A. Executive summary

The cybersecurity education community has identified the following goals for STEM teaching, especially in mathematics: improving teaching methods by expanding the use of inquiry-oriented pedagogy, and helping teachers become STEM education leaders. These priorities match local needs in Montana. The proposed project addressed these priorities via The Montana Math Teachers’ Circle. The Montana Math Teachers’ Circle is a three-year project, started in 2016, to create a state-wide community of practice for math teachers and mathematicians in Montana. Math Teachers’ Circles (MTCs) are powerful forms of professional development for teachers, in which teachers and mathematicians engage in collaborative problem solving activities. The Montana MTC works to improve teaching methods by (a) developing teachers’ knowledge of mathematical content and practices, and (b) improving teachers’ classroom practices by promoting inquiry-based pedagogy. The Montana MTC helps to produce teacher-leaders by developing teachers’ confidence in—and identification with—mathematics. The proposed project will support the second year of the development of the state-wide Montana MTC. Funding will support the professional development of 180 teachers and will help to build local capacity to continue the professional development work long after the grant period ends.

B. Proposed idea and program description

The cybersecurity education community has identified the following goals for STEM teaching, especially in mathematics: improving teaching methods by expanding the use of inquiry-oriented pedagogy, and helping teachers become STEM education leaders. These priorities match local needs in Montana. The proposed project addresses these priorities via The Montana Math Teachers’ Circle. In this section, we highlight a problem that is salient for both Montana and the cybersecurity community: students are not learning enough math, and teachers need support to accomplish the ambitious pedagogies that educational reforms demand. We then discuss our proposed solution, and we highlight how our project addresses local needs and the priorities of the cybersecurity education community. We then detail our program objectives and program activities.

Problem statement

It has been 20 years since the Third International Mathematics and Science Study (Beaton et al. 1996) demonstrated that American students’ understanding of mathematics, when compared to their international counterparts, decelerates across the middle school years of instruction leading to a performance gap that widens in high school and beyond. This is a critical issue for cybersecurity. As the Comprehensive National Cybersecurity Initiative (White House, n.d.) makes plain, the U.S. “must develop a technologically-skilled and cyber-savvy workforce and an effective pipeline of future employees”—and that pipeline begins with high-quality mathematics education.

A cascade of curricular proposals followed the TIMSS report. The National Council of Teachers of Mathematics’ Principles and Standards for School Mathematics (2000), the National Mathematics Advisory Panel (2008) and the Common Core State Standards for Mathematics (NGA, 2010) made strong recommendations for changes in the teaching of mathematics, presenting a clear picture of not only the content that is taught but also the mathematical practices in which students ought to engage. The identification of the importance of student engagement in mathematical practices such as problem solving, constructing viable arguments, modeling with mathematics, and making use of structure (NGA, 2010) is a key innovation in these documents, dovetailing with the recommendations of cybersecurity experts that students
ought to engage in problem solving and critical thinking in mathematics. Montana embraced this vision in 2011 when it adopted the *Montana Common Core Standards for Mathematical Practice and Content*.

In order to achieve the ambitious vision of *inquiry-based pedagogy* that is encoded in these standards and recommendations from cybersecurity experts, teachers need both deep content knowledge and experience in participating in mathematical practices (Ma, 2010; Hill, Rowan & Ball, 2005; TEDS-M, 2010). Recent studies, however, show that not all teachers in Montana have such a repertoire, and this has an effect on student learning. For example, recent NAEP score data show that mathematical achievement among 8th grade students is strongly associated with teachers’ content-specific education. Students in classrooms with teachers who majored in math education scored over 6 standard errors higher than their counterparts in classrooms without this degree.

These results identify a need to support Montana teachers during this critical period of educational reform. In particular, the results suggest that teachers need opportunities to *experience* mathematics as both content and practice so as to provide a model of *teaching* mathematics as both content and practice that aligns with the current vision of the Montana Common Core Standards for Mathematical Practice and Content. The *Montana Math Teachers’ Circle* is such an opportunity.

**The Montana Math Teachers’ Circle**

The Montana Math Teachers’ Circle is a part of a nation-wide organization of Math Teachers Circles. Founded in 2006, the Math Teachers’ Circle (MTC) movement ([www.mathteacherscircle.org](http://www.mathteacherscircle.org)) brings together communities of math teachers and university mathematicians who meet regularly to work on rich mathematical problems.

MTC gatherings are typically held in the evening or on a weekend morning. A typical gathering starts with 15-30 minutes of social time, during which participants eat a meal and catch-up with each other. Then, a facilitator introduces a mathematical problem that the group spends approximately 1.5 hours exploring. MTC problems are easy to understand, require minimal background knowledge, and admit a wide variety of approaches. This way, the problems are accessible for participants who have very different histories with mathematics. At the same time, the problems are truly “problematic” in that they can not be solved by known procedures, and they have deep extensions, sometimes into unsolved problems in mathematics. During the exploration, participants work collaboratively on the problem (engaging in problem-solving activity), and then present and critique each others’ approaches (engaging in mathematical argumentation). The gathering concludes with a discussion of the inquiry-based pedagogical approach employed in the gathering, and how teachers can adopt such an approach in their classroom.

The Montana MTC ([http://www.montanamathteacherscircle.org/](http://www.montanamathteacherscircle.org/)) was founded in 2013, holding gatherings in two locations in Montana. In 2016, the PIs on this grant embarked on a three-year project to expand the program across the state. In the first year, we expanded the local gatherings to five locations: four urban areas (Billings, Great Falls, Helena, and Missoula) and one Indian Reservation (the Salish Kootenai Reservation). To enable this expansion, we recruited local “lead teams” to organize and facilitate the gatherings. Lead teams consist of 2-3 local teachers and 1-2 mathematics faculty members in local colleges and universities. We also ran a successful 3-day “summer problem-solving retreat” for teachers, and launched a first-of-its-kind, fully-online “virtual MTC.” Across these various modalities, we had 180 participants across the state in 2016.
2017 is the second year of our project. This year, we plan to expand the Montana MTC by adding to two rural areas (Miles City and Havre, both near Indian Reservations) and one urban area (Bozeman), and to strengthen the existing community. The present proposal seeks partial funding for this phase of the project.

**How the Montana MTC addresses the problem**

The Montana MTC addresses the need to support Montana teachers’ ability to implement educational reform, which, in turn, align with the priorities of the cybersecurity education community.

1. **The Montana MTC works to improve teaching methods and student learning in mathematics.** By providing opportunities for teachers to engage in mathematical practice, the Montana MTC provides a venue for teachers to (a) deepen their *mathematics knowledge for teaching* through participation in mathematical practices, and (b) increase their use of effective classroom practices, including *inquiry-based pedagogy*, through participating in and discussing the educational affordances of inquiry activities.

   Recent research on Math Teachers’ Circles provides evidence that the program has these effects on participating teachers, and that these effects increase student learning in mathematics. With respect to teachers’ knowledge, White et al. (2013) found that participating in a MTC helped to improve teachers’ *math knowledge for teaching* (MKT). MKT is a special kind of math content knowledge that is especially necessary for teachers (Ball, Hill, and Bass, 2005). A teacher’s MKT, in turn, is positively associated with student achievement (Hill, Rowan, & Ball, 2005). With respect to classroom practices, participating in a MTC promotes inquiry-based teaching practices (Khaliqi, Marle, & Decker, 2013) and leads teachers to make more mathematical connections in the classroom (Donaldson et al., 2014). Each of these positively impacts student learning (Barron & Chen, 2008; Ito et al., 2012).

   Locally, interviews and surveys of participants in the 2016 Montana MTC reveal similar outcomes. For example, in a survey of 40 participants in the 2016 summer problem-solving retreat, over 80% indexed changes in classroom pedagogy as a result of participating in the retreat.

2. **The Montana MTC works to build teachers’ identities as mathematicians, producing teacher-leaders.** As teachers engage in mathematical practices, they develop confidence in their mathematical abilities and strengthen their identities as mathematicians (Fernandes, Koehler, & Reiter, 2011; White & Donaldson, 2011). These *practice-linked identities* (Nasir & Hand, 2008), in turn, help teachers develop into professional leaders. In a nation-wide survey of teachers that participated in MTCs, over 50% reported an increase in professional engagement, which they attributed to their growing confidence in—and identification with—mathematics (White & Donaldson, 2011; White & Yow, 2015). These results are supported by in-depth case study research (Donaldson, 2016).

   Locally, many participants in the Montana MTC have started to take on leadership roles. Two participants are now on the lead team for Miles City, a new location in 2017. Moreover, 14 participants stepped into leadership roles in the virtual circle, serving as facilitators for one monthly activity each.
The Montana MTC overcomes geographic barriers to create a sustained statewide community of practice for math teachers. It is well-known that professional development is more successful when it is supported by sustained participation in communities of practice (Borko, 2004; National Research Council, 2000, 2015). Communities are powerful sites for teacher learning for three reasons: (1) Communities are the sites in which practices develop and become normative; (2) Communities give rise and meaning to identities: people become particular kinds of people as the participate in, and become members of, communities of practice; and (3) Communities situate knowledgeable skills in the practices from which they derive meaning (Lave, 1988). For teachers, communities of practice help to support intellectual renewal and provide a sustained venue for new learning (Grossman, Wineburg, & Woolworth, 2001). Thus, communities of practice situate, drive, and sustain teacher knowledge, practice, and identity. With respect to MTCs, surveys, interviews, and case study research confirms that participation in a community is a key factor that drives the outcomes discussed above (Donaldson, 2016; White & Donaldson, 2011).

Whereas many MTCs operate locally, often in high-density urban regions, the Montana MTC is unique in that it is developing a state-wide community. Montana is a state of geographic challenge. The state is over 600 miles wide and 255 miles long with a population density of only 7 people per square mile. Of the 821 public schools in Montana, 40% enroll under 50 students (Montana Office of Public Instruction, 2016). The geographically dispersed population means that many mathematics teachers work in relative isolation. Many are the only mathematics teacher in their middle- or high-school. By creating a state-wide community, the Montana MTC works to overcome this geographic challenge. For many teachers in the state, the Montana MTC is the only professional community of practice in which they can participate.

Participants in 2016 enthusiastically discussed the importance of the state-wide community. For example, one participant explained in an interview explained how the community helped her develop confidence as a mathematician:

I think the high moments were the camaraderie. Um, I have some good friends now that I never knew before. I enjoyed working with people that I don't- that I didn't know before. And that we could develop a bonding, and it was- it was a bonding that was created because we worked together and felt safe. I felt safe. Intellectually safe.

This participant has since assumed a leadership role in the Montana MTC as a member of the Miles City lead team.

Summary, and benefits to the cybersecurity education community

In summary, the Montana MTC works to improve teaching methods and student learning in mathematics and to develop teachers as leaders, both of which are key goals of the cybersecurity education community. The Montana MTC works to improve teaching methods and student learning by (a) developing teachers’ knowledge of mathematical content and practices, and (b) improving teachers’ classroom practices by promoting inquiry-based pedagogy. The Montana MTC helps to produce teacher-leaders by developing teachers’ confidence in—and identification with—mathematics. Finally, the Montana MTC is working to build local capacity and to create a state-wide community of practice so that these outcomes can be sustained over the long-term.

(Narrative continues on page 6, after the table)
Table 1. Yearly objectives for the Montana MTC. The objectives for the proposed project are bolded.

<table>
<thead>
<tr>
<th>Year</th>
<th>Objective</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>1.1. Recruit “lead team” members from three new locations: Salish-Kootenai Indian Reservation, Helena, and Great Falls</td>
<td>Completed, 2/2016</td>
</tr>
<tr>
<td></td>
<td>1.2. Establish partnerships with state-wide organizations to assist in recruiting</td>
<td>Completed 2/2016</td>
</tr>
<tr>
<td></td>
<td>1.3. Hold a 3-day training and planning workshop for lead teams facilitated by the American Institute of Mathematics</td>
<td>Completed, 4/2016</td>
</tr>
<tr>
<td></td>
<td>1.4. Develop website and registration system</td>
<td>Completed, 4/2016</td>
</tr>
<tr>
<td></td>
<td>1.5. Hold biannual (spring and fall) MTC gatherings in 5 locations state-wide</td>
<td>Completed 5/2016 &amp; 10/2016</td>
</tr>
<tr>
<td></td>
<td>1.6. Conduct a 3-day problem-solving retreat for 20 participants in summer</td>
<td>Exceeded 7/2017: 40 participants</td>
</tr>
<tr>
<td></td>
<td>1.7. Design and launch a year-round fully-online “virtual MTC”</td>
<td>Completed, 8/2016</td>
</tr>
<tr>
<td></td>
<td>1.8. Overall, involve 100 participants in MTC activities</td>
<td>Exceeded, 180 participants</td>
</tr>
<tr>
<td>Year 2</td>
<td>2.1. Recruit lead team members from three new locations: Havre, Miles City, and Bozeman</td>
<td>In progress: MC team in place</td>
</tr>
<tr>
<td></td>
<td>2.2. Hold a 3-day training and planning workshop for lead teams facilitated by the American Institute of Mathematics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.3. Hold biannual (spring and fall) MTC gatherings in 8 locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.4. Conduct a 3-day problem-solving retreat for 40 participants in summer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5. Expand participation in the fully-online “virtual MTC” to an average of 15 participants per month</td>
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</tr>
<tr>
<td></td>
<td>2.6. Overall, involve 180 participants in MTC activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.7. Quantitative data shows that participating teachers gain in math knowledge for teaching</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.8. Qualitative data shows evidence that a community is forming, and participants are developing practice-linked identities</td>
<td></td>
</tr>
<tr>
<td>Year 3</td>
<td>3.1. Secure long-term, local funding sources for local gatherings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2. Secure long-term, sustainable funding for state-wide summer retreat and virtual circle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3. Hold biannual (spring and fall) MTC gatherings in 8 locations state-wide</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4. Conduct a 3-day problem-solving retreat for 40 participants in summer 2017</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.5. Overall, involve 180 participants in MTC activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.6. Quantitative data shows that participating teachers gain in math knowledge for teaching</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.7. Qualitative data shows evidence that a stable community has formed and that participants are developing practice-linked identities</td>
<td></td>
</tr>
</tbody>
</table>
Objectives

The overall goal of the Montana Math Teachers’ Circle is to develop a sustainable, state-wide community for mathematics educators in the state of Montana. The three-year development project has the following goals:

A. To increase K-12 math teachers’ knowledge of mathematical content and practices
B. To transform teachers’ classroom practice towards the use of inquiry-based pedagogy.
C. To foster teachers’ identities as mathematicians and develop teacher-leaders.
D. To establish a state-wide community of practice of teachers and mathematicians

To achieve these goals over the three-year period, we have created specific, measurable objectives for each year of the project. These objectives are outlined in Table 1.

As shown, we met or exceeded all of our objectives in 2016, a key demonstration of success. For 2017, we have obtained funding to support Objective 2.4 (the state-wide summer problem-solving retreat) and Objective 2.5 (the year-round virtual circle). The proposed project will help us meet the remaining objectives in 2017. The specific objectives for the proposed project are given below (and see Section E for the measurement mechanisms and success criteria for each objective).

Specific, measurable objectives of the proposed project

The proposed project has the following objectives:

2.1. Recruit lead team members from three new locations: Miles City, Havre, Bozeman
2.2. Hold a three-day training and planning workshop for lead teams, facilitated by the American Institute of Mathematics (AIM)
2.3. Hold biannual (spring and fall) MTC gatherings in 8 locations state-wide
2.6. Overall, involve 180 participants in MTC activities
2.7. Quantitative data shows that participating teachers gain in MKT
2.8. Qualitative data shows evidence that a community is forming, and participants are developing practice-linked identities

To accomplish the objectives, we will engage in the project activities detailed below.

Detailed description of project activities

Table 2 gives an overview of the project activities and timeline. Each activity is discussed in detail in the narrative following the table.

Table 2. Overview of project activities and timeline

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Relevant objective(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March, 2017</td>
<td>Recruit lead team members from Bozeman and Havre</td>
<td>2.1</td>
</tr>
<tr>
<td>April, 2017</td>
<td>3-day training and planning workshop for all lead team members, facilitated by the American Institute of Mathematics</td>
<td>2.2</td>
</tr>
<tr>
<td>May, 2017</td>
<td>8 locations conduct local gatherings. One coordinator from Missoula will attend each gathering.</td>
<td>2.3, 2.6, 2.7, 2.8</td>
</tr>
<tr>
<td>Sept-Nov, 2017</td>
<td>8 locations conduct local gatherings. One coordinator from Missoula will attend each gathering.</td>
<td>2.3, 2.6, 2.7, 2.8</td>
</tr>
</tbody>
</table>
Recruit lead team members from Bozeman and Havre

Local gatherings of the Montana MTC are run by “lead teams” of approximately five members that include one or two faculty members from a higher education institution, and 2-3 k-12 math teachers. These teams work closely with local schools, teachers, and college professors to build the MTC community and conduct MTC events.

In 2017, our goal is to recruit lead teams in three new locations: Miles City (Rural, eastern MT), Havre (Rural, northern MT), and Bozeman (Urban, southern MT). Thus far, we have recruited a team for Miles City. To recruit lead teams for the other locations, we will first recruit faculty members for each lead team, and then leverage those faculty members’ relationships with the local education community to recruit teachers. To recruit faculty members, we will leverage collaborative relationships between the PIs on this project and local faculty members. Roscoe, Peck, and Erickson each have collaborative projects with mathematics faculty members at Montana State University in Bozeman, and Wu has collaborative relationships with faculty at Tribal Colleges near Havre, including Stone Child College and Aaniiih Nakoda College.

Three-day training and planning workshop

The primary purpose of the training workshop is to train the members of the lead teams in the design and conduct of MTC activities, and best practices for recruiting and communicating with MTC participants. This training is important because the benefits of MTCs are associated with gatherings that are facilitated in particular ways. In order to learn to facilitate a gathering, novice facilitators must first experience the gatherings themselves, and then have a space to reflect on the features of the gathering that made it so powerful. The training will provide such an opportunity for members of the lead teams.

The secondary purpose is to provide a space for the lead team members to meet each other and collaboratively plan the logistics of the MTC for 2017. This face-to-face collaboration is vital to develop and maintain the Montana MTC as a state-wide community, rather than a set of unaffiliated local gatherings. During the planning time, the lead teams will reflect on their experience in 2016, discussing the successes and challenges experienced in each location. From there, the teams will design gatherings and develop recruiting strategies for 2017, building on the successes of 2016 and addressing the challenges.

We will partner with Dr. Brianna Donaldson of American Institute of Mathematics (AIM) to run the workshop. AIM helped to pioneer the MTC movement in the U.S., and Dr. Donaldson continues to organize training workshops. Dr. Donaldson will recruit two trained facilitators to design and conduct the workshop.

The location of the workshop will be Helena, MT, which is the most central city among all eight locations of the Montana Math Teachers’ Circle. The workshop will be three days (including travel time), and will be held Friday-Sunday to minimize disruptions to the lead team members’ teaching responsibilities. The tentative dates of the workshop are Friday April 21 - Sunday April 23, 2017.

The proposed project will provide support for all of the expenses associated with the workshop, including travel costs and room and board for lead team members and workshop facilitators, and an honorarium for the facilitators. See the included quote from the Radisson Colonial Inn in Helena for costs associated with room and board.

Biannual Math Teachers’ Circle gatherings at each location

Each of the eight locations will hold biannual gatherings in spring and fall, 2017. The local lead teams will organize and facilitate the gatherings. An example of a Montana Math Teachers’ Circle activity is described below. The gathering, which invites participants to consider the
mathematics behind “The Game of SET,” follows the general structure of MTCs as envisioned by AIM (Donaldson et al., 2014):

1. Check in and social time (15 minutes)
2. Exploration: Facilitators explain the rules of the game and participants to play the game with one another. (20 minutes)
3. Invite mathematical questions: Once participants have gained some familiarity with the game, the focus of the session will shift to mathematical inquiry. Facilitators invite participants to pose mathematical questions that the group might want to investigate in the second half of the session. (15 minutes)
4. Mathematical inquiry: Participants engage in collaborative mathematical inquiry around one or more of the group-generated questions. Facilitators offer suggestions, encouragement, and guidance as needed to facilitate collective mathematical inquiry. Once a critical mass of participants has reached a solution on a problem, participants engage in mathematical discussion in which they present and defend their solutions, and appreciate and critique the solutions of others (60 minutes).
5. Connection to the classroom: Participants discuss the mathematical content and practices from the evening, and develop ideas about how each can be incorporated into their classroom (20 minutes).

Participating teachers will receive credit towards the renewal of their teaching certificate, as well as a “take-away” that will help them implement inquiry-oriented pedagogy in their classrooms. The take-away might be a teacher-oriented book related to inquiry-oriented pedagogy, or it might be the materials that the teacher would need to implement the activity of the gathering in her own class. For example, for the exemplar activity described above, each teacher would receive a classroom set of “The Game of SET.”

The proposed project will help to support these gatherings by providing funding for supplies—including teacher take-aways—for each gathering, and by providing a $300 stipend for each lead team member to compensate them for the time it takes to recruit participants and organize and facilitate gatherings.

Based on 2016 attendance, we anticipate that 10-30 teachers will participate at each location, for a total of approximately 120-180 participants.

Key challenges and risks
The biggest challenge in the proposed project is recruiting participants. As discussed above, Montana is a state of geographic challenge. While many MTCs across the country operate in metro areas with millions of people, most of the Montana MTC gatherings take place in regions with well-under 100,000 people. This means that the pool of math teachers is small, and hence the Montana MTC has to recruit a much higher percentage of math teachers to its gatherings than do most MTCs in the country. For this reason, we developed a number of key partnerships in 2016. In 2017, we will continue to leverage these partnerships to help surmount the recruiting challenges, as described in the next section.

C. Target participation/recruitment
Target population
The target population for this project is K-12 math teachers. We will also invite K-12 administrators, pre-service teachers, and university mathematicians to attend gatherings.
Recruitment

The Montana MTC will implement a statewide recruitment strategy, drawing on best practices for recruiting teachers to MTCs (Donaldson et al., 2014), and by partnering with multiple math teacher networks across the state, as described below:

- Based on our recruiting efforts in 2016, we have a database of over 200 teachers who registered on our website. Each registrant indicated their location in the state and the local gatherings that they are interested in. We will use this database to recruit participants.
- We have established a partnership with the Montana Council of Teachers of Mathematics (MCTM) and will recruit teachers via its network and dissemination channels (email list of teachers, newsletters).
- We have established a partnership with the Montana Office of Public Instruction (OPI), and will recruit teachers via their network. Jake Warner, the Mathematics Content and Instruction Specialist at OPI, serves as an advisor on the Montana MTC project and facilitates the partnership.
- We have established a partnership with the Montana GEAR UP program. Montana GEARUP supports 18 high-poverty middle and high school systems to increase students’ college and career readiness. Thirteen of the partner schools are on or near Montana’s seven American Indian reservations. All 18 schools have a high need in mathematics. The GEARUP program director, Zach Hawkins, and Senior Project Manager, Suzin Kratina, facilitate this partnership and will assist in recruiting teachers from GEARUP schools.
- We will host “mini Math Teachers’ Circle” events at the annual MEA-MFT conference. This conference is a state-wide professional development conference for teachers of all disciplines and levels in Montana. All schools across the state are closed during the conference in order to allow teachers to attend. We have run the mini Math Teachers’ Circle at the MEA-MFT conferences in the past a few years and this has helped to attract some teachers to join the existing gatherings. We will continue this effort in 2017.
- We will invite current students and alumni of the teacher education programs at the institutions of lead team faculty members. For example, the University of Montana has two undergraduate programs and two graduate programs for teachers, and we will recruit students and alumni from these programs. We will also recruit alumni from the following institutions: Rocky Mountain College (Billings lead team), Montana State University (Bozeman lead team, anticipated), University of Great Falls (Great Falls lead team), Stone Child College (Havre lead team, anticipated), Aaniih Nakoda College (Havre lead team, anticipated), Helena College (Helena lead team), Miles Community College (Miles City lead team), and Salish Kootenai College (Salish-Kootenai lead team).

In addition to the above state-wide efforts, we will ask lead teams to engage in local recruiting. Faculty and K-12 teachers can draw on their personal networks to make personal recruiting efforts. Teachers will recruit heavily at their schools and districts. These personal recruiting efforts have the highest likelihood of successfully recruiting new participants.

D. Personnel, Facilities, and Other Resources

Personnel

The Montana MTC project team has strong experiences, skills, connections, and background to conduct the proposed activities and achieve the stated objectives. The most salient evidence
for this comes from the program team’s demonstrated success in meeting or exceeding each of the 2016 program objectives. Further evidence is provided below, with descriptions of the responsibilities and qualifications of each member of the project team.

**Dr. Frederick Peck, PI.** Peck is the director of the Montana MTC. He will serve as the lead for managing and implementing the proposed project. He will work with Dr. Donaldson at AIM to organize the training workshop. He will recruit teacher participants, manage budget/payment to all project personnel, and write quarterly and annual reports to the funding agency. He will attend MTC gatherings in Great Falls, and will be responsible for assisting and mentoring the lead team in this location. He will also facilitate communication and cooperation between the lead teams at each location.

Peck’s qualifications include:
- PhD in mathematics education
- Assistant professor, Department of Mathematics, University of Montana, 2015-pres.
- High school math teacher, 2006-2012
- Director of the Montana MTC, 2016-present
- Lead designer and facilitator of teacher professional development, including: Montana MTC summer retreat, Math on the *Planes*, Denver Public School District, Cherry Creek School District, and Colorado Department of Education, 2013-present

**Dr. David Erickson, Co-PI.** Erickson will attend gatherings in Billings and Miles City, and will be responsible for assisting and mentoring the lead teams in these locations. He is part of the lead team for the Missoula MTC.

Erickson’s qualifications include:
- PhD in mathematics education
- Professor, Department of Teaching and Learning, University of Montana, 1994-pres.
- Co-founder of the Montana MTC, facilitator of gatherings and co-director, 2013-pres.
- PI, NSF Noyce Scholar, *Learning Assistants Become Teachers*, 2012-present
- PI, DoE ITQ, *Before It’s Too Late*, 2005-2010
- Co-PI, DoE MSP, *LEAD*

**Dr. Matt Roscoe, Co-PI.** Roscoe will help to recruit the lead team in Bozeman. He will attend MTC gatherings in Bozeman and Helena, and will be responsible for assisting and mentoring the lead teams in these locations. He is also part of the lead team for the Missoula MTC.

Roscoe’s qualifications include:
- PhD in mathematics education
- Assistant professor, Department of Mathematics, University of Montana, 2012-pres.
- Director of UW-Madison Middle School Mathematics Specialist Program, 2011-2012
- Math teacher 2000-2003
- Co-founder of the Montana MTC, facilitator of gatherings and co-director, 2013-pres.
- Contributor to the *MTCircular*, the semi-annual national newsletter for MTCs
- Co-PI DOE MSP, *Standards-based Teaching Renewing Educators Across Montana* 2015-present

**Dr. Ke Wu, Co-PI.** Wu will help to recruit the lead team in Havre. She will attend MTC gatherings in Havre and on the Salish-Kootenai Reservation, and will be responsible for assisting
and mentoring the lead teams in these locations. She is also part of the lead team for the Missoula Math Teachers’ Circle.

Wu’s qualifications include:
- PhD in mathematics education
- Associate professor, Department of Mathematics, University of Montana, 2008-pres.
- Co-founder of the Montana MTC, facilitator of gatherings and co-director, 2013-pres.
- PI, NSF S-STEM, *MT-Squared: Increasing Diversity in Mathematics*, 2013-present

**Facilities**

Facilities for the 3-day AIM training workshop: The AIM training workshop will be held at the Radisson Colonial Hotel in Helena. The proposed project will provide funding for a meeting room in the hotel as detailed in the included quote and budget. In addition, the proposed project will provide funding for supplies necessary to conduct the workshop.

Facilities for MTC local gatherings: MTC gatherings are held in classrooms on the campuses of each local lead team’s faculty member. These facilities are provided for faculty use by the institution. The proposed project will provide funding for any supplies necessary to conduct the local gatherings.

**Other resources**

Administrative support: The Department of Mathematical Sciences at the University of Montana employs an office and financial manager. This individual will assist the PI in coordinating the logistics of the Math Teacher Circle gatherings, including coordinating reimbursements for materials and travel.

**Administrative**

Process by which tasks will be administered

There are three main tasks in this project: (1) recruiting lead team members in new locations, (2) the AIM training workshop, and (3) biannual MTC gatherings in 8 locations. Please refer to the section titled “detailed description of project activities” in Section B for a detailed discussion of how the tasks will be administered.

**Relevant collaborations**

This proposal has not been sent to other funding agencies, and we do not expect to do so. Relevant collaborations include:
- The partnerships described in Section C, “Target populations/recruitment” including MCTM, Montana OPI, and Montana GEARUP
- The American Institute of Mathematics (AIM). We have a strong working relationship with Dr. Brianna Donaldson, the director of Special Workshops at AIM. Dr. Donaldson’s responsibilities include organizing training workshops for new MTC leaders. Dr. Donaldson will help to coordinate the AIM training workshop, including recruiting expert facilitators.
- The Montana Office of the Commissioner of Higher Education (OCHE). Through a Title IIa Improving Teacher Quality grant awarded to the project team, OCHE has provided funding for Objective 2.4 (the state-wide summer problem-solving retreat) and Objective 2.5 (the year-round virtual circle) in 2017.


E. Program Legacy / Impact on Area of Interest

Evaluation of project objectives

The immediate legacy of the program will be the accomplishment of our project objectives. As shown in Table 3, this includes expanding the Montana MTC to three new locations, training at least 30 lead team members in best practices for organizing and facilitating MTC gatherings, holding biannual gatherings in 8 locations with at least 180 participants, and obtaining preliminary evidence that the Montana MTC is meeting its overall goals.

Table 3. Evaluation criteria for program objectives.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Measurement mechanism</th>
<th>Success criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Recruit lead team members from three new locations</td>
<td>Number of new lead teams formed</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of new lead teams = 3</td>
</tr>
<tr>
<td>2.2</td>
<td>Hold a three-day training and planning workshop for lead teams, facilitated by the American Institute of Mathematics</td>
<td>Number training workshops held</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of workshops = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of lead team members at the training workshop</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of lead team members trained ≥ 30</td>
</tr>
<tr>
<td>2.3</td>
<td>Hold biannual (spring and fall) MTC gatherings in 8 locations state-wide</td>
<td>Number of local gatherings held in spring and fall 2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of spring gatherings =</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of fall gatherings = 8</td>
</tr>
<tr>
<td>2.6</td>
<td>Overall, involve 180 participants in MTC activities</td>
<td>Number of participants in at least one MTC activity in 2017</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of participants ≥ 180</td>
</tr>
<tr>
<td>2.7</td>
<td>Quantitative data shows that participating teachers gain in math knowledge for teaching</td>
<td>Pre-post scores on the Learning Mathematics for Teaching instrument</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Post – Pre) &gt; 0</td>
</tr>
<tr>
<td>2.8</td>
<td>Qualitative data shows evidence that a community is forming, and participants are developing practice-linked identities</td>
<td>Number of publications submitted documenting the development of community and identity</td>
</tr>
<tr>
<td></td>
<td></td>
<td># of publications = 1</td>
</tr>
</tbody>
</table>

Program legacy

Beyond the immediate objectives discussed above, the proposed project should have an enduring legacy with respect to mathematics education in Montana, and to the cybersecurity education community. The project contributes to the work of the Montana MTC to improve teaching methods and student learning in mathematics and to develop teachers as STEM education leaders, both of which are key goals of the cybersecurity education community. In particular, the Montana MTC works to improve teaching methods and student learning by (a) developing teachers’ knowledge of mathematical content and practices, and (b) improving teachers’ classroom practices by promoting inquiry-based pedagogy. The Montana MTC helps to produce teachers as leaders by developing teachers’ confidence in—and identification with—mathematics. Finally, the proposed project will develop local capacity and will contribute to the development of a state-wide community of practice so that these outcomes can be sustained over the long-term.