher leaders receives direct support from faculty and staff at the RiSE Center to lead professional learning for 90 colleagues, who then organize study groups for an additional 600 teachers around the state. These investments in leadership have allowed the RiSE Center to provide high-quality professional learning opportunities for a large number of Maine's STEM teachers, even as the available resources have decreased. Figure 3 shows the number of teachers participating in the RiSE Center's professional development from 2011 to 2017. In 2011 and 2012, fewer than 100 teachers received intensive professional learning experiences at the RiSE Center. In 2013, through investments in teacher leadership and use of teacher leaders to lead professional learning experiences for colleagues, more than six times as many teachers were able to participate in professional learning opportunities. This number increased to over 1,000 teachers through investments from both the MainePSP and MaineESP in 2014, then dipped in 2015 as the partnership began requiring that participating districts pay part of the cost. In 2016 and 2017, the numbers of participating teachers increased, even as grant funding was significantly reduced and district payments continued to be required. Figure 3 also shows the number of PK–12 students taught by teachers actively involved in RiSE Center professional development. The map in Figure 4 shows growth in district membership.

We have evidence that this model of statewide professional learning can be successful in positively affecting Maine students. The final evaluation for the MaineESP found positive impacts to grade 5 students' MEA science test scores and attitudes toward STEM and STEM careers (Zoellick and Millay 2016). For example, 69 percent of students whose teachers participated in the MaineESP tested proficient or above on the MEA science test, and 32 percent expressed interest in a science career. In comparison, 64 percent of students whose teachers did not participate tested proficient or above on the MEA Science Achievement test, and 28 percent expressed interest in a science career. The significance threshold for chi-squared testing of independence was set at $p<.05$, and these differences are statistically significant.

FIGURE 4: **The RiSE Center's School District Partners, by Year of Entry**



KEY STRUCTURES SUPPORTING GROWTH FOR TEACHER LEADERS

The history of teacher leadership at the RiSE Center involves structural decisions made about our reform projects and the transition to focused leadership programming and roles within our professional community. Through these structures, teachers have taken on new leadership roles within our projects and have gained skills and expertise in leadership.

The RiSE Center's teacher leadership programs began with the MainePSP. The initial goal of this partnership between the University of Maine and 26 participating school districts was to improve the quality of grades 6–9 physical science instruction by selecting and implementing rigorous science instructional materials. Using grant funds, MainePSP purchased science materials so that they could be provided to schools free of cost, and MainePSP provided extensive and ongoing STEM professional learning opportunities that focused on implementation of the science program. In addition, the partnership sought to build a professional community among science teachers in the state that crossed school and district boundaries and connected teachers with faculty at the University of Maine, as well as with other community partners and stakeholders such as the Schoodic Institute.

Several key choices shaped the early years of our professional community, laying groundwork for science teachers to work with faculty and administrators to make decisions that would directly influence and advance their own classroom practices. An underlying philosophy of the project was to focus on investing in and supporting teachers as a strategy for building capacity to improve education in Maine. School administrators were involved with University of Maine faculty in the early development and grant-writing phase and supported a working model that included direct partnership between university faculty and science teachers. Given the rural setting of the early adopters of the MainePSP, many science teachers had great autonomy in their schools, and the building administrators were often happy to have them involved in a project that provided colleagues and resources. In addition, university faculty who were the initial leaders of the MainePSP hosted many early events at schools rather than at the University of Maine, to emphasize that the work was school centered, not university centered and to put faculty and teachers on more equal footing.

Collaborative Selection of Science Instructional Materials

As work began in 2010 to select physical sciences instructional resources for use in grades 6–8, the RiSE Center involved middle and high school teachers, school administrators, and University of Maine postdoctoral fellows, graduate students, faculty, and staff. These task force members collaborated on the development and implementation of an evidence-guided process for selecting science instructional materials and used an evaluation protocol adapted from the American Association for the Advancement of Science (Roseman, Kesidou, and Stern 1997). The decisions made regarding materials selection and the reasoning behind those decisions formed the basis for subsequent years of targeted professional learning and evidence-guided improvements. The 28 members of the original task force, 20 of whom were teachers, became ambassadors to the larger community in communicating about the goals, priorities, and methods that task force members had negotiated. In addition, members of the first task force became leaders and facilitators of later task forces.

Since the first task force, the RiSE Center has facilitated four additional task forces to review and select instructional resources, and a fifth task force process is ongoing. In 2011, a second task force selected instructional resources for grade 9 instruction. In 2013, middle and high school teachers who had participated in the early processes worked with faculty and staff to guide a task force to select instructional materials for grades PK–5. In 2017, a fourth task force revisited the physical sciences materials selected for middle school and grade 9 and reviewed middle school life sciences materials. Currently, a task force is reviewing new materials for elementary sciences instruction.

Through the process, teachers have collaborated with other members of our professional community to review evidence, consider the needs of students and teachers, consider standards and goals of instruction, and make key decisions for their own classrooms while making important recommendations to administrators and other teachers. These decisions are supported by the RiSE Center infrastructure that provides materials to schools at reasonable cost as well as ongoing support for implementation of the instructional resources. Increasingly, these professional learning opportunities are facilitated through collaborations among teacher leaders and RiSE faculty, staff, and other partners. Prior to implementation, the community agrees upon assessments of student learning to use in determining the strengths and weaknesses of the instructional resources. Data from these embedded assessments are collected and analyzed at the RiSE Center and guide the community's ongoing improvements of the selected resources.

The diversity of perspectives brought by the members of each task force have strengthened the process and the collaborative work of the task forces has been foundational in building the Maine STEM Partnership. Research faculty, postdoctoral fellows, and MST students from the RiSE Center bring expertise in the content, nature, and practice of the STEM disciplines; knowledge of literature and theory to guide improvements in education; an understanding of the frontiers of current academic knowledge about teaching and learning in the STEM disciplines; and practical experience from other research-guided improvement efforts. Teachers bring knowledge of schools, students, pedagogy, and the current on-the-ground reality of teaching and learning within their content areas. Preservice teachers bring content expertise from their previous education and, in some cases, diverse work experiences from previous positions in STEM, education, or other professional spheres. Administrators bring perspectives on school and district-level priorities and challenges for student learning and vertical alignment of instruction.

A Collaborative Model for Professional Learning

RiSE Center professional learning experiences for teachers focus on building a diverse professional community while developing content knowledge, pedagogical content knowledge, and specialized content knowledge to support inquiry-based and standards-aligned STEM teaching. University faculty, postdoctoral fellows, graduate students, staff, and teachers have all taken on roles as leaders of professional learning experiences, with sessions designed to meet community needs. Professional learning has been offered throughout the summer and school year, through a variety of structures and subcommunities. Ongoing evaluation and a culture of iterative improvement has supported growth and responsiveness to changes in the needs of the professional community.

Intensive Teacher Leadership Academies

In addition to fostering professional collaborations that provide leadership opportunities, the RiSE Center runs a formal program to prepare and support teacher

leaders. Development of the Leadership Academy in 2013 created an opportunity for teachers to participate in inquiry-based professional learning that was specifically focused on developing teacher leadership. Initially, 11 middle and high school STEM teachers began attending extra meetings focused on leadership during the school year and summer. Members of the leadership academy were asked to contribute to decisions about the direction of the program, considering questions about how to best move forward in building their own leadership while also developing their classroom practices. Members also worked on team building, reflected on leadership styles and on themselves as leaders, and developed leadership skills in communication and facilitating adult learning.

Toward the end of the first year, teachers in the leadership academy developed projects that would give them practical leadership experiences within the RiSE Center professional community. Teachers learned about writing proposals and applied for internal grants for projects that included facilitating the task force for selection of elementary science materials, leading a professional development study group for fellow teachers that focused on increasing the quality of productive talk in science classrooms, and leading a cross-district collaboration to support proficiency-based grading of students' competency with science practices.

The cohort continued to meet throughout a second academic year to discuss the projects and support development of the skills that members were practicing throughout the year. Members of the initial leadership cohort have taken on key leadership roles within the professional community, and the projects they began have continued, resulting in new opportunities for the teaching community. For example, some members of the cohort took on roles as co-investigators and developers for new programs that received external grant funding, including the Elementary Sciences Partnership and an NSF Teaching Fellowship Program. Some members moved into roles as school administrators or staff members at the RiSE Center and have contributed to professional learning experiences and leadership development for teachers in these capacities. Other leaders have taken on roles in presenting at national and state conferences, facilitating professional development sessions for new teachers, and mentoring preservice teachers. Ongoing support from, and participation in, the professional community with opportunities to take on a variety of roles has been important for leadership development, with teachers simultaneously participating as leaders and as learners in different aspects of the collective work of the community.

TEACHER LEADERSHIP AS AN ENGINE OF CHANGE

The RiSE Center has strategically invested in teacher leadership to improve PK–12 STEM education. Empowering teachers as codesigners and coleaders of professional learning opportunities for other teachers has been an effective and cost-efficient way to bring about change and professional growth. Increasingly, teacher leaders have also taken on roles as presenters at national and state conferences. Due to demand from school districts, the RiSE Center is currently in the process of supporting teacher leaders in becoming professional coaches and consultants for school districts throughout the state.

The RiSE Center has also included teachers' voices in the formal decision-making processes of the Maine STEM Partnership. Teacher leaders participate in the governance structure of the Maine STEM Partnership, which includes a leadership team and a curriculum modification review board comprised of representatives from across the STEM education community. The leadership team meets monthly to make strategic decisions about partnership activities and direction. The curriculum modification review board makes decisions about proposed changes to the STEM instructional materials recommended and supported by the RiSE Center for use in PK–12 classrooms. This structure has led to an improvement community that includes teachers, researchers, and professional staff in the leadership that plans, designs, and implements learning opportunities, responding to the needs of teachers and students.

New grants and initiatives have provided opportunities for teacher leaders to support preparation and induction of preservice teachers, some of whom have already begun to join the professional community as new teachers. The RiSE Center received additional funding from a National Science Foundation grant in 2016 to support recruitment, retention, and induction of new STEM teachers. This funding supported development of a group of mentor teachers and coaches to support new and preservice STEM teachers. Teacher leaders also are involved in preservice teacher-preparation courses along with faculty and staff.

VISION AND FUTURE NEEDS

Teachers are leaders by nature in their professional position. They lead a classroom of students every day. They lead the design and implementation of year-long learning progressions for their students, and they play a leading role in each individual student's growth and developmental journey. The question is not whether teachers are leaders; it is whether they identify and feel valued as leaders beyond their classrooms.

The RiSE Center's work has provided leadership preparation and supported opportunities that prepare teachers to use their expertise to strengthen STEM education more broadly. It has brought teachers working toward educational improvement to the decision-making table, along with faculty, administrators, and researchers, with each participant having a respected voice. For many teachers, the invitation to be part of a leadership cohort provided a new and empowering way to look at themselves as part of a significant enterprise to improve STEM education. Being able to have this far-reaching impact, while remaining teachers rather than administrators, has been attractive to these individuals and powerful for the community. This leadership development has led teachers to assume the professional agency present in other professions, in which leading members of the profession have a voice in defining the standards, needs, and policies related to their work. By assuming these broader, outside-the-classroom roles, teachers move from a reactive to a proactive position, crucial for using their expertise to guide the improvement of education.

With over 260 teachers statewide who have successfully assumed leadership roles connected with the RiSE Center and a model to expand this leadership capacity among teachers, Maine now has a powerful teacher leadership network. This network, launched and nurtured through the NSF and Maine Department of Education investments, positions the state to become a leader in STEM education. Furthermore, this network can sustain the improvements in science education achieved through the initial grants and also expand to provide high-quality, affordable professional learning opportunities for teachers to reach all Maine students in science and in important additional content areas such as mathematics and computer science.

If Maine continues investing in this community, it can realize a vision of excellence as a national leader in STEM education and workforce development. The STEM disciplines, taught well, provide the communication skills, problem-solving abilities, teamwork practice, creativity, and critical-thinking development needed for innovation in the twenty-first-century workplace. With a tested, cost-effective model, we envision a state that provides an education that opens doors to the future for all students. Teacher leadership is an essential ingredient to this vision since it leads to the selection of high-quality instructional resources, targeted ongoing professional learning opportunities for teachers, evidence-guided continuing improvement in our educational system, and a supportive community for this change.

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Susan R. McKay is the founding director of the Maine Center for Research in STEM Education (RiSE Center) and a professor of physics and astronomy at the University of Maine. She was the principal investigator for the grants discussed in this paper. Her research interests include strategies to engage all students in STEM learning and the development of cost-effective models to support STEM teachers.

Laura Millay has worked in her current capacity as research and evaluation coordinator at the University of Maine's RiSE Center since 2014. She supports discipline-based and interdisciplinary STEM education research and conducts evaluations for programs to improve STEM education in PK–12 and university-level instruction.

Erika Allison currently works as member services director for 1Berkshire in Pittsfield, Massachusetts. Erika was project director at the RiSE Center from 2011 to 2016. She left the corporate engineering world in 2008 to join the New York City Teaching Fellows and encourage more underrepresented youth to consider careers in STEM.

Beth ByersSmall is the coordinator of the National Science Foundation Teaching Fellowship Program at the University of Maine's RiSE Center. She has over 20 years of teaching experience at the elementary, middle, and high school levels. ByersSmall has also worked as an assessment developer for the Maine Mathematics and Science Alliance.

Michael C. Wittmann is a professor of physics at the University of Maine, a founding member of the RiSE Center and of the Physics Education Research Laboratory, and a Fellow of the American Physical Society. He was a coprincipal investigator on the NSF-funded Maine Physical Sciences Partnership. He conducts physics education research, teaches courses for physics students and preservice STEM teachers, and facilitates professional learning for teachers.

Mickie Flores, Albert Einstein Distinguished Educator Fellow and 2015 Hancock County Teacher of the Year, currently teaches grades 5–8 science and mathematics at Deer Isle-Stonington Elementary School in Deer Isle, Maine.

Jim Fratini is a middle school life and physical science teacher at Hermon Middle School in Hermon, Maine. He is also codirector of the Maine State Invention Convention.

Bob Kumpa teaches grade 8 science at Brewer Community School in Brewer, Maine. He has taught middle school for the past 17 years and science for the past 14 years.

Cynthia Lambert is a National Board Certified STEM teacher at Trenton Elementary School in Trenton, Maine, and Mount Desert Elementary Schools in Northeast Harbor, Maine.

Eric Pandiscio is an associate professor of mathematics education at the University of Maine and a member of the RiSE Center. He was a coprincipal investigator on the state-funded Maine Elementary Sciences Partnership. Eric teaches mathematics education courses for current and prospective K–12 teachers. His research interests include proportional reasoning skills, analytic and synthetic geometric ideas, and inductive and deductive thinking.

Michelle Smith is an associate professor in the School of Biology and Ecology at the University of Maine, a member of the RiSE Center, and holds the Merrifield Professorship in Life Science Education. Her position was created through the Maine Physical Sciences Partnership. Smith's research focuses conceptual difficulties among biology students, factors that influence instructors' decisions about teaching, and effective peer discussion.