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The Ohio Valley Educational Cooperative (OVEC) proposes an early-phase Education Innovation and Research (EIR) project under *Absolute Priority 1*, *Absolute Priority 2,* and *Competitive Preference Priority 1*. **The proposed Computer Science Micro-Credential (CSMC) project will develop and evaluate self-paced, competency-based micro-credential program, allowing teachers to learn the skills and components of the code.org elementary and middle school curriculum and the fundamental principles of Computational Thinking.** An increase the number of teachers prepared to teach computer science in elementary and middle grades will expand access to and participation in rigorous computer science coursework, especially for students who are racial/ethnic minorities, girls, living in rural areas, and who live in low-income households.

OVEC is an educational support agency in North-central Kentucky, providing professional learning, advocacy, and services to educators, administrators, and students. Nine of our 15 school districts have committed to this project. Those districts represent over 170 schools that serve 3rd through 8th graders from very rural areas, suburban neighborhoods, and Kentucky's most urban neighborhoods. Because of the geographic and socio-economic diversity of those districts, OVEC's research will show the efficacy of the CSMC program in a variety of settings.

A. Quality of the Project Design

1. The extent to which the goals, objectives, and outcomes to be achieved by the proposed project are clearly specified and measurable

The goal of the Computer Science Micro-Credential (CSMC) project is to increase the number of teachers who are credentialed to teach elementary and middle school Computer Science, thereby offering a solution to the regional, statewide, and national shortage of computer science teachers (see Section A.2.). To achieve this goal, OVEC has established the following objectives:

Objective 1: Participating teachers will demonstrate greater content knowledge and confidence in computer science instruction than non-participating peers.

Outcome 1.1: 90% of participating teachers will complete 118 hours of professional learning.

Outcome 1.2: 90% of participating teachers will develop 6 computer science lessons (total of 756 lessons).

Outcome 1.3: 90% of participating teachers (n= 126) will obtain the Computer Science Micro-Credential.

Objective 2: Students in CSMC-participant classrooms will demonstrate higher rates of math achievement than peers in non-participating classrooms.

Outcome 2.1: Student in CSMC-participant classrooms will demonstrate higher rates of growth in math achievement, as measured by NWEA Measures of Academic Progress (MAP), than peers in non-participating classrooms.

Outcome 2.2: Student in CSMC-participant classrooms will demonstrate higher rates of math proficiency, as measured by Kentucky Performance Rating for Educational Progress (K-PREP) testing, than peers in non-participating classrooms.

Objective 3: Parents/guardians of students in participating classrooms will increase their awareness of computer-science related career opportunities for students.

Outcome 3.1: Participating districts will offer 6 hours of computer science family/parent engagement activities.

Outcome 3.2: Participating parents/guardians will increase their knowledge of computer-science related career opportunities for students, as measured by a pre- and post-activity survey.

An infograph (p. 3) and logic model (Appendix I, p. 78) depict our theory of action. The ultimate impact of increasing teacher capacity is more students entering computer science careers.

CSMC Theory of Action Infograph

Urban

Inputs: •Development of Computer Science (CS) Micro-Credential (MC)

•Alignment of CS Standards with other content areas •Inclusion of culturally-responsive teaching in MC

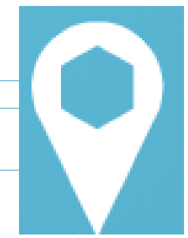
•Ongoing professional development (e.g., coaching, regional PLC) •Family Night STEM Programs

•Rigorous analysis of MC in urban, suburban, and rural settings •Sharing results regionally and nationally

Rural

CSMC Teacher

Computer Science Careers



Median Salary of $86,320

$38K>National Median Salary

Underrepresented

Outcomes:

•140 teachers increase CS content knowledge, CS teaching skill, integration of CS standards, and use of culturally responsive teaching strategies •Administrators increase awareness of CS

•Students increase engagement in CS instruction and achievement in math & science

•Students are prepared for high school and post-secondary career pathways in Computer Science

•OVEC and partners demonstrate the reliability and replicability of CSMC

2. The extent to which the design of the proposed project is appropriate to, and will successfully address, the needs of the target population or other identified needs

By addressing Competitive Preference Priority 1 of the early-phase EIR program, OVEC will address the lack of access to high-quality computer science instruction in grades 3 through 8, particularly by underserved communities. In order to do this, the Computer Science Micro-Credential (CSMC) project will offer teachers in 10 of OVEC's member districts an alternative to traditional subject-area certifications, increasing the number of qualified computer science teachers in those districts.

Target population. The CSMC project will target elementary and middle school students (3rd – 8th grade) in ten school districts in north-central Kentucky. By preparing teachers to integrate computer science principles and computational thinking into multiple disciplines at these levels, their students will enter high school with the skills needed to function in the computational world, pursue more advanced coursework in STEM subjects, and demonstrate greater proficiency in those subjects.

Locale Code	**Participating Districts**
11 – City: Large	Jefferson Co.
21 – Suburb: Large	Bullitt Co.
32 – Town: Distant	Franklin Co., Frankfort Independent, Shelby Co.
42 – Rural: Distant	Eminence Independent, Gallatin Co., Henry Co., Owen Co., Trimble Co.

The districts participating in the CSMC project are largely rural, as indicated by their locale codes. Those districts with locale codes of 32 or 42 are also characterized by high poverty; in those eight districts, 62% of students qualify for free or reduced lunch and nearly 23% of children under 18 live in poverty (U.S. Census Bureau, American Community Survey 5-Year Estimates). The project also includes the largest and most racially diverse district in the state – Jefferson County Public Schools (JCPS) – and Kentucky's largest city of Louisville. JCPS serves nearly 95,000 K-12 students, more than 65% of whom are eligible for free or reduced lunch, and 57% identify as racial and ethnic minorities.

Identified Need. In an era when advanced technology is a part of the lives of all citizens, schools are far behind in preparing students to function and work in a computational world. The U.S. Bureau of Labor Statistics (BLS) projects that between 2018 and 2028, employment in computer and information technology occupations is expected to grow by 12 percent, compared to 5.2% growth for all occupations. 598,700 new computing jobs are projected, with another 290,200 jobs in other Science, Technology, Engineering, and Math (STEM) fields. However, fewer than 11% of STEM graduates study computer science, according to the National Center for Education Statistics, creating a sizable gap between the number of jobs available and the number of qualified applicants to fill those positions; this also creates great opportunity for those who do pursue certifications or degrees in computer science.

In Kentucky, only 39% of high schools offer a foundational computer science course, compared with 45% nation-wide, putting Kentucky students at a disadvantage for pursuing post-secondary studies in computer science and filling the thousands of available CS positions; only 117 schools in the state offered Advanced Placement (AP) courses in Computer Science during the 2018-2019 school year. In a state where about one quarter of children live in poverty, and more than half live in households considered low-income (200% of the federal poverty level or less), the lack of access to computer science education is also a barrier to high-wage jobs. In 2019, the BLS reported that the average annual wage for Computer and Mathematical Occupations in Kentucky was $72,220, compared to $44,020 for all occupations.

One of the primary barriers to access is that there are very few teachers qualified to teach computer science. In 2018, the seven Kentucky institutions that offered teacher preparation in CS did not graduate a single teacher prepared to teach it. By offering an accessible alternative for teachers to earn micro-credentials in computer science and increasing the number of teachers introducing computer science principals and Computational Thinking into their classrooms, OVEC's CSMC project will meet Competitive Preference Priority 1, expanding CS opportunities for underserved populations, specifically racial and ethnic minorities and students from rural communities and low-income households.

Racial and ethnic minorities are under-represented in the number of students currently accessing computer science courses in high school; of the 1,627 CS AP exams taken in Kentucky in 2019, only 70 were taken by Hispanic or Latino students, 43 were taken by Black students, and 3 by American Indian or Alaska Native students. In Jefferson County Public Schools, which serves 78% of the 121,629 students in our participating districts, more than 57% identify as racial or ethnic minorities, and 65% qualify for free or reduced lunch. Of the students served by the remaining nine districts, 62% attend schools in districts considered rural. Child poverty rates in the ten districts in range from 13.3% to nearly 30%, averaging 23%.

Math assessments during the 2018-19 school year showed that 60% of 3rd and 8th graders performed below grade level in the ten participating districts. Building a foundation of computer science skills and knowledge in elementary and middle school will improve math achievement and increase the number of students who enroll in CS courses in high school and beyond. This expanded access will prepare students – especially those who are racial or ethnic minorities, living in poverty, or living in rural areas – to meet the demands of the increasingly complex computational world and to fill high-wage, high-demand jobs in Computer Science occupations.

3. The extent to which the design of the proposed project reflects up-to-date knowledge from research and effective practice

The proposed project draws from and expands on current research and best practices related to professional learning design and student math achievement. While some teachers could return to a college or university to earn certification in computer science, it is a costly and time-consuming solution and will not yield the immediate results needed to adapt educational practices to workforce demand. Micro-credentials based on the code.org curriculum and principles of Computational Thinking (CT) will enable teachers to develop computer science expertise at their own pace and demonstrate competency via a portfolio of evidence created and implemented in their classrooms as they progress through the professional learning program.

CSMC will collaborate with BloomBoard, Inc. (BBI), the nation's leading platform for educator professional advancement via micro-credentialing, to provide participating teachers access to the CSMC cluster of micro-credentials. Content will align with code.org Computer Science Fundamentals and Computer Science Discoveries courses for students in grades K-8.

The code.org curriculum for students blends online and non-computer activities to teach computational thinking, problem solving, programming concepts, and digital citizenship. The International Society for Technology in Education (ISTE) emphasizes Computational Thinking as a "problem-solving process that includes a number of characteristics and dispositions. CT is essential to the development of computer applications, but it can also be used to support problem solving across all disciplines, including the humanities, math, and science. Students who learn CT across the curriculum can begin to see a relationship between academic subjects, as well as between life inside and outside of the classroom."

Absolute Priority 1: Demonstrates a Rationale
The CSMC Project's Research Base • **Cycles of Inquiry** • **Meaningful Collaboration** • **Teacher portfolios** • **Instructional systems coherence**

Four foundational elements validated by research support BBI's micro-credential-based PD programs. BloomBoard micro-credentials utilize ***CYCLES OF INQUIRY*** uniformly based on the "ADDIE" model of instructional design. The primary purpose of an inquiry cycle is to improve classroom practices by (a) establishing current thinking; (b) identifying needs and questions; (c) requiring investigation of information, ideas, and data; (d) sorting the information and making meaning out of it; and (e) applying the learnings. The analysis yields new actions, which then initiates a new cycle of inquiry, continuing the cycle with each new analysis (Cushman, 1999).

The BloomBoard micro-credential process promotes **MEANINGFUL COLLABORATION**. Hill et. al. (2010) found group learning to be most effective for teachers working "not as isolated individuals but through job-embedded professional development, and as members of collaborative, interdisciplinary teams with common goals for student learning." CSMC teachers will work at their own pace within a nine-month window to earn the micro-credentials, and upon completion will receive a [redacted] stipend. They will collaborate with peers through a virtual and in-person Professional Learning Community (PLC). CSMC coaches on OVEC's staff will offer regular "office hours," allowing cohort members to join virtual meetings, ask questions, seek feedback from the coach, and engage with fellow educators.

As teachers progress through the CSMC program, they will develop **PORTFOLIOS** demonstrating competence, growth, and achievement. Teachers have viewed portfolio development as a useful professional learning activity, since it supports their reflection and improvement in teaching practice (Gearhart & Osmundson, 2009). In the early 2000s, many districts used teacher portfolios for evaluation and PD (McNelly, 2002) and multiple studies took steps toward validating the positive impact of portfolios on teaching performance, reported learning, and student achievement gains (Chung, 2008; Sato, Wei, & Darling-Hammond, 2008).

BloomBoard micro-credentials are subject to rigorous evaluation and assessment by calibrated expert assessors trained to deliver feedback to educators. The key elements of BBI's review process are inter-rater reliability, calibration, and consistent feedback. Two National Center for Education Evaluation (NCEE) impact studies demonstrated providing educators with performance feedback and offering pay-for-performance bonuses can improve student achievement (Garet, 2008).

Research on **INSTRUCTIONAL SYSTEMS COHERENCE** (Newmann et al, 2011, Forman et al., 2017, and Cobb & Jackson, 2011) shows that a set of interrelated programs for students and staff guided by a common framework for curriculum, instruction, assessment, and learning climate and pursued over a sustained period are more likely to advance student achievement than multiple, unrelated efforts. Based upon this theory, the CSMC project will include workshops for participating teachers, their fellow teachers in math, science, and English Language Arts (ELA), and their districts' instructional leaders. Educators will align Kentucky's K-12 Computer Science Standards, Next Generation Science Standards, and Common Core Standards in math and ELA to integrate computer science within multiple disciplines and within district learning goals.

Placing a priority on addressing racial, ethnic, and gender disparities in computer science education and the workforce, CSMC leaders and BloomBoard will incorporate culturally responsive teaching pedagogical practices into the code.org micro-credential cluster. In the CSMC PLC, teachers will discuss strengths and weaknesses of curriculum designs and instructional materials and identify changes needed to make improvements that engage a greater diversity of students in computer science instruction (Gay, Culturally Responsive Teaching: Theory, Research, and Practices, 2001). Observational tools used by CSMC coaches will be designed to assess multicultural competency and relevance of materials and instruction and to guide improvement in these areas.

The Louisville Urban League (LUL) has committed to support the cultural competence of the micro-credential and participating teachers (see Appendix C, p. 46). LUL brings expertise in education and workforce development. With oversight from their director of Education Policy and Programming, Dr. Kish Cumi-Price, LUL will review communication materials so that the project attracts diverse teacher participants, advise BBI on key concepts in culturally responsive teaching strategies, review effectiveness of training on these strategies, review an initial sample of teacher-leaders' lessons, and advise project leadership on trends in leadership. LUL will strengthen our approach to culturally responsive teaching strategies, which are **critical for increasing CS engagement of underrepresented students (Comp. Pref. Priority 1).**

Multiple research studies (O'Donnell, Kirkner, & Meyer-Adams, 2008; Auerbach & Collier, 2012; and Portwood, Brooks-Nelson, & Schoeneberger, 2015) show that providing family classes and opportunities for parents to work with their children on learning activities increased parents' knowledge of how to help their children and the types of help they were able to provide to support their children's academic success. To encourage family engagement, CSMC will provide micro-grants to participating teachers to design weekend or evening programs where parents and children work together on games and activities rooted in Computational Thinking and computer science and parents learn about STEM career opportunities to promote and encourage at home.

The American Institutes for Research (AIR) will carefully measure CSMC effectiveness using an evaluation design that will generate findings expected to meet What Works Clearinghouse (WWC) evidence standards without reservations. The project will use insights gained during its development phase to guide future replication or testing of CSMC in other settings. Key project staff will share research findings via multiple communication channels and address the extent to which micro-credential-based professional learning increases the number of teachers prepared to deliver instruction in computer science and Computational Thinking with increased content knowledge and ability to impact student mathematics achievement.

4. The potential contribution of the proposed project to increased knowledge or understanding of educational problems, issues, or effective strategies

In 2016, the Title II Report of National Teacher Preparation Data revealed that only 72 new teachers in the U.S. graduated prepared to teach computer science by subject, area, or certification. However, the CSMC project has the potential to outline an effective solution for increasing the number of credentialed computer science teachers at the elementary and middle school levels that can be utilized in a variety of educational settings, including the most rural districts. The CSMC will provide valid and reliable performance data on the use of micro-credentials to increase teachers' content knowledge of computer science and Computational Thinking and improvement in their students' mathematics achievement. If proven successful, this strategy will improve outcomes in math and computer science among racial and ethnic minority students, girls, students from low-income families, and students in rural areas.

B. Adequacy of Resources and Quality of the Management Plan

The management plan (p. 12) includes milestones, activities, responsible parties, and timelines. Senior project leaders will use the plan to ensure all project components are implemented.

Project Management Plan

Key to Responsible Persons:

PD-Project Director **DA**- District Administrators **SA**- School Administrators

MT- Microcredential Teacher-candidates **TL**- Teacher Leaders **C**- Coaches

PT- Peer Teachers **BBI**- BloomBoard **E-** Evaluator (AIR) **UL**- Urban League

2021	2022	2023	2024	2025

1 = January - March **2** = April - June

3 = July - September **4** = October - December

Milestone: Project Initiated	**2021**	**2022**	**2023**	**2024**	**2025**
1 Announce award to public and partners. **PD**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
2 Obtain approval of Memoranda of Agreement with districts and partners. **PD, DA**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
3 Update management plan based upon reviewers' comments & instructions from ED. **PD**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
4 Randomly assign teachers to one of two project cohorts. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
5 Post coach (C) job-openings, interview, and hire C. **PD**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Milestone: Micro-Credential Developed and Piloted	**2021**	**2022**	**2023**	**2024**	**2025**
1 Adapt Code.org CS Fundamentals Express and CS Discoveries courses for Micro-Credential Coursework and establish online file-sharing platform. **BBI, UL**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
2 Develop communication materials for the micro-credential, including competencies checklist for teachers, logo, and digital badge/certificate of completion. **BBI, UL**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
3 Test coursework, file-sharing, & other technical elements. Provide feedback to BBI. **TL**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
4 Update online coursework, file-sharing, and comm. materials in light of feedback. **BBI**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Milestone: Micro-Credential Attained by Teachers	2021	2022	2023	2024	2025
1 Complete 6-course micro-credential sequence. **MT**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
2 Participate in five regional Professional Learning Community meetings. **MT, C**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
3 Design a computer science lesson during each course to demonstrate learning. **MT**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
4 Provide feedback to MTs on structure, content, and assessment of each lesson. **C, BBI**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
5 Observe each MT lesson, provide feedback, and assist with lesson revision. **C**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
6 Revise lesson and upload the BBI file-sharing platform. **MT**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
7 Assess lesson for demonstration and competency. **BBI**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
8 Provide additional assistance to MTs below competency prior to resubmission. **C**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4

Milestone: Computer Science Emphasized in School Communities	2021	2022	2023	2024	2025
1 Participate in standards alignment workshop. **SA, MT, PT**	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4	1 2 3 4
2 Host family and parent event focused on computer science. **DA, SA, MT**	1 2 3 4	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4
3 Provide PTs access to computer science lessons developed by MTs. **PD, SA, BBI**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

Milestone: Evaluation Plan Implemented	2021	2022	2023	2024	2025
1 Collect data on MT/student/classroom characteristics that may moderate impact. **E**	1 2 3 4	1 2 3 4 Cohort 1	1 2 3 4 Cohort 2	1 2 3 4	1 2 3 4
2 Propose data collection procedures that comply with FERPA. **E, PD, DA.**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4

No.	Activity	2021	2022	2023	2024	2025	
3	Administer the Computational Thinking Scales to treatment and control groups. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
4	Administer a survey of MT knowledge of the K-12 Computer Science Framework. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
5	Collect Measures of Academic Progress data from beginning to end-of-year. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
6	Collect K-PREP data from prior school year. Compare treatment/control groups. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
7	Analyze program implementation data (e.g., teacher online usage data, attendance at summer workshops and PLCs) to determine implementation fidelity. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
8	Conduct check-in calls with a sample of MTs to identify barriers to implementation. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	**Cohort 1** **Cohort 2**
9	Report results of annual program evaluation to PD, DA, and SA. Suggest interim adjustments to project design in order to improve outcomes. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
10	Conduct in-depth statistical analysis of teacher/student outcomes for both cohorts. **E**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
11	Complete the Annual Performance Report to the US Dept. of Ed. **E, PD**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
	Milestone: Project Findings and Resources Disseminated	**2021**	**2022**	**2023**	**2024**	**2025**	
1	Propose to present at state-wide content-area conferences. **TL**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
2	Present project evaluation findings at a conference of national significance. **PD, E, BBI**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
3	Submit articles to publications, e.g. American Educational Research Journal. **PD, E.**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	
4	Share findings with districts/states interested in the microcredential. **PD, BBI.**	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	

1. The adequacy of the management plan to achieve the objectives of the project, including clearly defined responsibilities, timelines, and milestones for accomplishing project tasks

A team of senior leaders from OVEC and project partners will use the project management plan to accomplish project tasks on time. OVEC's Alicia Sells (see resume, Appendix B, p. 32) will serve as Project Director, who oversees the project, collaborates with partners, and serves as the main point of contact with districts and schools. AIR's Rachel Garrett, PhD, will act as the evaluation lead, overseeing the design, data collection and analysis, and reporting and dissemination of findings; she will lead a team of research assistants and our additional AIR staff during the five-year project. In addition, BloomBoard will provide professional development content, platform licenses, and support services for CSMC participants. Louisville Urban League will bring support and leadership to the project's emphasis on culturally responsive teaching. We estimate the following contributions of time and effort for the project's senior leadership:

Senior Leadership – Full-Time Effort	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
OVEC	0.5	0.5	0.5	0.5	0.5
BloomBoard	1.5	1.0	1.0	.3	.3
AIR	0.5	1.0	1.0	0.66	0.40
Louisville Urban League	0.5	0	0	0	0
TOTAL	3.0	2.5	2.5	1.46	1.2

Support letters from each entity show their commitment to and role in the project (p. 43-64).

2. The extent to which the costs are reasonable in relation to the objectives, design, and potential significance of the proposed project

At the close of the five-year CSMC project, 140 teachers instructing 8,400 students in grades 3-8 will have completed their micro-credentials at a cost of [redacted] per student. If proven effective, the model will offer an economical solution to the shortage of teachers prepared to teach computational thinking and computer science skills and principles in the elementary and middle grades. A computer science micro-credential that is shown to improve math achievement, particularly among racial and ethnic minorities, girls, and students living in rural areas and/or in poverty has significant potential for commercialization and scalability. Further, evidence generated from the project could be used to advocate with state policy-makers for the use of micro-credentials as a path to computer science teaching endorsement. In Kentucky, where in 2018 there were no teachers completed their preparation programs prepared to teach computer science, this could encourage teachers across the state to pursue this qualification, in turn preparing Kentucky's students to meet the ever-growing demand in computer science careers.

3. The qualifications, including relevant training and experience of key project personnel

Alicia Sells is the Director of Innovation at OVEC, and she will lead the design and implementation of the CSMC project. In her role at OVEC, Ms. Sells works with students, educators, and families to invent innovative places and ways for students to learn. She has extensive experience with the start-up and implementation of federal, state, and private grant projects. She acted as the project director for the creation and execution of Kentucky's first leadership academy for early childhood educators funded by a Race to the Top Early Childhood Challenge Grant. Ms. Sells, along with the superintendents of five OVEC districts, founded a radically innovative regional career academy. She was the director of innovation and communication in a Race to the Top District grant that included 32 Kentucky districts.

Rachel Garrett, PhD, is a senior researcher at the American Institutes for Research

(AIR) and will serve as the Evaluation Lead on the project. Dr. Garrett's major areas of interest and expertise include educator effectiveness, teacher professional development, and program evaluation. Dr. Garrett has extensive experience with projects similar to CSMC. For example, she has served as the project director for a National Science Foundation-funded, 48-school randomized trial of the Intensified Algebra Study. She is also the project director for the Institute of Education Sciences (IES)-funded Goal 4 Effectiveness Study of ASSISTments and the Goal 4 Effectiveness Study of a Brief Self-Affirmation Intervention. Dr. Garrett has overseen study design, data collection, analysis, and dissemination for these and other large-scale evaluation studies. Her work has been published in peer-reviewed journals, including *Educational Evaluation and Policy Analysis* and *Early Childhood Research Quarterly*. She holds a doctorate degree in public policy from the University of Chicago.

Mr. Jason Lange is co-founder and president at Bloomboard, Inc. (BBI). Mr. Lange has been instrumental in designing and directing implementation of the 14 statewide micro-credential initiatives that are using the BBI platform, including the 4 programs with a CS focus. Prior to BBI, Mr. Lange worked with NewSchools Venture Fund (NSVG), where he researched and presented recommendations for the positioning of NSVF in the growing educational VC marketplace. In addition, he has served as a volunteer, treasurer, executive board member, and junior board president for the Working in the Schools (WITS) organization. Mr. Lange is a graduate of Yale University, where he earned a B.A. degree in Psychology and Philosophy. He also holds a Masters of Education and MBA from Stanford.

4. The adequacy of procedures for ensuring feedback and continuous project improvement

OVEC has incorporated improvement strategies into the project's professional learning services and program evaluation. Teachers who participate in the CSMC project will submit lesson plans during each of the six courses for the micro-Credential. Our partner, BloomBoard, reviews the lessons for evidence of competence. This process provides a quality checkpoint that will inform adjustments to coaching, the work of our regional computer science PLC, and, as needed, planning for additional professional learning activities. For whole-group events, such as our summer standards alignment workshop, OVEC will use a participant survey to gauge the quality of professional learning, improve the workshop for future cohorts, and identify any necessary follow-up. CSMC coaches will uses observational tools to assess instruction and materials for their cultural responsiveness, and offer feedback to teachers for improvement in this area.

The evaluation plan (p. 19-25) will provide regular feedback on the quality of the project. Evaluation methodology includes formative feedback through Northwest Evaluation Association's Measures of Academic Progress (NWEA MAP). Measures of implementation fidelity will show us if CSMC teachers need more time, support, or resources in order to complete the micro-credential. Research partner, AIR, will conduct direct teacher interviews through check-in calls with a sample of participants (n=35). These fifteen minute sessions will reveal barriers to participation and professional learning, and information will be shared with OVEC's project director. Our collection of student data also supports continuous improvement. Participating districts' use of adaptive formative assessment, NWEA MAP, will allow the project to track student growth over the academic year. AIR and OVEC will analyze data from three testing windows each year, discuss trends in math performance, and propose additional supports.

5. The extent to which the results of the proposed project are to be disseminated in ways that will enable others to use the information or strategies

The collaboration among OVEC, AIR, and BBI will result in a field-tested computer science micro-credential for elementary and middle school teachers as well as the 756 computer science lessons developed by teachers and aligned with Kentucky's standards. Through dissemination activities in Years 4-5 we will share findings related to our project in ways that will allow others to use the information for further research, to drive recommendations for changes in policy and practice, or for development of similar micro-credential offerings. Specifically, OVEC, AIR, and BBI will propose to present CSMC findings at conferences such as the American Educational Research Association and the International Society for Technology in Education. We will also submit papers to peer-reviewed journals, including *The American Educational Research Journal* and *Education and Information Technologies*. Four teacher leaders will be recruited from project participants to present at statewide conferences, such as those held by the Kentucky Society of Technology in Education and the Kentucky Council of Teachers of Mathematics.

The Computer Science Micro-Credential has significant potential for commercialization and scalability and could, therefore, increase the number of qualified computer science teachers and access to rigorous coursework for students. That access could be life-changing, particularly for students living in poverty or rural areas, and for girls and racial/ethnic minority students who have been under-represented in this high-growth, high-wage field. With only 72 newly certified computer science educators in 2016, an evidence-based micro-credential could serve as a desirable and cost-effective alternative, emergency, or provisional certification. BloomBoard has interest from multiple states on this micro-credential (see Letter of Support, p. 44).

C. Quality of the Project Evaluation

AIR will conduct an independent evaluation of CSMC that will include an implementation study to inform immediate program improvement and an assessment of program impact designed to meet WWC standards without reservations. Research questions (RQs) 1–4 focus on the impact of CSMC on teachers' content knowledge and students' math achievement, and RQs 5–6 focus on program implementation evaluation (see Section C.1). Section C.2 defines the valid and reliable performance data used to answer each RQ. Section C.3 defines fidelity thresholds for the key program components and the mediators to be assessed during the evaluation.

Impact Questions:

(RQ 1) What is the impact of CSMC on teachers' computer science content knowledge?

(RQ 2) What is the impact of CSMC on student math achievement in Grades 3–8?

(RQ 3) To what extent does teachers' content knowledge mediate the impact of CSMC on student math achievement?

(RQ 4) To what extent do student and classroom characteristics moderate (increase or decrease) the impact of CSMC on student math achievement?

Implementation Questions:

(RQ 5) To what degree is CSMC implemented with fidelity?

(RQ 6) What are the barriers and facilitators of CSMC's implementation?

1. The extent to which the methods of evaluation will, if well implemented, produce evidence about the project's effectiveness that would meet the What Works Clearinghouse standards

We will produce strong evidence about CSMC effectiveness using an experimental design that will generate findings expected to meet WWC evidence standards without reservations. The impact evaluation to answer RQs 1–4 will use a blocked cluster randomized controlled trial (RCT), with AIR randomly assigning teachers within school blocks to either participate in the CSMC program or continue with "business-as-usual" professional development (PD). This approach allows for comparisons among teachers within a common school context, which increases statistical power to detect effects, reduces costs, and enables us to examine the distribution of impacts across schools. Our intent-to-treat samples of 140 volunteer teachers and the 8,400 students they serve will be identified prior to randomization.

The main threat to internal validity for this design is potential selection bias resulting from sample attrition. AIR will carry out random assignment as late as possible at the beginning of each evaluation year to minimize attrition. Attrition risk also is lower because CSMC is completed within one school year, compared to the risk of losing participants in multiyear interventions. Attrition also can result from missing outcome data, which this design minimizes by leveraging student achievement based on district administrative records and by providing incentives to teachers for survey completion. Another potential challenge is crossover effects (i.e., teachers in the control group obtain materials or learn skills from teachers in the CSMC group). Because only teachers assigned to CSMC will have accounts to the online BBI platform, crossover effects will be unlikely, but we will document any occurrences. Previous studies of teacher PD with teachers randomized within school have found little evidence of teachers sharing what they learned (e.g., Garet et al., 2016).

Sample. The study will include a large sample representing urban and rural districts across northern Kentucky with racial diversity (see Table I.3 in Appendix I). It will include 140 teachers in 35 schools across years 2 and 3. The evaluation is powered to detect a minimum detectable effect size (MDES) of 0.23 for teacher outcomes, a reasonable MDES given significant effect sizes of 0.24 to 1.5 using teacher survey measures found in previous STEM PD intervention studies (e.g., Meyers et al., 2016; Newman et al., 2012). For student-level outcomes our MDES is 0.14, also a reasonable effect size given the focus on grades 3-8 in which education interventions have demonstrated effects ranging from 0.15 to 0.89 on standardized math tests achievement (e.g., Lipsey et al., 2012; Lynch et al., 2019; see power calculations, Appendix I.4).

Analyses of impact (RQs 1–4). We will employ intent-to-treat analyses to estimate the impact of being randomly assigned to participate in CSMC (see Appendix I.5 for technical details of all analytic models). To answer RQ 1, we will use a single-level model with school fixed effects to assess teacher content knowledge. School fixed effects (or blocks) ensure that only teachers within the same school are compared with one another, which is most appropriate in this design. We also will control for teacher/classroom characteristics (e.g., grade[s] taught and classroom demographics) to increase the precision of our impact estimates. To answer RQ 2, we will assess impacts on student math achievement using a two-level model that nests students within teachers. Again, we will control for teacher-/classroom-level characteristics, student-level characteristics (e.g., race, gender), and school blocks.

To answer RQ 3, we will estimate the extent to which teachers' content knowledge mediates CSMC's impact on student math achievement (see Appendix Figure I.5.1). We will run multiple models to calculate the mediated effect, conducting single-level models when estimating teacher survey outcomes and two-level models when estimating student achievement outcomes. We will assess the differential impacts (or moderator effects) of CSMC (RQ 4) on various types of students and classrooms by incorporating a treatment-by-moderator interaction term in the models for RQs 1–2, where the moderator is a characteristic of the student or classroom (see Appendix Table I.5.2). These results will indicate where CSMC may be best suited and suggest refinements to better support teachers and students in specific settings, and provide insights to inform later efforts to scale.

Analyses of program implementation (RQs 5–6). AIR will evaluate teacher progress and program completion by conducting descriptive analyses on online usage data from the BBI platform and attendance lists for PD activities (see Section C.3 for specific thresholds for a rubric we will use to assess acceptable implementation based on the key CSMC components). We will examine online usage data to monitor teacher (a) completion of code.org courses, (b) initiation of each online CSMC learning module, and (c) participation in online coaching. AIR also will collect and monitor attendance records to document participation in the summer workshop, in-person coaching and regional PLCs. These data will provide information on not only fidelity but also the feasibility of implementing the program as currently designed. For example, if participation or activity completion is low, we may need to consider program modifications to improve feasibility. To further inform program improvement, AIR will review the feedback from BBI microcredential assessors through teacher evidence submissions—using a rubric adapted from previous AIR studies of coaching—to ensure feedback is (a) clear and (b) actionable. Finally, AIR will calculate rates of teachers attempting and earning microcredentials to gauge how the program supports teacher success.

To understand the factors that hinder and facilitate implementation (RQ 6), AIR will conduct semistructured interviews with a sample of 18 participating teachers with varying levels of program fidelity (see Section C.3) midway through each implementation year. Interview protocols will ask teachers to share experiences about program components to allow for comprehensive teacher input. AIR will thematically code the interview data and triangulate them with the other data for a systematic review across sources.

2. The extent to which the evaluation plan clearly articulates the key project components, mediators, and outcomes, as well as a measurable threshold for acceptable implementation

The rigorous evaluation design will be bolstered by using multiple, well-established, valid, and reliable outcome measures that capture the key constructs in the logic model. See Appendix I.1. for a summary of all proposed data collection.

Teacher content knowledge. As shown in the logic model (Appendix I, p. 78), teacher participation in CSMC is hypothesized to lead to improved teacher computer science content knowledge. AIR will develop and administer survey items to capture teacher knowledge of the

K–12 CS Framework per the focus of the CSMC program. We also will use the Computational Thinking Scales to assess teacher content knowledge in algorithmic and critical thinking and problem solving. Research with adult populations has demonstrated validity of the scales through factor and item distinctiveness analysis as well as strong reliability (alpha = .82; Günbatar & Bakırcı, 2019; Korkmaz et al., 2017; Tang et al., 2020). Last, we will ask treatment and control teachers to report on the computer science PD in which they engaged across the year to assess "service contrast." Teachers will complete an online survey using an individualized link distributed via e-mail; completion will be incentivized by a [redacted].

Student math achievement. Computational thinking has been shown to engage similar cognitive processes as math (i.e., spatial ability, problem-solving) (National Research Council, 2010; Román-González et al., 2016), and instruction in computer science has been empirically linked to improvement in K–12 math performance (Rodríguez-Martínez et al., 2020). We will capture student math achievement, a key outcome in the logic model, using two well-established measures: the Kentucky statewide assessment (K-PREP) and the Northwest Evaluation Association Measures of Academic Progress (MAP) math assessment. These are authentic, educationally relevant assessments already embedded in the educational settings. The K-PREP will allow the evaluation to examine program impacts using a state policy-relevant measure. The MAP assessment is an adaptive computerized test that has demonstrated strong reliability in studies conducted across all 50 states, including Kentucky (marginal reliability coefficient = .920 to .981; NWEA, 2011) and has concurrent validity with numerous state assessments (r = .64 to .88). This will allow the evaluation to build evidence of program effectiveness using an outcome widely used in the U.S., making the findings relevant for contexts beyond Kentucky. For both measures, we will analyze student scores from spring administrations of each evaluation year.

3. The extent to which the methods of evaluation will provide valid and reliable performance data on relevant outcomes.

The evaluation design is informed by clearly articulated key components, mediators, and program outcomes, as described in the evaluation plan (Section C.1) and depicted in the logic model (Appendix I, p. 78). The five key components of the CSMC program are a summer workshop, coaching sessions, regional PLCs, participation in Code.org courses, and the submission of documentation in order to earn CSMCs (see Section A.3). The logic model specifies key outcomes for teachers (i.e., computer science content knowledge) and students (i.e., math achievement), as detailed in Section C.2. Teachers' computer science content knowledge will also be a key mediator for the impact of CSMC on math achievement.

We will develop and validate implementation measures and associated thresholds for all five program components to assess implementation fidelity. Based on a review of RCTs that produce the intended impacts (Durlak & Dupre, 2008), the initial proposed **thresholds for low (<60%), moderate (60–80%), and high (80%+) fidelity levels** are based on the percentage of participating teachers who (a) attend the summer curriculum alignment workshop, (b) participate in at least five coaching sessions (in-person or through video conference); (c) participate in four regional PLCs; (d) complete five Code.org courses; and (e) submit evidence for review to earn CSMCs at least five times during the year. The data collected from these measures will also be used to identify and recruit teachers with variation in implementation fidelity to our interview sample (see Section C.1). Measures such as project documentation records and user interviews are commonly used metrics for assessing implementation fidelity (Mowbray et al., 2003), and the proposed thresholds meet the criteria for "high fidelity" as defined by a review of the implementation literature (Hill & Erikson, 2019), while allowing for further exploration of productive adaptations to inform continued program improvement (Quinn & Kim, 2017).