Computer Science Opportunities, Development, and Education in Rural Schools (CODERS): Developing an Early Phase Project for Rural Students and Teachers

A. Quality of the Project Design

A.1 Goals, Objectives, and Outcomes

Missouri State University proposes a collaboration of Computer Science (CS), Science, Technology, Engineering, and Mathematics (STEM), English, Education faculty and high-needs rural school districts in Missouri to address the EIR Early-Phase program focusing on **Absolute Priorities 1 and 2** and **Competitive Preference Priority 1** designed to expand opportunities in Computer Science for underserved populations. In this proposal, the underserved populations consist of some of the most rural and impoverished school districts in the nation.

Missouri State University proposes The CODERS Project that involves 150 teachers (30 per year) and 13,500 students in grades 3-8. The CODERS Project includes a three-year field trial and impact study of teacher and student programming in CS. Year 1 of the grant includes developing course modules, needs assessments with teacher participants and schools, and planning for the Summer Teacher Launch in Summer 2021. Modules will be developed to use in teacher professional development (summer and academic year with teacher stipends provided and optional graduate credit) then in direct classroom instruction with students supported by The CODERS Council, the leadership team of the grant. The CODERS modules, described in detail later, center on high-quality interdisciplinary curriculum (computer science and physical science content supported with evidence-based writing instruction). The grant provides CODERS kits consisting of CanaKit Raspberry Pi 4 starter kits, keyboards and mice, SunFounder Raspberry Pi Smart Video Robot Car, teacher professional development in the summer and academic year, stipends for participation, academic year integration, instructional design support, and co-teaching to effectively incorporate CS, STEM, and writing as a mode of critical thinking into standards-based lesson and unit plans.

The CODERS project will improve computer science learning in high need rural areas in grades 3-8 using a four-part rationale: 1) Develop interdisciplinary modules aligned with Missouri standards in CS, math, science, and ELA; 2) Develop teachers' knowledge and efficacy to implement computer science modules that incorporate writing, math, and science to increase students' computational thinking; 3) Reinforce students' computational thinking and reflection skills through student-created instructional videos; 4) sustain and disseminate modules developed during the grant through an instructional video library hosted by Missouri State University.

The QED study design includes measures that probe Computer Science/STEM perceptions and attitudes, confidence, content knowledge, interest, and efficacy for students and teachers. The impact and effectiveness of this proposed project will be understood through three measurable goals (Table 1), each with listed objectives, creating a framework for the purpose of evaluation. Our goal is to develop this framework to improve interdisciplinary learning for grades 3-8.

Table 1. *CODERS* Goals, Objectives, and Outcomes
Goal 1: Engage high need rural grades 3-8 students in school-based Computer Science (CS) and STEM experiences.
• **Objective 1**. In Years 2-5, at least 85% of CODERS students will report an increase in computing confidence, interest, and utility. **Measure:** *Elementary Student Coding Attitudes Survey (ESCAS)* (Mason & Rich, 2020), *Reliability*: Cronbach's α = 0.81-.93; *Validity* established with Confirmatory factor analysis (CFA) **Timeline:** Biannually. • **Objective 2**. In Years 2-5, at least 70% of CODERS students will report an increase in computational thinking. **Measure:** *Programming and computing efficacy* (Kong, Chiu, & Lai,

2018) (grades 3-5), *Reliability:* Cronbach's α = 0.82-0.92 on four scales, *Validity:* established with CFA; and *Computational Thinking survey* (Weese & Feldhausen, 2018) (grades 6-8). *Reliability:* Cronbach's α = 0.87. **Timeline:** Biannually.

- **Objective 3**. In Years 2-5, CODERS students will report at least a 50% increase in mean scores for STEM attitudes. **Measure:** *S-STEM upper elementary and secondary* (Friday Institute, 2012a & 2012b); *Reliability:* Cronbach's α = 0.84-0.91 on four scales, *Validity:* CFA; **Timeline:** Biannually.
- **Objective 4.** In Years 2-5, CODERS students will report at least a 60% increase in mean scores for STEM career interest. **Measure:** *S-STEM* (Friday Institute, 2012); **Timeline:** Biannually.

Goal 2: Develop teachers' content knowledge and efficacy for teaching CS and STEM interdisciplinary curriculum.

- **Objective 5**. Each year, at least 85% of teachers participate in at least 30 hours of CS and STEM professional development. **Measure:** PD attendance tool; **Timeline:** Annually.
- **Objective 6**. Each year, 85% of teachers report positive gains in their STEM attitudes and teaching efficacy. **Measure:** Teacher Survey that includes the *T-STEM* (Friday Institute, 2012c) *Reliability:* Cronbach's Alpha = 0.945, *Validity:* Confirmatory factor analysis validates presence of seven constructs; **Timeline:** Biannually.
- **Objective 7**. Each year, 85% of teachers report positive gains in their CS teaching efficacy. **Measure:** *Computer science pedagogical content knowledge* (Yadav & Berges, 2019) Item goodness of fit used Rasch; *Reliability*: TBD with our sample*;* **Timeline:** Biannually.

- **Objective 8**. Each year, at least 75% of pre-service teachers report positive gains in their science teaching efficacy. **Measure:** Technological Pedagogical Content Knowledge (TPACK) (Schmidt et al., 2009); *Reliability*: TBD with our sample*;* **Timeline:** Biannually.

Goal 3: Provide students with academic supports to foster success in school.

- **Objective 9**. In Years 2-5, at least 50% of students will score "on target" for STEM literacy by year end. **Measure:** MAP reading (3-8); **Timeline:** Beginning and year end.
- **Objective 10.** In Years 2-5, at least 50% of students will score "on target" for math by year end. **Measure:** MAP math (3-8); **Timeline:** Beginning and year end.
- **Objective 11.** In Years 2-5, increase by 8% the percentage of grade 3-8 students who demonstrate proficiency on the ELA EOG assessment over prior year baseline. **Measure:** MO EOG ELA; **Timeline:** Annually. **Baseline:** 47%.
- **Objective 12**. In Years 2-5, increase by 10% the percentage of grade 3-8 students who demonstrate proficiency on the math EOG assessment over prior year baseline. **Measure:** MO EOG math; **Timeline:** Annually. **Baseline:** 41%.
- **Objective 13**. In Years 2-5, increase by 20% the percentage of grade 5 & 8 students who demonstrate proficiency on the science EOG assessment over prior year baseline. **Measure:** MO EOG science; **Timeline:** Annually. **Baseline:** 43%.
- **Objective 14.** In Years 2-5, at least 60% of students in grades 3-8 will demonstrate an increase in functional writing as evidenced by beginning and ending module assignments. **Measure:** Teachers score written submission; **Timeline:** Biannually.

Fidelity Index: By the end of Year 2, *CODERS* program components will be implemented with 75% fidelity; 80% fidelity in Years 3-5.

A. 2 Appropriateness of the Design to Meet the Needs of the Target Population

CODERS focus on improving access to "new, high quality educational opportunities" for students and increasing the number of highly effective teachers by connecting non-fiction writing in STEM-based fields to rural teachers in STEM and ELA. The second principle is that interdisciplinary partnerships are vital for adults as well as students. Using geographic location and cultural context extends student learning and, in turn, is a platform for teaching essential cross-disciplinary skills: improving non-fiction writing, problem-solving, computational thinking, investigating, questioning, reading closely, interdisciplinary reading and writing, and thereby increasing students' achievement in all of these areas. The CODERS Teacher Launch five-day summer institute will develop teachers' understandings of inquiry-oriented experiments focused on coding, computation, robotics, and physical science in the real world. Participant teachers will experiment with CODERS kits, experience the integration of informational and interdisciplinary writing, and be provided with CODERS kits to use with students following the Summer Teacher Launch. A parallel strand of CODERS emphasizes the integration of reading and writing to equip students with literacies that are key to success in college, career, and community.

Table 2. *CODERS* Logic Model (Detailed Model in Appendix I)

Inputs	Core Strategies & Activities	Outputs	Intermediate Outcomes
CODERS Council CODERS Kits Modules Rural Teachers	Summer Teacher Launch Experiential learning with CODERS Kit	# Teachers trained PPD hours received Teacher Confidence in teaching CS	Increase Computer Science (CS) teacher and students' knowledge Increase teacher efficacy

Rural Students WWC Practice Guides	& Modules (teacher & student) Non-Fiction Writing Create publicly available instructional videos	# Students taught by teachers, by grade level and school	Sustain with instructional video library, PLC, and FB groups. Increase students' time spent on CS and NF writing Increase student attitudes and interest in CS

We define "rural" as school districts in southern Missouri that are designated Small Rural School Achievement (SRSA), Rural Low-Income Schools (RLIS), or both, or have a Title I designation, thus, have a significant portion of high-needs students. The target number of schools for this Early Phase proposal is 8-10 school districts with 30 teachers participating each year for a total of 150 teachers over the course of the grant. If over 30 teachers from the schools agree to participate, the project leaders will interview school district personnel to choose teachers and schools that have the best chance of participating in a 3-year impact QED. SRSA, RLIS, and Title I schools will have a priority placement (Letters of support for Cohort 1 can be found in Appendix C). The target number of 30 teachers between Grades 3-8 will come from a variety of disciplines. Each year would bring in a new cohort of rural teachers, conservatively (averaging 30 students per teacher), 13,500 students in the five-year project. The CODERS project recruitment goal will be to secure 5-8 teachers from a district to create a local professional learning community. A teacher could teach multiple subjects or grades (for example, 3-8). The recruitment plan attempts to offer the PD to an interdisciplinary group within a centralized rural location and virtually to increase numbers and to create professional learning communities that last beyond the scope of the grant. During the recruitment phase, the CODERS Council will work with school districts to pull together interdisciplinary groups of teachers (elementary, either at the same elementary or several elementary teachers from a grade level that teach math and/or science, middle school ELA, math, science, and business/computer teachers).

The schools are selected because of their urgent need for quality CS and STEM education and their inability to afford to augment any sort of STEM-based curriculum through available academic supports such as university-based STEM outreach (for computer science, physics, math, science, and STEM-based literacy). In southern Missouri, 236 rural schools within reach of the CODERS program have Title I status which shows the need and potential opportunities for generalizability, partnership, and continued evaluation of the impact of this work beyond the scope of this grant.

CODERS Summer Teacher Launch

The CODERS Teacher Launch will take place over five, 6-hour days in the summer and will focus on engaging teachers' interdisciplinary inquiry-oriented experiments focused on coding, computation, robotics, and physical science in the real world. Alongside CS and STEM content instruction, teachers will also receive professional development on using writing to scaffold the development, application, and mastery of computer science and STEM concepts with students. Participant teachers will be provided with “CODERS kits” to use with students during the academic year following the summer professional development.

The CODERS Summer Launch will enroll teachers from partner schools in staggered cohorts (see Table 3) and participants of early cohorts will work as co-trainers of later cohort participants. Additionally, virtual PLCs will be formed to build a space for continued inquiry and instructional support with rural teachers beyond this grant. This model is intended to decenter the university as the center of instructional expertise and build a network of instructional leaders throughout southwest Missouri.

Table 3: Module Development and Instruction					
Summer PD	Cohort 1	Cohort 2	Cohort 3	Cohort 4	Cohort 5
2021	Modules 1-5				
2022	Modules 6-10	Modules 1-5			
2023	Modules 11-15	Modules 6-10	Modules 1-5		
2024	Train Cohort 4	Modules 11-15	Modules 6-10	Modules 1-5	
2025	Train Cohort 4	Train Cohort 5	Modules 11-15	Modules 6-10	Modules 1-5

Shaded modules are led by Missouri State University faculty; unshaded modules are led by previously trained cohorts (cohort 1 will train cohort 4; cohort 2 will train cohort 5).

Modules 1-5 for Year 1 (1. Flexible problem solving through scientific writing; 2. Introduction to programming in Alice; 3. Introduction to programming in Scratch, Algorithmic and Computer logic concepts; 4. Simulation of electricity and magnetism in Scratch; 5. Workshopping and individualizing lessons and content for individual classrooms.)

Modules 6-10 for Year 2 (6. Descriptive and functional science writing; 7. Testing coding principles in physical world including force and motion; 8. Coding Robot-cars; 9. Workshopping and individualizing lessons and content for individual classrooms. 10. Extended challenges including goal-oriented coding competitions -- advanced Scratch programming.)

Modules 11-15 for Year 3 (11. Beyond block coding to code in Python by creating animations and games; 12. Developing software to solve STEM-related problems in Python (inquiry based); 13. Instructional writing for digital production -- planning for instructional video library; 14. Digital production for coding and STEM modules -- creation of instructional video library content; 15. Workshopping and individualizing lessons and content for individual classrooms.)

The CODERS project reflects state standards for teacher development (Learning Forward, 2017). According to Desimone (2009), 90 hours over 2 years qualifies as sufficient duration for significant impact on changes in practice. Nine studies found that teachers who averaged 49 hours of "substantial" professional development "boost their students' achievement by about 21 percentile points" (Yoon et al, 2007, p. 2). CODERS professional development will total 30 hours in each of Years 1, 2, and 3 for a total of 90 hours of professional development during the 3-year cycle for rural in-service and pre-service teachers.

School-Based Programming

The proposed project connects teacher professional development and school-based programming to support teachers as they implement their new learning. In September of Year 2, following their teachers' participation in the CODERS Summer Teacher Launch, students in grades 3-8 will participate in 5 CS/coding modules taught by their teacher. The CODERS Council will partner with teachers during module lessons to support teacher efficacy and to serve as content and instructional coaches during lesson implementation. The CODERS Council will support classroom instruction to provide additional point-of-need scaffolding for teachers as they implement CS/coding/STEM/ELA instruction in their own educational contexts for the first time. These modules can be supported virtually and in person, as required by individual districts' circumstances.

Each module will introduce a new computer science/coding/STEM/ELA topic; writing instruction and STEM activities will serve to enrich and support students' computer science and coding proficiency. For example, In Year-1/Module-2, will incorporate building animations of objects in the Alice 3D virtual world environment. Alice is a 3D virtual world programming environment that offers a drag-and-drop interface and a library of 3D objects. With Alice, one can easily create interactive stories or games in Raspberry Pi. Participants will learn how to position objects in a scene, manipulate the objects, control camera views, lighting, and sound. In Year-2/Module-8, the participants will learn block-based coding in Scratch to control a robot-car that uses Raspberry Pi as the primary processing and control system. In Scratch, the participants will connect visual blocks logically. In Year-3/Module-11, the participants will develop proficiency in text-based coding and apply algorithmic thinking for problem-solving. They will get familiar with the software design process, iterations, software testing, and improvements based on end-user and peer feedback. The STEM portion of the CODERS Kits will reinforce each of these steps by connecting them to physical results in a classroom setting. As an example, when related to robot-cars, students will use the physical measurements of speed, velocity, and distance to confirm the results of their prior modeling. Writing will be used to support student problem solving in both the coding and experimental phases of the module activities. Computer science concepts will be linked to the science applications. Before each visit (whether virtual or face to face), students will view a short video on the capabilities of the CODERS Kits, brainstorm ideas with a peer, and write a task list for a particular project using a graphic organizer. The task list and the associated writing will be used as a formative pre-assessment tool by the teacher and the CODERS team before arrival. Summative assessment including age appropriate student writing and short-form video preparation for the modules will be permanently stored and available to the teachers in an online instructional video library hosted by Missouri State University.

The CODERS project, by providing quality teacher training and school-based interdisciplinary Computer Science and STEM programming to elementary and middle school students, will create a pathway for students who choose to continue into STEM programs and career pathways in high school and beyond. The interdisciplinary and scaffolded nature of the CODERS project is its strength: engaging students in real world computer science, STEM, literacy activities and interdisciplinary inquiry projects presents CS and STEM concepts as useful tools in solving real world problems in their own communities (Fischer et al., 2014). Because the program focuses on supporting teachers in becoming local experts and instructional leaders, the impact of the project will be felt in the selected rural communities beyond the period of the grant.

A.3 Design Reflects Up-to-Date Knowledge from Research and Effective Practice

Using strategies with strong evidence of effectiveness is vital. The CODERS project utilized WWC practice guides to identify approaches with strong evidence in improving student achievement. The goals of CODERS are specifically outlined to address improvements in teaching, specifically in literacies necessary for success in STEM, especially Computer Science. Two target interventions meeting WWC standards for moderate to strong evidence (*Explicitly Teach Appropriate Writing Strategies Using a Model-Practice-Reflect Instructional Cycle* and *Teach Students to Intentionally Choose from Alternative Algebraic Strategies when Solving Problems*) have been shown to improve teaching and learning and were consulted in the development of this grant. Implementing instructional strategies with a high degree of fidelity to the professional learning has been shown to improve student achievement. If teachers use the model and the evidence-based strategies, they will meet the criteria of a highly effective teacher (Ching, et al., 2019; Thomas, A., 2020).

The intended influence of the professional development is that CODERS participants implement the evidence-based instructional strategies with a high degree of fidelity, increase teacher efficacy through their participation, and become rural interdisciplinary literacy leaders in their schools and regions. The teachers' experience in the professional development and their growing understanding of Computer Science, STEM, and non-fiction writing as a pedagogical approach would lead to an increase in student engagement and teacher efficacy in rural areas with less access to these opportunities. CODERS completers will have tested and developed a collection of resources to be shared across the nation.

A.4 Potential Contribution of Project to Increase Knowledge or Understanding of Educational Problems, Issues or Effective Strategies

This proposal expands on three promising new strategies that have anecdotal evidence of success with thousands of students. A key part of CODERS is communicating, enhancing, and studying the impact of our work when resources are leveraged for maximum effectiveness, developed cohesively, aligned with standards, and connected to the local context and needs of rural communities. Integrating elements of seemingly disparate disciplines into traditional STEM learning but with a focus on computer science and critical thinking can pay dividends.

B. Quality of the Management Plan

B.1 Adequacy of the Management Plan to Achieve Objectives on Time and Budget

The CODERS Council is comprised of the PI and Co-PIs and will meet monthly ensuring the project is on budget and meeting all deadlines. The CODERS Council will review implementation data and student achievement data, as well as manage school district/partner relationships. Upon funding, the PI will convene the CODERS Council and propose an annual work plan. The annual work plan will consist of procurement, hiring, weekly team meetings, collection of feedback from teams, analysis of feedback and improvement, and training to support high fidelity to the CODERS project. The Project Director/PI, Dr. Keri Franklin, will chair the search committees for support personnel alongside the CODERS Council. Our evaluation will be led by Dr. Melissa Page and Olivia Stevenson, M.S. of The Evaluation Group (TEG), an external evaluation firm selected via a procurement process in compliance with 2 CFR 200.317-326, EDGAR 75.135, and local policies. Using Shanahan and Shanahan's model (2008), the CODERS Council consists of disciplinary experts in computer science, STEM fields, including physics, technology, math, literacy, and instructional design The Council sets the groundwork by establishing a common language, developing the curriculum, CODERS kits, and modules. The infrastructure begins with deep planning, feedback loops among the planning team, evaluation group, and teachers in the early months to lead to high fidelity. CODERS Council will develop a scope and sequence of evidence-based practices from WWC practice guides, CODERS kits, and writing activities.

Table 4. Milestones and objectives						
Goal 1: Engage high need rural grades 3-8 students in school and summer Computer Science (CS) and STEM experiences.						
Obj	**Milestone**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
1	Develop CS Modules and Programming	X	X	X	X	X
2	On-Site Visits (virtual & F2F)	X	X	X	X	X
Goal 2: Develop teachers' content knowledge and efficacy for teaching CS and STEM interdisciplinary curriculum.						
Obj	**Milestone**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
5, 7-8	CODERS Summer Teacher Launch	X	X	X	X	X
5-8	Facilitating, Coaching, & Team Teaching	X	X	X	X	X
8	Pre-Service Teacher Training	X	X	X	X	X
Goal 3: Provide students with academic supports to foster success in CS and STEM.						
Obj	**Milestone**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
9-13	Provide CODERS Kits	X	X	X	X	X

9-13	Computer Science Teacher Programming	X	X	X	X	X
9-13	On-Site Visits (virtual & F2F)	X	X	X	X	X

Table 5: Overarching Project Milestones					
Milestone	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**
Personnel Hired	X				
Evaluation Team Contracted	X	X	X	X	X
Annual Plan in Place	X	X	X	X	X
Modules Developed	X	X	X		
Review feedback and make changes Continuous Improvement	X	X	X	X	X
New Group of Rural Districts/Teachers	X	X	X	X	X
Annual Project Meeting (Project Director/Evaluator)	X	X	X	X	X
Submit Performance Report	X	X	X	X	X
Submit Complete Data Report and ERIC Report					X

B.2 Costs are Reasonable Relative to the Scope and Potential Significance of the Project

The CODERS project will target 150 teachers who, in turn, will work with conservatively, 30 students per year, for a total of 13,500 students in five years, bringing the cost per student to [redacted] This impact on students is in addition to the expected impact of professional development on improved teacher retention and increased teacher leadership.

B.3 Qualifications of Key Project Personnel

PI, Dr. Keri Franklin has a Ph.D. in English Education and is the Associate Provost for Public Affairs & Assessment, and Director for the Center of Writing in College, Career, and

Community. She will oversee all aspects of the CODERS project. Dr. Franklin was a Co-PI on a USDE Investing in Innovation sub-grant and has received over $3 million in state and federal funding focused on teacher professional development and using writing to improve student achievement. The grant team, or CODERS Council, includes expert leaders and respected professionals in their fields with PhDs or Master's degrees in Computer Science, physics, math, English, reading, education, evaluation, and technical writing) (*Appendix B*). The project team described below has a defined area of responsibility and meets regularly to review data to improve and inform decision-making.

Dr. Razib Iqbal, Associate Professor of Computer Science, will lead the Computer Science (CS) Innovation Team and is responsible for overseeing the development of the Computer Science modules. He has four years of experience facilitating middle school Summer Coding Camps. Iqbal will co-facilitate the CODERS Summer Launch for Teachers, and support implementation of Computer Science and STEM curriculum.

The Professional Development Field Initiation and Innovation Team is led by co-Project Coordinators, Dr. Diana Piccolo, Associate Professor; Dr. Heidi Hadley, Assistant Professor and Dr. Tammi Davis, Assistant Professor. Dr. Piccolo, Associate Professor in the College of Education, holds a Ph.D. in Curriculum & Instruction, specializing in Mathematics Education and Statistics and has 12 years' experience as an elementary teacher and middle school math teacher, 10 years as a PI and Co-PI on a Missouri Department of Higher Education Instructional Teacher Quality grant for middle and high school math teachers in Missouri. Currently, she serves as the Elementary undergraduate and Outreach coordinator for 3 outreach campuses—all located in rural areas (Neosho, Lebanon, and West Plains). Dr. Hadley, Assistant Professor of English and Director of English Education, has led professional development for teachers for seven years, summer literacy camps with middle schoolers for three years, and taught in schools for five years. Dr. Davis, an Assistant Professor at Missouri State University, has been a teacher educator for 10 years, and has led and directed literacy professional development for teachers for 5 years, and taught upper elementary and middle school for over 20 years.

Dr. David Cornelison, a Professor in the Department of Physics, Astronomy, and Materials Science at Missouri State University, has conducted extensive research in condensed matter physics, focused on lab studies of astrophysical systems and semi-conductors, and is the founding Director of Phys-Biz, a project to connect elementary pre-service teachers and elementary students to the teaching and learning of Physics. Dr. Cornelison has done hands-on elementary school outreach for 20 years and began organizing pilot research projects 10 years ago through Phys-Biz, which created service-learning courses for elementary pre-service teachers to learn to teach Physics.

Dr. Melissa Page holds a Ph.D. in Family Studies and Human Development with a concentration on Program Evaluation and has over 20 years of experience designing, conducting, and managing participatory evaluations, particularly with a STEM focus. Dr. Page will coordinate our evaluation study with data architect, Olivia Stevenson, MA., who will work to clean and analyze data for data check-ins as well as for our impact study. The Middle School Team Lead will be by Dr. Andrew Homburg, an Associate Professor of Music and an Educational Assessment and Accreditation Consultant for CAEP, and has over 20 years teaching experience in K-12.

Dr. Judith Martinez, Outreach and Recruitment Coordinator, is an Assistant Professor of Modern and Classical Languages, a Diversity Fellow, and a founding leader of the Rural Teacher Corps, an initiative to connect diverse teachers to rural teaching placements. Dr. Martinez will oversee teacher recruitment, outreach opportunities, including contests, and act as a liaison between Team Leads and school districts. Julia Cottrell has an MA in Technical Writing and is an Assessment and Learning Outcomes Consultant. Cottrell will oversee the web content, public dissemination, and archiving of the resources developed through this program.

B.4. Procedures for Ensuring Feedback and Continuous Improvement

A thorough procedure will be developed for ensuring feedback is implemented to improve the professional development strategies, the program effectiveness, and the communication between all groups participating in the work. The following processes will be embedded to ensure feedback from all stakeholders and focus on continuous improvement throughout the life of the grant and beyond:

- Develop case studies of rural schools which will be shared with the CODERS Council.
- Collect reflections on the meeting process from the CODERS Council which will then be collected, typed, and shared with the group prior to the next meeting.
- Participants in the CODERS Project will complete evaluations and reflections at the end of each meeting with professional learning specialists. These evaluations and reflections will be collected, typed, and shared with the specialists and used to make changes to improve the next professional learning activities.
- In Year 2, when teachers begin piloting strategies from Year 1, teachers will video record their teacher and teams will review the videos with the teachers in a collaborative atmosphere to discuss the implementation of the strategies and provide insights. These insights will be collected and will inform the next meetings. Additionally, these insights will be aggregated across regions and utilized by the CODERS Council to guide next steps.

CODERS Council will meet monthly to review reports from evaluators, feedback from students, formative assessments, and reports. CODERS project's success relies heavily on continuous high-quality feedback, thus our evaluator will share results using charts and graphs for ease of interpretation, as well as through interim and annual reports, survey, and focus group snapshots provided by our evaluator to district administrators, principals, and project staff. This participatory approach builds stakeholders' ownership, increasing the likelihood that results will be used to improve the program and achieve positive outcomes. Scheduled quarterly reviews of the logic model will allow us to gauge early impact, suggest needed program changes, identify unintended outcomes, and ensure results are useful for continuous quality improvement.

B.5. Dissemination of Results and Strategies

Over the 3-year impact study, 15 Computer Science/STEM modules with integrated writing outcomes will be created and a coherent curriculum will be developed and publicly available on social media and websites hosted by Missouri State University as well as shared in publications and conference presentations. Hosting these modules online will make them readily available. These modules can always be accessed and can be utilized across the country. The following activities are currently funded and will continue after the five-year duration of the grant: 1) 15-20 computer science modules with integrated units; 2) YouTube channel with videos from teachers and students; 3) website with modules and feedback from those who have tried them and 4) conference presentations and publications.

Results from CODERS Council will be disseminated in three different capacities: 1) empirical research results to research journals, conferences, and the What Works Clearinghouse, practitioner journals, conferences, and model lessons and materials through the open access website, and through community-based publications and symposia. Our goal is to provide support and to help rural teachers implement evidence-based strategies for disciplinary literacy in STEM fields with a particular focus on computer science. An additional goal is to sustain, transfer, and generalize the work to other school districts, thus our primary focus for dissemination is on advancing knowledge about these issues in the fields of disciplinary literacy and teacher education. The evaluation team, having conducted a rigorous study on the program, will work towards presenting at nationally prominent research conferences. Next, the CODERS Council will utilize the Missouri State web server as the home of a website to serve as a clearinghouse for effective curricular materials and relevant research to improve their skills in all aspects of literacy. The CODERS Project website will provide access to materials and resources that can be used as follow-up support for teachers who have participated, but also make our work transparent and accessible to all. In addition, the proceedings of our rural summits, national presentations, and work with other rural organizations will be posted for public use. Participating teachers and project leaders will be encouraged and supported to further share their expertise with teachers at conferences and through the publication of practitioner journal articles and other materials. Finally, the work will be shared with the communities in which it occurs, offering student and teacher created products as well as public talks and town hall meetings, and presentations at localized conferences.

C. Quality of the Project Evaluation

C.1 Methods of Evaluation Meet WWC Standards

The Evaluation Group (TEG), selected via a procurement process in compliance with 2 CFR 200.317-326, EDGAR 75.135, and local policies will test the effectiveness of CODERS modules to improve student's CS and STEM knowledge and attitudes, as well as academic outcomes including benchmark tests and state end-of-grade (EOG) exams. TEG's capacity to conduct a rigorous, objective evaluation make them highly qualified to serve as our evaluator with qualifications and experience including: over 30 years evaluating K-12 education programs, experience conducting large-scale evaluations, including: 1) 12 current or former i3/EIR initiatives, multiple STEM and Computer Science focused evaluation projects; 2) PhD and master's-level professionals who have expertise in all evaluation areas, including research design, measurement, benchmarking, test and survey construction, data analysis, and reporting; and 3) expertise in creating quantitative instruments and qualitative data collection techniques. Our evaluation will be led by Dr. Melissa Page and Olivia Stevenson, M.S.

Our study has three confirmatory research questions: What is the impact of CODERS on students' Grade 3-8 ELA, math, and science EOG state assessments after three years of implementation? Beginning in Year 2 (SY2022-23), we will employ a rigorous, longitudinal quasi-experimental design (QED) that will meet the What Works Clearinghouse 4.1 (WWC, 2020) group design standards with reservations to provide a moderate level of evidence to assess the differences in academic achievement using valid and reliable standardized assessments (MO EOG Grade 3-8 **ELA**, **math**, and **science**). Our three-year QED will compare academic outcomes of 2,700 CODERS students to 2,700 comparison students within the same school whose teachers did not participate in the project and students from rural "business-as-usual" comparison schools where teachers are also not participating in the project (See Table 6 below). Teachers within the same school will be surveyed to assess contamination threat by evaluating their exposure to the intervention that changed their pedagogical practices. Students whose teachers were impacted will be eliminated as matches to control for contamination threat. A high student graduation rate (90%) and incentivized supports for teachers will likely result in low attrition rates for both teachers and students. Missing data will be handled using listwise deletion, if key variables are missing to ensure no data is imputed. An *a priori* power analysis (Dong & Maynard, 2013) indicates our study has enough power to test for statistically significant small to medium program effects (MDES = 0.235, $\alpha = .05$, power = .80). Treatment and comparison students will be matched 1:1 using nearest neighbor propensity score matching (PSM) without replacement to help ensure baseline similarity on state standardized assessments. The PSM will include key exogenous variables, such as baseline ELA, science, and math scores, economic disadvantage, minority status, and sex. These variables will be included as covariates in our hierarchical linear model (HLM) to statistically control for any remaining differences between treatment and comparison students. Our outcome measures of state standardized math, science, and ELA achievement were selected because they predate **CODERS** and are avoiding any potential over alignment. Our impact model is:

$$Yijk=\beta 0+\beta 1 Baselineijk+\beta 2 Treatmentijk+\beta 3 EconomicDisadvantageijk+\beta 4 MinorityStatusijk+\beta 5 Sexijk+\beta 6 Cohort1ijk+\beta 7 Cohort2ijk+\mu k+\epsilon jk+eijk$$

Exploratory analyses will be focused on gender, ethnicity, low income, and disability subsets of our data. Analyses will include teacher and student mediators from survey scores (pedagogical practices, teacher efficacy and content knowledge gains, and student attitudes and efficacy) as well as covariates such as teacher experience (pre-service, in-service and number of years teaching). Design, data, and analyses of these subgroups will mirror our confirmatory HLM but only include data from each subset.

Table 6. *CODERS* Impact Study Sample Cohorts

Year	Cohort 1	Cohort 2	Cohort 3
2021-22	3rd-8th Grade (Baseline)		
2022-23	1 Year	3rd-8th Grade (Baseline)	
2023-24	2 Year	1 Year	3rd-8th Grade (Baseline)
2024-25	3 Year Outcome	2 Year Outcome	1 Year Outcome

C.2 Evaluation Plan

Our evaluation design includes formative and summative evaluation to assess progress in achieving program outcomes and objectives and to provide continuous feedback to guide implementation allowing for mid-course corrections. In academic year (2021-22), we will launch a comprehensive longitudinal fidelity of implementation study to systematically track, document, and assess the extent to which actual implementation aligns with proposed implementation (Arby, Hulleman, & Rimm-Kaufman, 2015; Century, Rudnick, & Freeman, 2010). In partnership with the CODERS Council, Research and Evaluation Team, TEG, and faculty, we will develop the CODERS Fidelity Index consisting of components that align with the key strategies in the logic model (See sample in *Appendix I*). Implementation data obtained from multiple sources (surveys, training records, attendance) will be used to compute fidelity scores, and within each program component, fidelity scores will be computed based on student and teacher indicators of adherence (ex: # teacher PD hours), exposure (ex: # of STEM/CS units implemented), quality (ex: % of teachers who report self-efficacy), and responsiveness (ex: % of students who report increased attitudes and efficacy) to give us a comprehensive assessment of CODERS implementation (Nelson, Cordray, Hulleman, Darrow, & Sommer, 2012). TEG will revisit the index annually as part of our continuous performance feedback loop, and a fidelity index completed with our comparison schools/teachers will assess if comparison students were exposed to the intervention. To support replication in other settings, our formative evaluation will answer three questions: 1) To what extent was CODERS implemented with fidelity? 2) What are the strengths of and barriers to implementation of CODERS? 3) What components of CODERS are suitable for replication in other settings? Results and documented processes will be published to a public website with biannual updates. Further, published results will be shared in ERIC at the end of the grant program and will include key implementation documents, such as a fidelity index.

C.3 Valid and Reliable Data on Relevant Outcomes

TEG implements a mixed-methods, utilization-focused evaluation (Creswell & Creswell, 2017; Patton, 2014) that combines quantitative and qualitative data to triangulate results, thereby increasing the validity of findings and ensuring that results are useful for continuous quality improvement. Our logic model in *Appendix I* provides a sound theoretical foundation to guide the program design, evaluation, and interpretation of evaluation findings (Knowlton & Phillips, 2012). The model articulates key components (school STEM/CS curricula, virtual experiences, and teacher professional development), mediators (pedagogical practices, teacher efficacy and content knowledge gains, student attitudes and efficacy), and long-term outcomes (student academic achievement). TEG's study design will be logical, feasible, and related to the proposed goals of the project and will include participation of project stakeholders in all phases of the evaluation process. TEG will facilitate our Research and Evaluation Team and CODERS Council monthly to build consensus on the critical evaluation questions, methods, instruments, data collection protocols, and reporting formats that will define the evaluation. CODERS' success relies heavily on continuous high-quality feedback, thus evaluation results will be shared via multiple formats, and this collaborative approach builds stakeholders' ownership, increasing the likelihood that results will be used to improve the program, achieve positive outcomes, and sustain the program after funding ends. TEG will collaborate with MSU to secure IRB approval prior to engaging with the teachers and students or conducting any data collection from participants. Our evaluators will analyze quantitative data (e.g., student attendance, surveys, formative assessments) using appropriate statistical testing; Hedge's g effect sizes will be computed between groups and disaggregated by subgroup (i.e., school, grade level, gender, minority, free and reduced lunch status). Survey scores will be included in our exploratory analyses as a mediator.

A combined survey given to students biannually in Grades 3-8 will measure computer science attitudes and efficacy (Mason & Rich, 2020), computational thinking (Kong, Chiu, & Lai, 2018; Weese & Feldhausen, 2018), students' attitudes about math, science, engineering, 21st century skills, and career interest for twelve broad career fields (Friday Institute, 2012a & 2012b). Each measure has reliability and validity data reported in Table 1. Our treatment teachers will complete the T-STEM teacher survey (Friday Institute, 2012a-b) (reliability reported in Table 1). Teachers will also complete the TPACK (Schmidt et al., 2009) and the CS PCK (Yadav & Berges, 2019). Reliability will be established for these and all surveys given at each administration to ensure scale items surpass a threshold of 0.70; items or scales below this threshold will be modified or removed to improve reliability. Focus groups and interviews with teachers and project staff, as well as open-ended survey items will provide a rich qualitative perspective for deeper inquiry into the process, challenges, and successes of CODERS. Qualitative data analysis will be guided by code development (Saldana, 2016), informed by scholarly literature, and member checking (Creswell & Miller, 2000; Lub, 2015) and will provide a rich context in which to interpret our quantitative data. The constant comparative method (Glaser & Strauss, 1967) will be used to increase the trustworthiness of results, and each qualitative data collection process will stop when saturation (Sanders, et al., 2018) is reached. TEG will comply with annual US ED reporting, including the six performance measures and our project objectives. Through evaluation of CODERS, we expect to impact rural students' STEM/CS interest and efficacy at an earlier age than high school, thereby, increasing the number of underrepresented students from rural locales pursuing STEM/CS in high school and beyond.