Rural Tennessee STEM.LD
2020 EIR Grant Application, Mid-Phase

Introduction

The Niswonger Foundation (NF) submits this proposal to the U.S. Department of Education for a mid-phase grant award under the Education Innovation and Research (EIR) competition. Under this proposal, NF will contribute to existing education research through the implementation of replicable programs that improve science, technology, engineering, and mathematics (STEM) learning opportunities and college- and career-readiness for rural students.

Specifically, NF proposes **Rural Tennessee STEM.LD ("STEM.LD")**. This project will design in-person and virtual STEM-rich learning environments in rural northeast Tennessee for students to accelerate learning and exposure to STEM subjects while exploring their interests in these fields. As proposed, the project will also test and scale strategies for student outreach and engagement, expanding participation of underserved rural students in these learning environments. In conceiving this proposal, NF was influenced by the concept of *Learning Design* (i.e., the "LD" in "STEM.LD"), defined as "the creative and deliberate act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational aims in a given context".[1] NF believes that designing student-centered learning ecosystems and pathways can lead to positive student outcomes, from K-12 student achievement to meaningful employment in the workforce post-high school. A strong team of national and regional partners will support the implementation of STEM.LD.

Absolute Priorities

NF submits this proposal under **Absolute Priority 1 – Moderate Evidence**, and **Absolute Priority 2 – Field-Initiated Innovations—Science, Technology, Engineering, or Math (STEM)**. We are applying as a **rural** applicant.

Priority 1. Moderate Evidence

This proposal builds on the evidence base of a proven model of professional development (PD). The STEM.LD program incorporates components of interventions that have demonstrated positive impacts on short-term student achievement outcomes, and that were tested with methods that meet WWC standards for moderate evidence (see Evidence Form). The STEM.LD program will be offered to a population similar to that in the cited study, rural middle school teachers and students. It also builds on work (documented in What Works Clearinghouse) from the NF's 2010 i3 grant that expanded access to rigorous courses and had a significant, positive impact on students taking AP courses.

Priority 2. Field-Initiated Innovations--STEM

Nationwide and in Tennessee, STEM careers are among the fastest-growing, in-demand occupations. STEM careers are projected to increase faster than the average for all other occupations nationwide.[2] In Tennessee, the number of job openings in STEM-focused careers is expected to increase at twice the rate of all other occupations in Tennessee, with more than half of this growth concentrated in computer and engineering occupations. Information technology (IT) jobs are considered a priority occupation group across about two-thirds of Tennessee's economic development regions. Northeast Tennessee, serviced by NF, is expected to see continuous growth in several IT occupations that include computer and information systems managers, computer systems analysts, software developers, and several other critical jobs.[3] Outside of IT occupations, many other in-demand, STEM-focused occupations in Northeast Tennessee include mechanical engineering and industrial engineering technicians, healthcare occupations spanning from medical doctors to physical therapists, and advanced manufacturing

occupations. But 2018 ACT data suggest that only 45% of 2018 graduates were interested in STEM majors or occupations, and only 20% of graduates met the ACT STEM Readiness Benchmark.[4] Student achievement, engagement, and interest in STEM fields have room to improve to meet workforce demand and improve student mobility.

STEM.LD addresses all major elements of STEM. Each of the fields of Science, Technology (including Computer Science), Engineering, and Mathematics is strongly addressed in all grade levels in the project and in each component of the project.

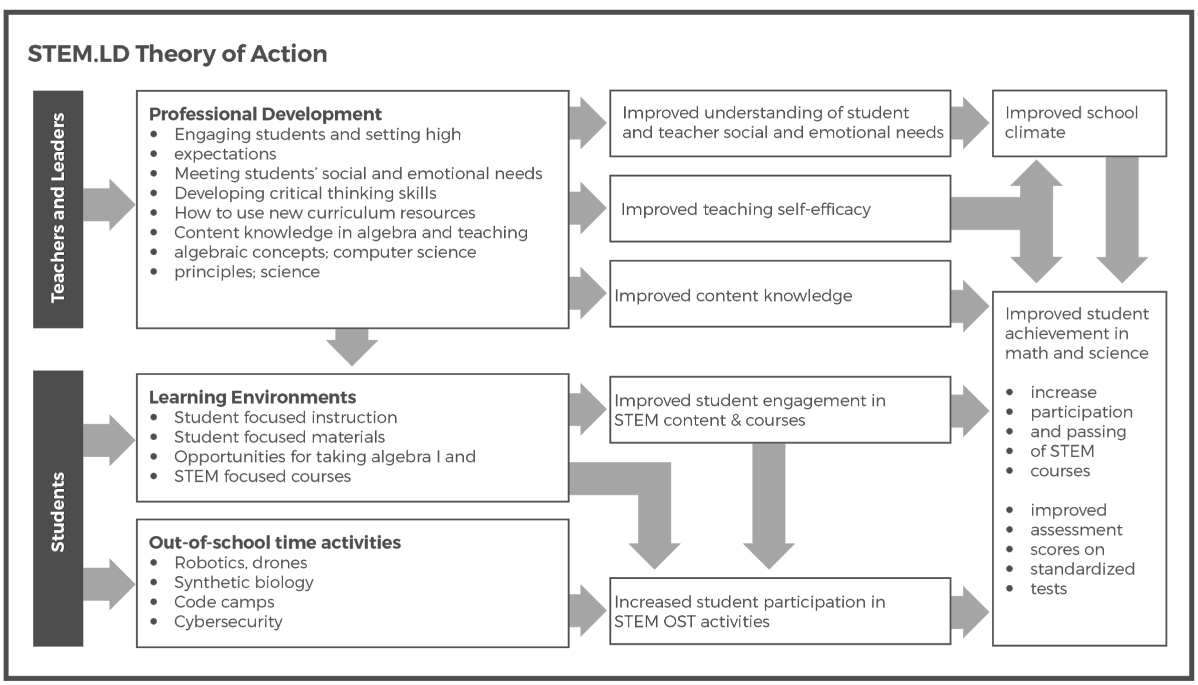
Our proposal includes three major components. First, we intend to strengthen the teaching and learning experiences in classrooms by (a) supplementing STEM curriculum with additional engaging materials for students and (b) professional development (PD) for teachers. This first component is designed to serve *all* students. Second, we will provide experiential out-of-school time (OST) opportunities to explore STEM content; although all students would be welcome, the voluntary nature of the offerings would likely appeal to a smaller subset of interested students. The third component would expand participation in existing rigorous STEM courses and expand the range of dual enrollment (DE) course offerings for students interested in accelerating their learning in STEM and improving career options in those fields. Figure 1 shows the project's "theory of action" to improve outcomes for students in rural Tennessee.

"Rural" and "High Need"

The overall project will serve students enrolled in 126 schools in 21 LEAs and 14 counties currently supported by NF. Of these 126 schools, 79 (or 63%) have a qualifying "rural" locale code.[5] (see Appendix F). These schools enroll over 57,000 students in grades 6-12.[6] We estimate that approximately 28,500 students will participate in initial project-related activities; a deferred implementation (for control schools) would serve the remaining students.

We define "high-need" students as "low-income" students. It is well documented that low-income students trail more advantaged students in most measures of student performance and in levels of academic post-secondary attainment. In each of the project's three major components, we will address both the "achievement gap" and the "opportunity gap." These gaps refer to the achievement disparities that exist between different student groups, as well as the differences in opportunity these students experience in terms of rigorous coursework, meaningful work-based learning experiences, college access, and other postsecondary opportunities. The "opportunity gap," in particular, is compounded in rural communities due to the geographic isolation these communities experience. Approximately one half (48%) of the project's students would be identified as low-income. This is actually an understatement of the situation; Tennessee uses a definition that differs from that in most states.

Figure 1: Rural Tennessee STEM.LD Project Theory of Action



Selection Criteria

Section A: Significance

A1. The project will contribute to increased knowledge or understanding of educational problems, issues, or effective strategies.

Existing research shows the impact of professional development on improving student outcomes. When school districts are able to foster instructional development among teachers and leaders, positive educational change can occur. A review of several evaluations of professional development interventions found that when teachers receive substantial professional development in *specific content knowledge*, student achievement increases by an average of 21 percentile points.[7] STEM-focused professional development also shows positive student outcomes. In a meta-analysis of 95 STEM teacher development programs, researchers noted that programs with above-average student outcomes *blended curriculum and professional development* with targeted support for teachers to improve not only content knowledge in STEM fields, but knowledge in how students learn these concepts.[8] More specifically, *curriculum supplemented with additional materials* can improve student test scores in the math and science subjects, both critical benchmarks in a student's academic journey toward STEM fields.[9]

Out-of-school time (OST) where students are exposed to career experiences provides meaningful preparation for STEM careers. Consistent research suggests that targeting students' STEM interests before eighth grade has strong predictive power in determining student persistence in the STEM career field. OST opportunities provide key, evidence-based strategies where middle-school students develop motivation, engagement, and further interest in these career fields beyond the classroom. A study comparing participation in two STEM afterschool

programs between participants and nonparticipants found that program participants were much more likely to value science, as well as demonstrate overall science competence. These students were also more likely to express interest in postsecondary education over time.[10] Similar OST opportunities, such as programs for computing education that are geared toward work-based learning and career exposure, can have positive effects on students. OST opportunities provide students with meaningful exposure to STEM fields, increasing engagement and further interest in the field beyond high school. Research highlights the nuance in OST opportunities, with program design, intentionality, and the frequency of participant attendance playing significant roles in program effects.[11] Importantly, more research is needed to understand what key characteristics in these opportunities promote student achievement in rural contexts and scale nationwide.

Experts recommend that rural school districts and states provide dual enrollment courses so students have access to more meaningful post-secondary career options, including in STEM fields.[12] Students who participate in dual enrollment courses are more likely to attend college, as well as persist and complete a postsecondary certificate or degree.[13] Considering that students taking math and science coursework in high school are likely to express interest in STEM careers, STEM-focused dual-enrollment courses provide an important avenue to improving student mobility and meeting workforce demand.

Finally, COVID-19 requires research-practitioners to look at instructional models that work in virtual and remote settings as well. With the COVID-19 outbreak and ensuing uncertainty, student access and success in online learning platforms is now more important than ever. Like most states, Tennessee has issued (COVID-related) back-to-school guidance that points to a more flexible delivery system of learning opportunities and to the specific need for professional development. Most teachers can benefit from quality support in improving student

engagement, especially in times when remote- and blended-learning environments are “in the mix” with traditional classroom instruction.

STEM.LD integrates these evidence-based strategies (above) to better prepare students for STEM careers by providing robust professional development with curriculum supplements to middle & high high school teachers. In particular, the design offers opportunity to expand the evidence-based strategies to the extent to which educator professional development - coupled with high-quality curriculum supplements - can increase student achievement and academic engagement in preparation for STEM careers.

Additionally, the design will provide insight into what programmatic structures and existing relationships are critical to providing meaningful, OST opportunities for students that result in positive student outcomes. As the project unfolds, the design also makes room to explore research around how advanced course-taking in high school - dual enrollment courses in particular - can increase student access and success in STEM fields.

Project staff and partners will focus on expanding access to curriculum, quality instruction, and OST activities so rural students will have more opportunity in STEM fields. And as effects of COVID-19 persist in education in the months and years ahead, STEM.LD will use expert-recommended methods to expand access to learning opportunities for rural students and refine remote-learning strategies. These approaches will create a STEM-rich culture in rural Tennessee that will lead to more students participating in high quality STEM academics and opportunities which, in turn, will drive greater interest in pursuing STEM careers.

Section B: Quality of the Project Design

B1. Project goals, objectives and outcomes are clearly specified and measurable

NF proposes a project design to develop, pilot, implement, and evaluate a set of innovations to support rural Tennessee middle and high school students in STEM. NF presents goals, objectives, and specific outcomes that are rooted by a theory of change captured in the logic model in Appendix I.

STEM.LD aims to achieve the goals and objectives shown in Table 1 below.

Table 1: Rural Tennessee STEM.LD Goals and Objectives

Project Goals	Objectives
Goal 1: Build educator STEM knowledge, skill, and pedagogy by providing teacher **professional development** to effectively implement curriculum supplements.	*Objective 1.1:* Provide professional development to support effective teaching of new curriculum supplements and STEM. ● Create a work group to focus on teachers' implementation of curriculum supplements and messaging around participation in advanced STEM courses (see B3 and C2 below). ● Design, host, and adapt an annual summer institute for teachers in years 2, 3, and 4 of the project. Summer Institutes will address content, pedagogy and messaging around STEM, careers, use of new supplements, and advanced coursework. ● Support middle school educators in obtaining Tennessee's Algebra 1 Employability Standard, a key standard to teach Algebra 1; support additional innovative approaches to increase the employment of properly credentialed STEM educators.
Goal 2: Deepen exploration and enhance readiness for STEM coursework among rural middle/high school students through increased access to and awareness of high-quality **OST activities.**	*Objective 2.1:* Create and pilot 3-5 new, locally delivered **in-person**, OST experiences for middle and high school students. These include code camps, robotics contests, architecture contests, synthetic biology contests, and cybersecurity experiences. *Objective 2.2:* Create, pilot and curate 3-5 new real-time **virtual, and asynchronous** web-delivered OST experiences for middle and high school students, drawing on existing online offerings. *Objective 2.3:* Recruit 40 "local champions" from an estimated 40 rural communities. Champions will supervise and provide informal mentoring to rural students participating in OST STEM activities. Champions will be recruited from STEM career fields to the degree possible. *Objective 2.4:* Provide virtual coaching for the network of "local champions" to support them in providing out-of-school STEM learning

	opportunities for students and ensuring at least 4 contact hours per month between champions and students. *Objective 2.5:* Develop online platform to provide students and champions with direct access to 3 kinds of OST STEM activities a) new individual learning activities, b) courses and group activities; c) information about location-based activities. *Objective 2.6:* Develop, pilot, and implement strategies for informing parents, teachers and students of available OST activities, to increase participation of new students in new and existing activities (see Section C2 for details).
Goal 3: Provide more challenging **opportunities** for students **and** increase student academic **readiness** to meet these opportunities.	*Objective 3.1:*, Develop, pilot, adapt and widely implement strategies to drive higher participation in advanced courses. Strategies will be piloted and adapted in years 1 & 2 and then rolled out to all participants starting in year 3. *Objective 3.2:* Expand number of treatment schools providing access for MS students to Algebra 1 courses via online and in-person delivery. *Objective 3.3:* Develop/select, pilot, adapt and implement 10 new online STEM dual-enrollment and/or industry-certification opportunities for HS students using NF's existing online coursework platform.
Goal 4: Conduct **formative and summative evaluations** of the project in order to continuously improve over the grant period and add to the STEM evidence base.	*Objective 4.1:* Evaluate/track participation of teachers in PD forums (i.e., summer institutes, other). *Objective 4.2:* Evaluate the effects of offering teachers the employability standard on the number of Algebra 1 courses taught at the middle-school level. *Objective 4.3:* Provide RCT impact analysis of 8th grade mathematics achievement and school climate. *Objective 4.4:* Provide QED impact analysis of 10th grade student mathematics achievement and school climate. *Objective 4.5*: Produce conference presentations after the first 2 years of implementation that provide summative findings. *Objective 4.6:* Produce annual formative reports for public dissemination.

By pursuing the goals and objectives in Table 1, STEM.LD aims to achieve these measurable **outcomes in year five** for rural East Tennessee students who participate in the treatment, relative to comparison schools and students.

1. The climate in treatment schools will be more supportive of students and more engaging for students (as measured by the Tennessee School Climate Survey).
2. Pass rates for the EOC test in Algebra 1 will increase by 20 % (in grades 8/9) in treatment schools; the percentage of 8th grade students completing Algebra 1 will double.
3. Overall math and science achievement of students in treatment schools will improve compared to the students at control schools.

B2. The project will address the needs of the target population

STEM.LD's multiple interventions are specifically designed to address the needs of the low-income rural students. The primary intervention, enhanced PD for STEM teachers, will bring high-quality STEM instruction, using high-quality instructional materials, into the classroom; these changes will improve access to STEM content for every student in the treatment schools.

Specifically, STEM.LD will offer and evaluate the efficacy of two stages of professional development offered to educators at treatment schools. All educators in these schools will receive a base level of PD in STEM fields and will also have the opportunity to select advanced PD opportunities offered by the various STEM.LD partners. These advanced PD opportunities will include a broad variety of STEM fields which are discussed in further detail in section D.

NF plans to contract with TNTP, a national nonprofit that works to end the injustice of educational inequality by providing excellent teachers to the students who need them most and by advancing policies and practices that ensure effective teaching in every classroom. Before stakeholders in the STEM.LD initiative begin developing curricular supplements and professional development, TNTP will conduct a diagnostic in the spring of 2021 in order to develop a clear picture of the current state of student engagement and STEM instructional

practices. Based on this diagnostic and their previous study, *The Opportunity Myth* (2018),[14] TNTP will design and implement Phase 1 of the PD for treatment schools. *The Opportunity Myth* describes the four key resources at the heart of high-quality academic experiences for students as:

- Consistent opportunities to work on grade-appropriate assignments;
- Strong instruction that lets students do most of the thinking in the lesson;
- A sense of deep engagement in what they're learning;
- Teachers who hold high expectations for students and truly believe they can meet grade-level standards.

Using the context of *current* STEM curriculum standards and *current* instructional materials & practices as a base, TNTP, through Phase 1 PD, will support teachers' (and school leaders') development of new materials and practices.

The base level (or Phase 1) of learning will provide a framework and a common language to move to support later project activities. Following the introductory activities, schools and students will self-select additional activities. TNTP will offer a follow-up option for schools, opt-in support for middle schools to improve the instructional practices in mathematics classrooms. Other partners (described in Section D1) will also provide PD options in Phase 2. Any teacher in a STEM-related subject (science, engineering, CS, mathematics) can find a relevant Phase 2 PD activity and support for their development of engaging instructional activities.

The primary intervention (PD) is designed to benefit *all* students, especially those who have been lower-performing. The project's second component (OST activities) will provide enrichment activities for students with interest in STEM activities... quite likely a newly discovered interest, based on their classroom experiences. Other partners (Section D1) will be

contributors in the OST activities; in addition to working with teachers (Phase 2 PD) many will be instrumental in after-school clubs, summer (or weekend) camps, etc.

The first two project components will serve to help students become more academically prepared, more engaged, and to grasp how their learning is relevant to their place in the world. The third component, expanding participation in existing (and to-be-developed) rigorous STEM courses, follows logically. If students are prepared and invested in their own learning, many will self-select into rigorous STEM dual-enrollment classes in grades 11-12. Encouraging a high-quality Algebra 1 course as an option in middle school is specifically addressed in the project, as it is key to opening up rigorous course options in high school. Research shows that students who complete a mathematics course beyond the level of Algebra 2 are more than twice as likely to pursue and complete a postsecondary degree. Students who don't do well in algebra compromise their career options, especially in STEM fields.

B3. The project constitutes a coherent, sustained program of research and development.

Appendix I shows a logic model for the project, which includes the resources, activities, outputs, outcomes. The logic model demonstrates how each component of the program supports the larger goals and targeted outcomes. Section E describes the formative and summative evaluations in the independent evaluation research design.

In addition to the independent evaluation, NF will design an *improvement community* (IC) to facilitate continuous learning and improvement over the course of the project. ICs can be defined as "networks of practitioners and researchers that work together to solve a common problem and use methods of improvement science to get better at how they go about solving pressing problems" [15]. Well-structured ICs focused on specific goals can help organizations learn

quickly and allow practitioners to generate grassroots solutions to problems.

We anticipate establishing the following work groups within the IC, which will be facilitated by NF project team staff:

- **Educators work group**: The Educators work group will be composed of district staff and educators recruited from the 21 school districts partnering with NF on the project. The work group will: co-develop (along with the STEM Community Partners and Operating Partners work groups described below) curriculum supplements that emphasize student engagement via real-world applications of STEM content, problem-solving skills, and STEM career awareness; disseminate curriculum supplements to educators in their schools and communities; and plan and deliver professional development (see Table 1, Objective 1.1).
- **Operating Partners work group**: This work group will be composed of representatives of the seven operating partners that are providing PD and OST opportunities as well as Walters State and Northeast State Community Colleges. This work group will also review and share feedback on curriculum supplements developed by the Educators work group. Additionally, they will provide students with access to advanced, online and in-classroom coursework in STEM through OST activities, dual-enrollment opportunities, and industry certifications.
- **STEM Community Partners work group**: This work group will be composed of local practitioners currently working in STEM careers and a subset of individuals serving as STEM "champions" (see Table 1, Objectives 2.4 and 2.5). This work group will co-develop (along with the work groups described above) curriculum supplements and advise "champions" who are supervising students

participating in the project's OST activities.

The IC model is a good fit for this project design for the following reasons. First, an IC model allows practitioners to propose and test solutions in a timely fashion. The teachers, district staff, higher education institutions and STEM workforce partners in northeast Tennessee understand deeply the challenges that limit access to STEM opportunities in the region. The IC model allows local practitioners to generate and test solutions that will work in their communities. Second, an IC allows organizations to learn quickly. ICs are based on improvement science, and employ a Plan-Do-Study-Act methodology and rapid learning cycles that allow organizations to design and implement solutions to different challenges.[17] TNTP will facilitate NF project team staff and the Steering Committee through this approach to refine project components throughout the project, especially during the pilot phase.

B4. The project will increase efficiency, improve results, and increase productivity.

The nature of the project as a "shared-service" network increases the efficiency and productivity of the LEAs and schools. First. the work of the work groups of the IC will likely be of higher quality than comparable efforts by any of the LEAs or schools working independently. Additionally, the IC's sharing of the work, quickly and efficiently, to the schools (1) scales the work quickly and (2) allows for a more thorough refinement, based on implementation in more and varied settings.

Productivity is increased by the improved academic performance of students. A qualified student who takes Algebra 1 in the 8th grade in an online course saves in personnel costs, as one specific example. A larger financial factor is that the failure rates should be lowered; offering "repeat courses" or remedial classes in high school is expensive and wasteful.

In "human terms", however, an even more significant improvement is possible. Imagine a

capable, intelligent student in two different scenarios. One is "business as usual" in an under-resourced and uninspiring school environment. Compare that to the same student in a rich environment, with good instruction in school, the ability to explore a range of OST STEM activities and a "jump start' on a good career (with dual enrollment opportunities). Society benefits from informed citizens and a productive workforce.

The Steering Team of the IC will play a vital role in monitoring the efficient use of the project resources (time and money). They will collect and analyze data collected specifically to study cost-effectiveness; each event will provide attendance information, costs, perception feedback, and results... through the database described in D1. AnLar will work with them to process and interpret the data. Additionally, the Steering Team will be charged with building structures and culture that will be effective and productive beyond the grant period.

Section C: Strategy to Scale

C1. Identification of strategies to address barriers and reach scale

Academic under-preparation for STEM courses and careers is especially acute in rural Tennessee. **Instructor capacity** and **funding** present two key barriers to STEM course access for rural students. Without trained instructors and adequate resources, rural schools face difficulty in providing rigorous coursework and career experiences.[16] Additionally, rural schools have differential access to Advanced Placement (AP) and Dual Enrollment courses. In Tennessee, the median number of AP courses offered in rural high schools is significantly lower than city high schools. For instance, schools located in a locale designated as "City:Midsize" or "City:Small" offer a median number of eight courses. For rural schools in these designations, one AP course is offered. Conversely, rural schools have a higher median number of dual enrollment courses although many still lag behind urban and suburban schools.[18]

Youth **access** to enrichment activities is highly dependent on family income. The highest-income families spend almost seven times more on enrichment activities for their children, and this spending gap creates an opportunity gap.[19] While this gap exists somewhat in sports, it is significantly more pronounced for STEM OST activities. In rural areas, the gap is magnified by the remoteness; OST programs rarely exist in rural areas.

The Opportunity Myth reports another (more subtle) barrier. Their fourth key resource — teacher **expectations** for students' success against grade-level standards — demonstrated the strongest relationship to student growth in their study.

STEM.LD's evolving "learning design" addresses each of these barriers. Our PD will explicitly address how high expectations, with appropriate instructional activities, will help students grow academically and developmentally. The shared-network structures will provide a more robust academic program for the schools/LEAs, with improved cost-effectiveness. The project will deliver quality OST activities to students and families and support schools as they implement and incorporate new challenging offerings for their students.

C2. Information dissemination mechanisms

NF will use a variety of communications strategies to ensure information is widely shared. As part of STEM.LD's design, a series of work groups involving broad stakeholders (described in section C3) will be responsible for maintaining communication with participating schools. These work groups will regularly evaluate program activities and seek out best practices for dissemination across the region. The outreach and engagement plan will incorporate strategies that have been shown to positively impact student outcomes, including engaging parents in their children's learning through social networks, empowering parents with leadership roles in the school environment, providing parents with classes to help with their own education

or their child's education, and providing families with opportunities to engage with their children's education at home and at school.[20]

The WE Track database will serve as a vehicle for two-way communication and dissemination (see Section C1). Local champions will also help make sure STEM.LD opportunities are well communicated in the communities they serve.

For more broad dissemination of information, NF will publish annual public reports, with special reports on key findings to be crafted more regularly. Along with publishing these online, NF will actively seek out in-person and online opportunities - including conferences and webinars - where information can be shared with interested parties. NF will actively share out STEM.LD findings and strategies so that further development and replication of success can take place. Replication of these "rural" solutions could easily transfer to any non-rural setting.

Section D: Adequacy of the Resources and Quality of the Management Plan

D1. Capacity to bring project to scale

NF brings significant experience in scaling and managing large, federal grant projects including a 2010 i3 grant and a current EIR grant. Dr. Nancy Dishner, President and CEO of NF, will have ultimate responsibility and oversight of the project. She will be involved in high-level decision making and setting the strategic vision for the project. Dr. Dishner will be supported by Dr. Richard Kitzmiller, Vice-President of NF, who will serve as Program Director for the project. In this role, he will supervise project staff and track the completion of project milestones. Dr. Kitzmiller has over 40 year of education experience, including a decade as a district superintendent, and in roles managing complex organizations. Dr. Kitzmiller is currently responsible for overseeing NF's 2017 EIR grant. Mr. Law Loving, Director of Career and Workforce Readiness, will also support the STEM.LD project. Mr. Loving will launch the three

work groups listed in section B3 and facilitate the ongoing work of two (Operating Partners and Community Partners). From his work on the NF CareerConnect program, he has first-hand experience in working in each of these arenas and understands how to represent the student perspectives to the IC. Resumes for Dr. Dishner, Dr. Kitzmiller and Mr. Loving can be found in Appendix B.

NF plans to employ two additional experienced staff members, an Implementation Coordinator and a Curriculum Specialist; these may be new hires or transfers within NF. The Implementation Coordinator will have at least five years of experience in project management or implementing large-scale initiatives in school districts. The Coordinator will serve as the day-to-day contact for the project, develop and update project work plans, assist with scheduling, coordinate and plan IC events and other assigned tasks. The Curriculum Specialist will have at least seven years experience in teaching STEM subjects and curriculum development at the district level. This position will facilitate the Educators work group, help co-develop curriculum supplements, plan professional development for classroom teachers, and provide coaching to teachers.

NF maintains long-standing relationships with local LEAs through its Niswonger Consortium of school systems which now includes 29 LEAs across the state of Tennessee. This consortium was formed as part of an i3 grant in 2010 and has allowed for seamless cooperation between the Foundation and schools on a wide variety of projects and grants. NF will plan to use the existing partnerships within the consortium to scale the project quickly.

Established partnerships will further support the grant's scalability. NF has written commitments from seven key partners (see Appendix C) to support the implementation of this project; others may be added, as appropriate. In addition to the roles described earlier, TNTP will

lead in coordinating the Educators work group as part of STEM.LD's improvement community (IC). This IC and TNTP's role in the work group is discussed further in B3.

NF will contract with University of Alabama in Huntsville's (UAH) Center for Cybersecurity Research and Education (CCRE) to deliver several program initiatives. Since 2015, UAH has worked closely with elementary and secondary teachers in integrating cybersecurity into their curriculum, partnering with the NSA/NSF to provide these teachers with cybersecurity camps through the GenCyber program.

Another STEM.LD partner will be the BioBuilder Educational Foundation, which offers a comprehensive curriculum in the emerging field of synthetic biology, providing teacher professional development, in-class curriculum offerings and out-of-school time programs for advanced life science, DNA programming, and bioengineering. The BioBuilder strategy leverages teacher engagement and the excitement of problem-based learning to spark interest in students. Established as a nonprofit organization in 2011, BioBuilder co-develops its curriculum with secondary school teachers, drawing on cutting-edge science from MIT's Department of Biological Engineering.

If I Had a Hammer, LLC (Hammer) is another partner in STEM.LD. Founded in 1987, Hammer creates breakthrough learning experiences for any child, youth, or adult learner who needs to understand and retain foundational math so that they can then grasp higher level mathematics. The Hammer pedagogy includes effective hands-on learning through a Hammer House Build, classroom, an on-line curriculum, as well as specialized classroom materials.

Locally, the Niswonger Foundation has engaged with STREAMWORKS to provide additional STEM.LD programs. STREAMWORKS is an educational nonprofit organization that delivers enhanced opportunities for students (grades K-12) to participate in exciting mentor and

project-based programs that focus on science, technology, engineering, and math (STEM) skills; inspire innovation; and foster well-rounded life capabilities.

NF has also engaged East Tennessee State University's (ETSU) Center of Excellence in Mathematics and Science Education (CEMSE) to provide PD in several key STEM areas including, but not limited to: elementary data analysis using the open-source language R, epidemiology and public health, and global information systems. CEMSE will create customized sessions on these subjects by creating teams of content experts and pedagogy experts to create useful PD materials that are aligned with state educational standards.

Purdue's Department of Technology Leadership Innovation (DTLI) will provide key technical assistance (particularly for the field of engineering). At Purdue, the department prepares students to lead the development and successful introduction of high-tech solutions in business, industry, and the classroom. Dr. Greg J. Strimel, Assistant Professor in the department, will coordinate the department's contributions to STEM.LD, primarily in PD for teachers and support for curriculum development.

Table 2: STEM.LD Partner Involvement

Partner	Professional Development	Curriculum Development	Improvement Community	OST Activities	Delivery of for-credit Instruction
TNTP	▲	△	▲		
UAH	▲	▲	△	▲	△
BioBuilder	▲	△	△	▲	
If I Had a Hammer	△	△	△	▲	△
ETSU CEMSE	▲	▲	△		
STREAMWORKS	△		△	▲	
Purdue DTLI		▲	▲	△	

▲ – Heavy involvement in this task △ – Light involvement in this task

Partners' roles within STEM.LD are summarized in Table 2. Additional information on specific partners may be found in the Letters of Partnership (Appendix C).

Existing NF programs will be assets to the initial scaling of the project and the future scaling beyond the original project schools. Niswonger Online, with over ten years of successful operation, will serve as the online delivery of most (if not all) of the rigorous STEM courses, combining existing courses like several AP and dual-enrollment offerings and any new courses developed. NF's Comprehensive Educational Resources (CER) will serve to curate and distribute newly designed curriculum supplements and instructional activities.

The existing NF program that will be leveraged most significantly is the online database and tracking system, currently named WE Track, which has been used for 3 years to help schools and students keep "track" of 12th-grade students' progress toward a credential known as the Work Ethic Diploma. This database currently has nearly 7,000 student users and 352 adults have accounts for data entry and verification. It is our plan to build on this database, expand it to lower grades, and add functionalities that will be critical to the operational and data-collecting activities of the project. It will also serve as a repository for asynchronous learning activities (for students and staff) and as a vehicle for communication. The additions to the database functionality could be "rebranded" as a STEM.LD platform.

D2. Project costs are reasonable in relation to the objectives, design, and significance

In addition to the efficiencies described earlier, several unique features serve to reduce expenses. Providing OST activities to small groups in remote locations is inherently cost-inefficient. STEM.LD reduces costs with three features; we have designed the use of (contracted) local "champions" to organize and motivate students. We will supply OST "kits", specifically designed to be rotated among several locations. If the local "champion" is capable of supervising

the activity, there will be appropriate directions and guides; if not, videoconferencing will guide the activities “virtually”, with a team of adult mentors.

Project costs will be minimized also with much of the professional learning (including support of the local “champions”) delivered online; synchronous and asynchronous learning activities will be supported. By the later stages of the project, costs will average ~$26/student. This relatively modest spending will have positive impact on many of the 57,000 students and the “lessons learned” and the models built can be sustained or duplicated at an even lower cost.

D3. Potential for continued support of the project after the grant ends

STEM.LD has the potential for continued support after the grant ends. First, NF designed this project with long term sustainability in mind. NF is building online infrastructure that will continue beyond the grant period, similar to the online platform it created for its 2010 i3 grant, which is still in use today. In addition to online infrastructure, close partnerships with the region’s school systems have ensured the ongoing success of i3 legacy programs. These same partnerships will be leveraged to provide continuous school level support for STEM.LD programs beyond the grant’s life.

Additionally, this proposal aligns with long-standing education priorities in Tennessee. Governor Bill Lee, Tennessee’s 50th governor, has made STEM-focused career awareness a central theme in his education platform, noting the opportunity for this proposal’s ongoing support from the state level. Many have suggested that proven success will drive support, not only from governments, but other groups, as well. OST activities that demonstrate strong success can often receive support from philanthropic or workforce-development groups.

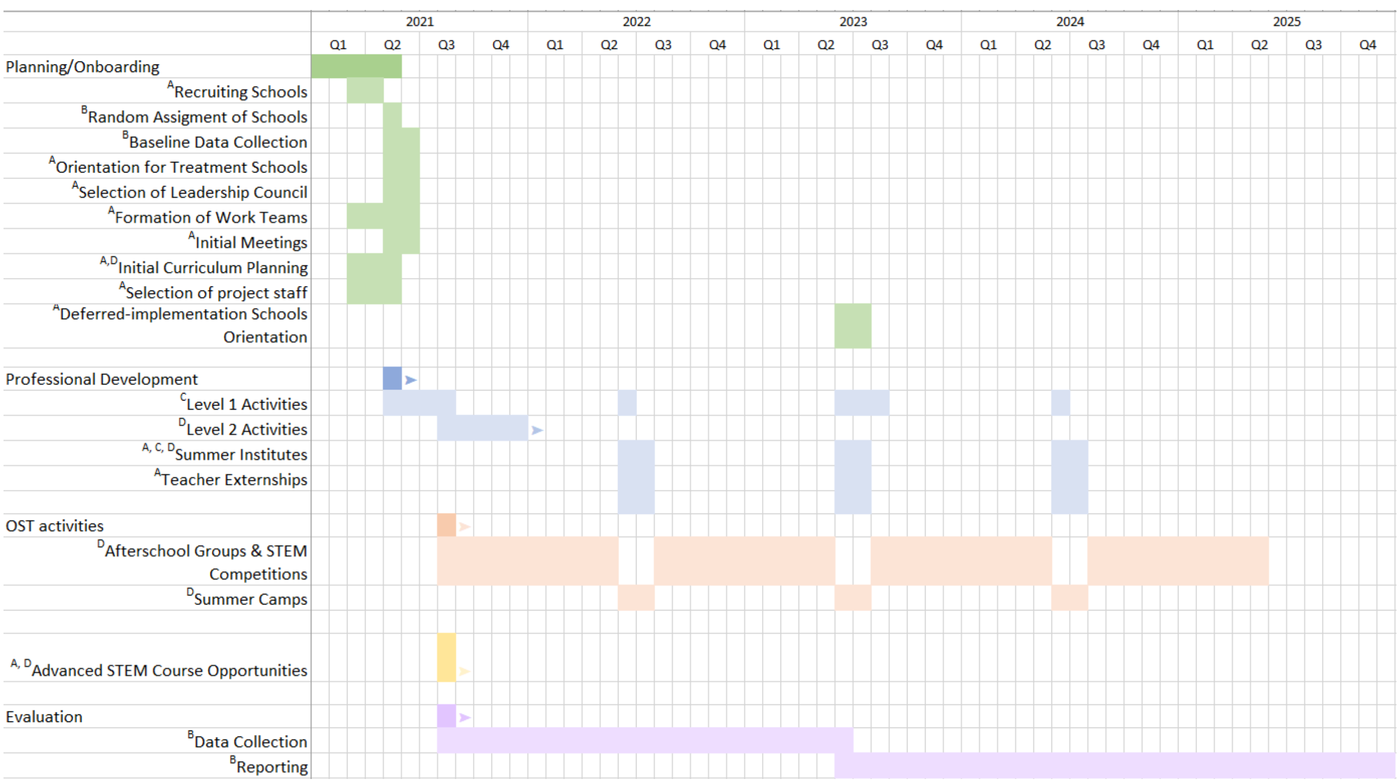
Project partners will be able to continue their work at the national level, armed with a refined set of offerings to benefit more students nationwide.

D4. Adequacy of the management plan to achieve the objectives on time and within budget

NF has extensive experience planning for and managing large federal grants and will bring that experience to the project management plan.

NF staff will establish a Steering Committee--comprised of NF staff, representatives from the work groups described in Section B3 and other key stakeholders in the project--to serve as a "hub" for the IC, making sure the project stays on budget, coordinating efforts across the network, facilitating work groups and knowledge sharing, conducting root cause analyses, proposing and implementing project improvements, documenting and sharing key learnings from the project, and coaching educators to improve specific practices. NF, with help from TNTP and other partners will facilitate quarterly meetings of the Committee.

Figure 2. - STEM.LD Project Management Timeline & Responsibilities



Arrows indicate continuous work on this activity through Year 5.

A - Responsibility of NF B - Resp. of AnLar C - Resp. of TNTP D - Resp. of Other Partner Organizations

Section E: Quality of the Project Evaluation

AnLar, LLC, will conduct the external evaluation of the STEM.LD program. AnLar currently serves as the external evaluator for the Niswonger Foundation's mid-phase EIR grant focused on using personalized learning to improve literacy in the middle grade and Knox County Schools' early-phase EIR grant that developed a 3-week STEM camp for elementary school students to improve their STEM knowledge and engagement. AnLar's research director, Dr. Laura Holian, also designed the summative and formative evaluations for the Niswonger Foundation's 2010 i3 grant. In addition to EIR and i3 evaluation experience, 20 percent of AnLar staff are WWC certified reviewers and understand tradeoffs of various research designs on the knowledge that can be produced. AnLar's experience working in Tennessee, with the Tennessee Department of Education, the Tennessee Education Research Alliance, the Niswonger Foundation, and the schools and districts in northeast Tennessee will provide a rigorous and high-quality evaluation, with low cost.

The design will examine the effects of the program on student scores on TNReady mathematics assessments, student attendance rates, student completion of Algebra 1 by the end of 8th grade (middle school study only), and school-wide measures of climate (Tennessee School Climate Survey). Positive school climates exist where adults 1) notice when students are having trouble learning; 2) try new strategies to strengthen learning; 3) connect what students are learning to life outside the classroom; 4) allow students to revise their work to learn from their mistakes; 5) assign work that encourages creativity and critical thinking; 6) adjust instruction to different needs and abilities of students; and 7) challenge all students to do their personal best, and praise students for their accomplishments.

The study will take place across 21 school districts in a rural region of northeast

Tennessee. All middle schools and high schools across the districts will both be recruited to participate. The middle schools will be randomly assigned to the STEM.LD or business as usual status. After the middle schools are randomly assigned, the high schools will be assigned to treatment or control based on the assignment of the middle schools in the district (if all of the middle schools are assigned to the STEM.LD status, the high schools will be assigned to business as usual). The high school study will utilize a quasi-experimental design, and will establish baseline equivalence of students and schools using prior achievement data. The research questions are in Table 3. After the first two years of implementation, the evaluation will follow students for two additional years to examine longer term outcomes.

Table 3. Research Questions for the Evaluation of STEM.LD

Impacts on Middle School Student Outcomes	
Q1	What is the effect of two years of attending a middle school supported by the STEM.LD program on 8th grade students' mathematics achievement?
Q2	What is the effect of two years of attending a middle school supported by the STEM.LD program on 8th grade students' attendance rates?
Q3	What is the effect of two years of attending a middle school supported by the STEM.LD program on passing Algebra 1 by the end of 8th grade?
Q4	Do student academic outcomes vary by student socioeconomic status or race?
Impacts on High School Student Outcomes	
Q5	What is the effect of two years of attending a high school supported by the STEM.LD program on 10th grade students' mathematics achievement?
Q6	What is the effect of two years of attending a high school supported by the STEM.LD program on 10th grade students' attendance rates?
Q7	What is the effect of two years of attending a high school supported by the STEM.LD program on highest level of mathematics completed by end of 10th grade?
Q8	What is the effect of attending a high school supported by the STEM.LD program on taking AP or dual enrollment courses in 11th/12th grade?

Impacts on School Outcomes	
Q9	What is the effect of receiving STEM.LD supports for two years on schools' ratings on supportive climate?
Fidelity of Implementation	
Q10	To what extent do teachers participate in the professional development training as designed? To what extent do teachers attempt certification to teach higher level mathematics courses?
Q11	What was the amount of variation in implementation fidelity across schools? Were any school characteristics associated with level of fidelity of implementation?
Fidelity and Student Outcomes	
Q12	Do student academic outcomes vary by student participation in afterschool or out-of-school time activities with a STEM focus?
Cost effectiveness	
Q13	What is the cost effectiveness of STEM.LD in rural communities?

E1. Ability to produce evidence about STEM.LD's effectiveness

The proposed evaluation design has the potential to produce strong evidence of the effectiveness of STEM.LD. The cluster RCT, if well-implemented, has the potential to meet WWC standards without reservations. Random assignment will occur at the school level, and student and school data will be obtained from the Tennessee Department of Education. In the 2021-22 school year, 86 middle schools with approximately 500 teachers and 8,000 students in grade 6 will participate in the STEM.LD project, with half assigned to the treatment group and half to the control group. The schools will participate in the intervention for the next two years, and outcomes will be measured when students are in 8th grade. This sample will satisfy the requirements for a large (includes more than 350 students) and multi-site (multiple districts, with multiple schools and teachers in each district) sample, as laid out in the expectations for EIR

mid-phase evaluations.

Power analysis. Power was calculated for the comparisons of students in STEM.LD middle schools and those in control schools using power equations for a cluster randomized design. With 86 middle schools and an average of 100 students per grade level per school, an assumed between-school variance of .20, power of .80, alpha level of .05, and a two-tailed test, we estimate the study has power to detect a minimum effect of .216 as statistically significant.

E2. Key project components, mediators, outcomes & threshold for acceptable implementation

The logic model (Appendix G) outlines the key project components, mediators, and outcomes.

The evaluation will assess the fidelity of STEM.LD implementation using a fidelity measure focused on the two key components in the STEM.LD logic model: (1) professional development and (2) out-of-school time activities. This fidelity measure includes quantifiable indicators for each of the key components and establishes thresholds for the levels of implementation of these indicators that represent fidelity to the model. Fidelity of implementation will be measured for all treatment schools.

Table 4: Key Components and Thresholds for Acceptable Implementation

Components and Indicators	**Threshold**	**Data Source**
Component 1: Professional Development		
Indicator 1.1. Teachers participate in summer institute to learn about new	90% of schools have at least 5 teachers/administrators attend summer institute trainings	Attendance trackers for registering and attending training

curriculum supplements		
Indicator 1.2. Teachers participate in supplemental PD opportunities focused on either climate issues or content	80% of schools send teachers to supplemental PD training sessions depending on school needs	Attendance trackers for registering and attending training
Indicator 1.3. Teachers are offered externship opportunities	25% of schools have at least 1 teacher participate in an externship	Log of opportunities and who has participated
Component 2: Out-of-school time activities		
Indicator 2.1. Teachers and community members are trained to offer OST activities	90% of schools have at least 1 teacher or community member participate in training	Training attendance log
Indicator 2.2. Schools communicate with students about opportunities for STEM OST activities	90% of schools disseminate information about opportunities through posters, social media, etc.	Administrator survey; artifacts
Indicator 2.3. Schools offer STEM OST activities	70% of school host an OST activity by end of 2nd year of implementation	Administrator survey; artifacts

E3. Valid and reliable performance data on relevant outcomes

The key student outcomes are mathematics performance and engagement. Student and school level data will be collected from both treatment and control schools. Mathematics performance at the end of the intervention will be assessed with a standardized measure and successful completion of mathematics course (grade 8 mathematics, Algebra 1 EOC test) (Table 5). These measures meet WWC outcome standards for reliability and validity. The mathematics tests will be individually administered to students at baseline (spring 2021), before students receive STEM.LD or business as usual, and again at the end of each school year (spring 2022

and 2023). The mathematics baseline measure will improve the precision of the impact estimates, and for the RCT study will ensure if high attrition occurs, the study will have the potential to meet WWC standards with reservations. For the QED study, the baseline measure will allow the study potential to meet WWC standards with reservations. Per WWC standards, AnLar will establish baseline equivalence for all measures in the same domain, if one measure has a difference from .05 and .25, baseline covariates will be included in analyses of all measures in that domain.

Table 5: STEM.LD Outcome Measures

Domain	**Measure**	**Reliability**	**Timing of Outcome Data**	**Baseline Measure**
Student outcome: General academic achievement	TN Ready Mathematics Grade 8 EOC tests in Algebra 1, Algebra 2, Geometry	In WWC, state administered standardized tests are assumed to meet reliability and validity standards.	Spring 2023	TN Ready Mathematics Grade 6 Spring 2021 TN Ready Mathematics Grade 8 Spring 2021
Student outcome: Student engagement in school*	Attendance rates	Attendance rate as measured by each school and reported to the state is assumed to be reliable.	Spring 2023	Spring 2021 (from 2020-21 school year)
Environmental Outcomes: School climate	TN School Climate Survey	Cronbach's alpha for scales range from .73 to .84	Spring 2023	Spring 2021

*Tennessee is working on creating a new measure of student engagement, particularly in the age of Covid-19 and increased use of distance learning. We may use an alternative measure of student engagement. The new measure will be a standard measure captured in all schools.

Summary

In closing, we submit (a) that STEM.LD is worthy of strong consideration for funding... as a *stand-alone* proposal. Consideration should also be given to (b) the fact that it builds on the success of other NF grants. STEM.LD would scale up and complement the work of the NF 2010-2015 i3 scale-up grant (HS college- and career-ready) and the ongoing Rural LIFE project. In 2017, NF received a mid-phase EIR grant to validate the use of personalized learning strategies to improve literacy outcomes for students in grades 6-8.

Because this network of LEAs is already in place, large scale studies/projects are more readily rolled out to schools. Rather than having to spend large amounts of time recruiting participant schools, NF already has a network of existing partners eager to collaborate on STEM.LD. Our current consortium is growing (in size and scope) and is larger than during either of the previous studies.

For **References** see Appendix Ic.