Improving Pre-Engineering and Computer Science Education Through Micro-Credentialing

Absolute Priority #1 (Demonstrates a Rationale)
Absolute Priority #3 (Field-Initiated Innovations—Promoting STEM Education)
&
Competitive Preference Priority (Expand access to and participation in rigorous computer science coursework)

Project Narrative

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Significance

Potential Contribution of Proposed Project to Increased Knowledge or Understanding

This proposed project is intended to support the development, implementation and feasibility testing of teacher micro-credentials as a set of scalable, competency-based certifications to improve the rigor and quality of pre-engineering and computer science instruction in Louisiana's STEM Jump Start Pathways. Louisiana's Jump Start Pathways—of which there are more than 50 in areas from nursing to welding—are comprised of curricula, career courses and workplace experiences developed by regional teams of school systems, colleges, and workforce experts in coordination with the Louisiana Department of Education (LDOE). Few studies have examined methods for preparing and supporting teachers' instruction in advanced science subjects like engineering and computer science (Martinez, Gómez, Moresi, & Benotti, 2016; Rinke, Gladstone-Brown, Kinlaw, & Cappiello, 2016; Thompson & Bell, 2013). While a small number of studies have suggested that micro-credentials are a promising strategy for improving teacher instruction (Murphy & Mancini-Samuelson, 2012; Acree, 2016), no studies of which we are aware have examined using micro-credentials for advanced teacher certification across a state, and no studies have employed a rigorous evaluation to investigate the causal impacts of teacher micro-credentials on STEM teaching and learning.

Growing Demand for Engineering and Computer Science Training

Fayer, Lacey, & Watson (2017) estimates that the number of STEM jobs between 2016 and 2026 will increase at a much faster rate than jobs in other fields. Engineering and computer science fields, in particular, face shortages. More than 500,000 computer science-related jobs have remained unfilled over the past few years (Godfrey, Bernard, & Miller, 2016; Kessler, 2017). About 82 percent of employers who hire engineers struggle to fill open positions (ManpowerGroup, 2017).

Louisiana's economy represents a microcosm of these national challenges. Many of the projected new jobs in Louisiana are "middle-skill" jobs that require high school and some additional training in engineering and computer-science related fields, but not a Bachelor's degree (National Skills Coalition, 2017). Louisiana's Pre-Engineering and Digital Design & Emergent Media (DDEM) Pathways are a response to a shortage of workers for Louisiana jobs projected to be areas of significant growth over the next several years (Louisiana Workforce Commission, 2017). The ambitious goal of the Pre-Engineering and DDEM Pathways: to provide students with the industry-based credentials they need to enter a middle-skills job or a college major in an engineering or digital design field after graduation (see LDOE, 2018a and 2018b for the high-demand careers for each of these Pathways, as well as the course sequences and requirements). To accomplish this lofty goal, the Pathways provide high-quality courses focused on enhancing students' 21st century skills, developing their computational thinking ability, and applying math and science to solve complex problems. The curricula for these Pathways have been developed by Louisiana State University (LSU) in partnership with LDOE. Over 40% of the courses within each pathway are computer science courses (e.g., Introduction to Computational Thinking and Data Manipulation and Analysis, among others) (LDOE, 2018a; 2018b).

No Scalable Certification Systems to Prepare Louisiana Advanced Science Teachers

The numbers of Louisiana high schools that have begun to offer the Pre-Engineering and DDEM Pathways has grown exponentially, from the original pilot school in 2016-2017, to seven schools in the 2017-2018 school year, to more than 30 for the 2018-19 school year. This huge growth reflects the high need and demand for these pathways.

For these pathway courses to live up to their goal of preparing students for jobs and college majors, they must be taught by qualified teachers who provide high-quality instruction closely aligned with the designed sequences and the requirements for industry-based credentials.

However, across the U.S.—and in Louisiana—there are almost no scalable certification systems to prepare teachers of advanced STEM courses, particularly the computer science courses which are included in the Pre-Engineering and DDEM Pathways. In 2015, only 51 college graduates in the country received a certification to teach in computer science (Title II, 2015). Engineering is even further behind than computer science; despite the documented increase in engineering employment, many high schools do not yet have standalone engineering courses (Virani and Burham, 2017) and thus, very few states have engineering-specific pathways to teacher certification. Current certification processes also do not have the flexibility to incorporate upskilling for current teachers of advanced science subjects, despite that advances in the STEM fields require that science teachers engage in continuous learning in order to convey relevant knowledge and skills to students (Thompson & Bell, 2013). The lack of robust teacher certification processes to anchor the Jump Start Pathways jeopardizes the Pathways' ability to prepare students for jobs in these fields.

In addition to the lack of scalable certification systems for STEM teachers, little is known about the best methods for preparing and supporting teachers to teach in advanced STEM subjects. One study found that elementary teachers who participated in a preparation program that integrated STEM literacies like engineering design and computer coding reported greater gains in STEM teaching efficacy and better facilitation of STEM content to students (Rinke, Gladstone-Brown, Kinlaw, & Cappiello, 2016). A few other studies have suggested that professional development in computer science instruction can improve teachers' instruction and self-efficacy to teach computer science (Martinez, Gómez, Moresi, & Benotti, 2016; Thompson and Bell, 2013). However, the reported professional development in these studies varied, and the surveys employed did not capture the nuances of the preparation and support that teachers received.

Louisiana is further ahead than the rest of the nation in providing support for teachers of advanced science subjects. In order to teach courses in the STEM Jump Start Pathways, teachers are currently required to attend six intensive summer weeks of graduate-level training courses offered by Louisiana State University (LSU) related to the courses they intend to teach, as well as eight highly encouraged Saturday sessions. The training courses reflect the content of the courses that teaching candidates will be expected to teach (e.g., Introduction to Engineering and Introduction to Computational Thinking). Teaching candidates must complete these courses and receive qualifying scores on the same end-of-course assessment their students will take in the course that they wish to teach. Despite these training requirements for Jump Start teachers, there are no existing, scalable certification mechanisms that give teachers the opportunity to demonstrate their preparedness to teach students in the STEM Pathways.

Micro-Credentialing as a Promising New Strategy that Builds On Existing Strategies

Teacher micro-credentials are a promising strategy for improving preparation and support for teachers of advanced science subjects. Given the dearth of programs that prepare teachers to provide computer science instruction, Code.org (2017) suggested that states might explore use of micro-credentials that allow teachers to teach computer science courses upon submitting a portfolio of evidence from their daily classroom practice demonstrating that they have developed the requisite competencies. In 2017, LDOE incorporated BloomBoard, Inc. (BBI) micro-credential programs into its distinction process for ELA and Math Content Leaders, as well as Mentor Teachers, and the Board of Elementary and Secondary Education (BESE) approved these programs to provide ancillary certification starting July 1, 2019 (Louisiana BESE, 2018). The certificates will lead to increased opportunities for teachers seeking to remain in the classroom, and may account for 40 percent of the experiential requirements for an Educational Leadership

Certificate. LDOE aims to build upon this promising new strategy to address the need for similar training and certification within STEM Pathways. The micro-credential programs designed by BBI—which will be used for this project—are supported by teacher learning research, including job-embedded cycles of inquiry, teacher portfolios, and rigorous feedback and evaluation.

Job-Embedded Cycles of Inquiry. BBI micro-credentials are grounded in cycles of inquiry and uniformly organized based upon the "ADDIE" model of instructional design. (Donmez and Cagiltay, 2016). Accordingly, teachers engage in the following steps to earn BBI micro-credentials: *Analyze, Design, Develop, Implement, and Evaluate.* Such cycles reflect processes for continuous improvement (Bryk, Gomez and Grunow, 2011; DeMonte, 2018), and are consistent with the finding that successful micro-credentialing programs are ones that encourage teachers to apply skills to classroom practice (Acree, 2016). Additionally, based on research suggesting that teacher collaboration is associated with learning gains (Harwell, D'Amico, Stein and Gatti, 2000), BBI encourages its partner organizations to use BBI's online micro-credentialing platform (the "BBI platform") to promote meaningful collaboration amongst educators engaging in these cycles of learning, including expert coaching and facilitation.

Portfolio-Based Learning. BBI-designed micro-credentials are a form of professional learning that involves teachers developing portfolios of evidence regarding their everyday classroom instruction, allowing them to demonstrate mastery in multiple ways (Acree, 2016)**.** Teachers regard the development of portfolios as an important learning activity that allows them to reflect on their teaching practice (Gearhart and Osmundson, 2009), and studies have linked portfolio development with improved teaching performance, self-reported teacher learning, and student achievement gains (Chung, 2008; Sato, Wei and Darling-Hammond, 2008).

Rigorous Evaluation and Assessment. A final key aspect of BBI micro-credentials is the rigorous third-party evaluation of each teacher's micro-credential portfolio submissions by expert assessors. BBI trains and certifies each assessor—based on their ability to score teachers' submissions reliably—to ensure they have the knowledge they need to provide a strong review with meaningful, consistent feedback, and assessors also participate in a calibration processes with other raters to ensure strong inter-rater reliability.

All these features of micro-credentials, taken together, suggest that micro-credentials are a promising avenue for preparing and supporting teachers of advanced science subjects, especially given that these teachers lack such advanced training options through traditional professional development. Yet, because such systems have just recently been developed and have not been initiated at any scale, we have no causal evidence on their effectiveness. Most of the current research on micro-credentials focus on teacher feedback about their experience and their perception of its effectiveness. Looking across 15 micro-credential programs, Acree (2016) found that most teachers report applying what they have learned through micro-credentials to improve their instruction. Other survey research indicates that teachers enjoy earning micro-credentials and report instructional improvement in the process (Teaching Matters, 2016; Digital Promise, 2016).

Louisiana's Jump Start Pre-Engineering and DDEM Pathways are fertile ground for the development, implementation and study of use of micro-credentials for improving teacher instruction and providing a scalable, competency-based certification system for Pathway teachers. The Pre-Engineering and DDEM Pathways have expanded to 30 schools for the 2018-19 school year, with almost 1,600 students enrolled, including 72 percent "high-needs" students (as defined in the abstract for this proposal) and 60 percent Black or Hispanic students. However, to succeed,

students need rigorous instruction from qualified teachers with demonstrated content knowledge and pedagogical skills. Those who wish to teach on the pathways are currently receiving as much training as LDOE and LSU have the capacity to offer. Yet, these teachers likely need hands-on time in the classroom delivering the content to actual students to be truly effective and improve student achievement, which can be promoted and monitored through micro-credentials requiring teachers to demonstrate competencies by uploading artifacts of their classroom practice (e.g., videos of instructional delivery, student work examples).

In addition to providing teachers with more training to teach advanced science subjects, micro-credentials could also create viable, competency-based certification systems for teaching in STEM Pathways. Currently, no such certification systems exist. Instead, teachers are allowed to teach Pathway courses if they attend the intensive summer training, complete all course work, and score 80% or higher on the same final exam their students will take at the end of the school year. If a micro-credential system is put in place for the Pre-engineering and DDEM Pathways—and evidence connects the micro-credentials with higher-quality teaching and improved student learning, as well as demonstrates the potential for its sustainability—the program could be spread to other Jump Start Pathways and impact more students.

Project Design

Clearly Specified, Measurable Goals, Objectives, and Outcomes

This project involved three key goals, which LDOE will undertake in partnership with LSU and BBI, along with independent evaluation through RAND Corporation. Project goals, objectives and measures are summarized in Table 1 and described in more detail in this section.

Goal 1: Develop, pilot and refine micro-credentials for teachers in Pre-Engineering and DDEM Pathways that provide a scalable, competency-based certification system

The first goal to develop the micro-credentials will require LSU to work in partnership with BBI—with LDOE oversight—to plan and develop micro-credentials that address key gaps in teachers' current training and focus on major competencies that teachers need to teach in the

Table 1. Project Goals, Objectives and Outcomes for Years 1-4 (Y1-Y4)

Goals and Objectives	Outcomes/Measures
Goal 1. Develop, pilot and refine micro-credentials for teachers in Pre-Engineering and DDEM Pathways that provide a scalable, competency-based certification system 1.1 In Y1, develop and pilot micro-credentials 1.2 In Y1, refine micro-credentials based on pilot feedback	1.1.1 5-10 volunteer teachers of Pathway courses pilot the micro-credentials 1.2.1 18 teacher micro-credentials are created and refined through the development process
Goal 2. Implement the micro-credentials successfully with a randomly selected cohort of teachers who progress through the credentials and receive certifications 2.1 In Y2, incentivize and randomly assign teachers to enroll in the micro-credentials 2.2 In Y2, provide teachers pursuing micro-credentials with expert facilitation and feedback from assessors to improve their teaching 2.3 In Y2, teachers complete the micro-credentials, including teachers of high-needs students	2.1.1 53 teachers are randomly assigned to complete the micro-credentials 2.2.1 90% of teachers progress through the micro-credentials as intended (as noted in Fidelity measures) 2.3.1 85% of teachers complete all the micro-credentials 2.3.2 At least 1,500 students are taught by teachers who receive the micro-credentials, including 1,080 high-needs students, by beginning of Y3
Goal 3. Improve teaching and learning through implementation of micro-credentials 3.1 In Y2 and Y3, participating teachers report greater feelings of preparedness and provide students with more opportunities to learn Pathway curricula content 3.2 In Y2 and Y3, students of participating teachers report more engaging and challenging instruction, and experience higher achievement 3.3 The number of teachers qualified to teach pre-engineering and computer science courses within the pathways increases in Y2 through Y4	3.1.1 90% of teachers meet fidelity of implementation measures set for micro-credentials 3.1.2 75% of participating teachers report feeling prepared to teach Pathway courses, and provide opportunities for students to learn Pathway curricula content 3.2.1 75% of teachers' students report engaging and challenging instruction from their teachers 3.2.2 60% of all students receive scores of proficient or higher on standardized mathematics and science assessments, as well as 50% of high-needs students 3.3.1 At least 45 additional teachers are qualified through the micro-credential program by the end of the grant, impacting at least 1,500 more students and 1,080 high-needs students
Goal 4. Improve, spread and sustain the micro-credential model in Louisiana 4.1 Provide feedback for ongoing improvement and sustainability 4.2 Execute independent study examining development, implementation effects of micro-credentials 4.3 In Y3 and Y4, embed the micro-credentials in teacher training, and design policy incentives and requirements related to micro-credentials	4.1.1 Estimates provide cost per student for provision of micro-credential, starting in Y2 4.1.2 Data and annual briefings provide feedback to inform design and implementation of micro-credentials 4.2.2. Public report in Y3 summarize the development process and best practices micro-credential development 4.2.3 Public report in Y3 providing findings regarding implementation and outcomes of micro-credentials 4.3.1 Policy incentives and requirements for micro-credentials introduced to Louisiana BESE

Pre-Engineering and DDEM Pathways. Table 2 displays the current plan for micro-credentials that will be developed, although the development period will include additional work to develop the final clusters of micro-credentials. The final clusters will serve as templates for the development of sets of micro-credentials for other current STEM Pathways; the "First Level" micro-credentials and the final three computer science "Third Level" micro-credentials are intended to be included in each set of future micro-credentials for additional STEM Pathways.

Table 2. Micro-credential Course Sequences

PRE-ENGINEERING PATHWAY MICRO-CREDENTIALS[1]	
Level	**Micro-Credential Working Titles** (subject to change)
First Level[2]	Micro-Credential 1.1: Developing Technical Reading, Writing, & Presentation Skills
	Micro-Credential 1.2: Facilitating Project-Based Learning
	Micro-Credential 1.3: Understanding Computational Thinking **(CS)**
Second Level[2]	Micro-Credential 2.1: Understanding Engineering Ethics and Safety
	Micro-Credential 2.2: Understanding the Engineering Design Process
Third Level[2]	Micro-Credential 3.1: Teaching Technical Drafting in 2D and 3D
	Micro-Credential 3.2: Teaching the Foundational Concepts of Robotics
	Micro-Credential 3.3: Teaching Electrical Circuitry and Programming
	Micro-Credential 3.4: Teaching Engineering Economics and Project Management
	Micro-Credential 3.5: Teaching the Software Development Cycle **(CS)**
	Micro-Credential 3.6: Teaching Basic Programming Skills **(CS)**
	Micro-Credential 3.7: Teaching Data Manipulation & Analysis **(CS)**
DIGITAL DESIGN & EMERGENT MEDIA PATHWAY MICRO-CREDENTIALS[1]	
Level	**Micro-Credential Working Titles** (subject to change)
First Level[2]	Micro-Credential 1.1: Developing Technical Reading, Writing, & Presentation Skills
	Micro-Credential 1.2: Facilitating Project-Based Learning
	Micro-Credential 1.3: Understanding Computational Thinking **(CS)**
Second Level[2]	Micro-Credential 2.1: Digital Media Ethics & Digital Citizenship
	Micro-Credential 2.2: Understanding the Digital Design Process
Third Level[2]	Micro-Credential 3.1: Teaching Digital Storytelling
	Micro-Credential 3.2: Teaching the Foundations of Digital Production & Practice
	Micro-Credential 3.3: Teaching Media Exhibition and the Digital Media Industry
	Micro-Credential 3.4: Teaching Programming for Digital Media **(CS)**
	Micro-Credential 3.5: Teaching the Software Development Cycle **(CS)**
	Micro-Credential 3.6: Teaching Basic Programming Skills **(CS)**
	Micro-Credential 3.7: Teaching Data Manipulation & Analysis **(CS)**

Goal 2: Implement the micro-credentials successfully with a randomly selected cohort of teachers who progress through the credentials and receive certifications

This goal requires that teachers are willing to be randomly assigned to enroll, progress

[1] Teachers will be asked to complete three micro-credentials from Level 1, two micro-credentials from Level 2, and two micro-credentials from Level 3.
[2] The six shaded micro-credentials (1.1-1.3 and 3.5-3.7) will be identical across all STEM Pathways; the others will be pathway specific.

through and complete micro-credentials despite that completion of micro-credentials will not yet be an expectation for all Jump Start teachers. We expect to have a robust sample of teachers who are willing to be randomly assigned and progress through micro-credentials for several reasons. First, 56 teachers have voluntarily completed the current summer trainings and are teaching engineering and DDEM courses in the Pathways, and LSU estimates that 60 new teachers (30 in each year) will pursue summer training in 2019-20. Thus, approximately 106 Jump Start Pathway teachers will be eligible to be randomly selected to complete the micro-credentials, taking into account that 5-10 teachers will pilot the micro-credentials before they are tested through a randomized-controlled trial. Second, teachers will be provided with a $1,000 stipend if they are assigned to take the micro-credentials and complete them, which will encourage most eligible Pathway teachers to volunteer to be part of the pool of teachers eligible to be randomly assigned to take the micro-credentials. Lastly, existing, recently-developed micro-credential programs in Louisiana to certify teachers as content leaders and mentor teachers are popular; although those micro-credential programs just began last year, over 600 teachers have voluntarily completed those programs to date. The success of Louisiana's existing micro-credential programs suggests that this new focus on STEM teaching credentials will attract a lot of teachers.

RAND will work with LSU to recruit teachers who are willing to be randomly assigned and aims to select approximately 53 teachers to earn the micro-credentials over the course of the second year of the project (2020-21). To earn micro-credentials using the BBI platform, the teachers will log into their BBI account and be directed to the appropriate set of micro-credentials (Pre-Engineering or DDEM). The platform directs teachers through learning cycles that include preparation activities (LSU training materials and some suggested supplementary materials in this case), requirements for what artifacts and evidence to submit, and scoring rubrics for each ADDIE component. Teachers participate in learning cycles in collaboration with peers in their cohort—

with whom they can share ideas and resources via a Discussion page in the platform—and support of a certified facilitator. Then, they submit evidence (e.g., student work examples, video of instruction) reflecting how they applied their newly-learned competencies in the classroom. To earn the micro-credential, the teacher must earn a "Demonstrated" score for the evidence they submit for each component, based on a rating from a certified assessor. If the teacher receives a "Progressing" or "Not Met" score, they can review their feedback and receive support to resubmit.

BBI platform reporting tools will also provide ongoing data to facilitators and designated administrators from BBI, LDOE and LSU regarding how well teachers are progressing through the micro-credentials, and teachers who are not progressing as intended can receive support.

Goal 3: Improve teaching and learning through implementation of micro-credentials

The performance assessments in which teachers engage to complete the micro-credentials are expected to provide them with greater feelings of preparedness, given that micro-credential tasks ask them to apply what they have learned in training to their instruction, which in turn can lead to short- and long-term improvements in teaching and learning. Our logic model provides details on the expected relationships among resources, proposed project activities and outputs and outcomes. Little is known about this promising new approach to providing teachers with the job-embedded training and certification they need to support student learning in advanced subject areas. Our evaluation approach to studying the development and implementation of micro-credentials, as well as conducting a random controlled trial to study their effects, promises to provide evidence that could support the spread of micro-credential programs in advanced science subjects where there is a crucial need for better mechanisms for teacher preparation and support.

Goal 4. Improve, spread and sustain the micro-credential model in Louisiana

This project is designed to improve, spread and sustain the micro-credential model through several mechanisms. First, as we will discuss, this project will follow tenets for continuous

improvement and design-based implementation research that will support iterative improvement to the micro-credential model. Second, based on their work to evaluate and document micro-credential development and implementation, RAND will publish a report that summarizes what it takes to develop strong micro-credentials for engineering and computer science teachers, as well as prospective implementation challenges. Third, LDOE will use continuous improvement and evaluation data to make determinations about the design of resources, incentives and policies to support broader implementation of the micro-credentials across Louisiana.

Quality of Conceptual Framework and Logic Model Underlying the Proposed Research

Our logic model builds on considerable existing resources to support the development and implementation of micro-credentials to prepare teachers of engineering and computer science courses in Jump Start Pathways. These resources include Pre-Engineering and DDEM Pathways of course sequences and curricula designed by LSU in collaboration with LDOE and input from workforce and higher education partners, in which students in 30 schools are already participating. These partnerships are already in place and can be leveraged to provide ongoing feedback on the development and research on the micro-credential program. Our work also builds on the existing experience and expertise of BBI and LSU to design a strong set of micro-credentials reflecting both best practices for micro-credential programs and strong content and pedagogical expertise in engineering and computer science.

The activities and outputs in our logic model are closely aligned and intended to lead to short-term outcomes that begin with improved instruction. Specifically, the key characteristics of micro-credentials that will underpin their development—including job-embedded cycles of inquiry, portfolio-based learning and rigorous assessment—are tied with improvements to teaching (Richardson & Liang, 2008) and learning (e.g., Chung, 2008; Sato, Wei & Darling-Hammond, 2008; Cotabish et al., 2011). By improving the quality of teachers' instruction, micro-

credentials have potential to improve students' motivation to pursue STEM college or career (Chang, 2015; Akinsola & Olowojaiye, 2008; Tok, 2015), their retention and completion of courses, and improved student learning and achievement (Cotabish et al., 2011; Tok, 2015), eventually leading to better student postsecondary outcomes including college enrollment and careers in STEM.

Adequacy of Procedures for Ensuring Feedback and Continuous Improvement

Three main mechanisms will be put in place to ensure feedback and continuous improvement throughout the grant period. First, through annual webinars highlighting current project work and findings, LDOE, LSU and BBI will seek feedback from higher education and industry partners on the development of the micro-credentials and their implementation to ensure the micro-credentials and the plan for a scalable competency-based teacher certification system is aligned with expectations of students in the Pre-Engineering and DDEM Pathways.

Second, BBI will offer customized training sessions to coach teachers on the process of engaging in competency-based professional development, convey best practices for preparing and submitting the portfolios required to earn a micro-credential, and provide guidance on how to efficiently navigate the BBI platform. In addition, the project team will use the reporting tools built into the BBI platform to obtain data regarding the progress and levels of success of teachers who are enrolled in the Pre-Engineering and DDEM micro-credential programs. BBI also uses survey data from participants to gauge the teachers' perceptions of the program and identify opportunities for enhanced participant support and program refinement.

Third, the partners for this project will collaborate with RAND to engage in design-based implementation research (DBIR), using the data RAND and BBI collect along with feedback from all stakeholders. As recommended through research on DBIR and continuous improvement (e.g., Penuel, Fishman, Haugan, Cheng and Sabelli, 2011; Coburn, Penuel & Geil, 2013), this work will

involve ongoing discussion and research to identify key challenges associated with development and implementation; a commitment among partners to iterative design aimed at developing solutions to these problems and challenges; and regular discussion about how the project is leading to improvements in teaching and learning. DBIR work will be made possible through monthly calls with LDE, LSU, and BBI staff to solicit information about program implementation and provide updates on evaluation progress and findings to date, and annual webinars developed by RAND in collaboration with partners to solicit feedback from stakeholder.

Management Plan

Adequacy of Management Plan to Achieve the Objectives on Time and within Budget

Table 3 provides a timeline of activities, as well as responsible personnel. This timeline allows a year to ensure adequate time for the development and testing of the micro-credentials so that they can be refined prior to our experimental study to examine the implementation and outcomes associated with them. Importantly the teachers who are randomly selected to complete the micro-credentials are studied and compared to control teachers who do not take the micro-credentials for a full two-year period before any additional Jump Start teachers are given the opportunity to take the micro-credentials. This timeline allows RAND to gather data on teaching and learning for a full year after teachers have completed the micro-credential in order to understand long-term impacts of the micro-credentials. This timeline also provides ample time for partners to reflect upon implementation and how to improve it before fully embedding the micro-credentials in professional development and policy structures in Louisiana.

Qualifications of Key Project Personnel

LDOE and its partners have put together a strong team whose qualifications will position the project to achieve significant results. More details on all team members are included in Appendix B of this report. LDOE, LSU and BBI will be responsible for the project design, meeting

Table 3. Project Timeline

Goal 1: Develop, pilot and refine micro-credentials for teachers in Pre-Engineering and DDEM Pathways that provide a scalable, competency-based certification system		
Activities	**Timeline**	**Responsible Staff**
Develop preliminary micro-credential content and configure BBI platform to deliver program content	Fall 2019-Winter 2020	LSU and BBI
Pilot micro-credentials with small set of teachers	Winter 2020-Spring 2020	BBI
Train and calibrate micro-credential facilitators	Winter 2020-Spring 2020	BBI
Train and calibrate micro-credential assessors	Winter 2020-Spring 2020	BBI
Refine micro-credentials based on pilot and calibration	Spring 2020-Summer 2020	LSU and BBI
Monitor and document development process	Fall 2019-Summer 2020	RAND
Goal 2: Implement the micro-credentials successfully with a randomly selected cohort of teachers who progress through the credentials and receive certifications		
Recruit teachers for random selection	Summer 2020	LDOE, LSU and RAND
Randomly select teachers to take micro-credentials	Summer 2020	RAND
Teachers undertake and complete micro-credentials, receiving training and monitoring to support their progress	Fall 2020-Spring 2021	LSU and BBI
Goal 3. Improve teaching and learning through implementation of micro-credentials		
Collect qualitative and quantitative data on whether micro-credentials are implemented as intended	Fall 2020-Spring 2021	RAND
Develop, administer and analyze teacher logs to gather data on teachers' instruction	Administration in Fall 2020 and Fall 2022	RAND
Develop, administer and analyze student surveys to gather data on students' STEM efficacy, motivation and perceptions of their instruction	Administration in Fall 2020 and Fall 2022	RAND
Gather and analyze secondary outcomes data	Ongoing	RAND
Goal 4. Improve, spread and sustain the micro-credential model in Louisiana		
Monthly partner meetings	Ongoing	Coordinated by LDOE
Annual public webinar on progress and findings to date	Summer, annually	All partners
Report on what it takes to develop and implement micro-credentials	Fall 2021	RAND with partner input
Final report on implementation and outcomes associated with micro-credentials	Summer 2023	RAND with partner input
Embed micro-credentials in professional development and policy structures in Louisiana	Fall 2021 - Summer 2023	LDOE and LSU

project goals, and grant management. **Jill Cowart** (Assistant Superintendent of Academic Content, LDOE) and **Breigh Rhodes** (Director of Math, Science and STEM, Academic Content, LDOE) will lead the state team overseeing the project and ensuring all key deliverables are met in the given timeframe, as well as provide regular feedback to partners. Both Ms. Cowart and Ms. Rhodes have experience as STEM educators and state administrators supporting STEM programming.

Faculty from LSU will work with BBI to develop the content of the micro-credentials and ensure they are aligned with current Pre-Engineering and DDEM coursework, industry and higher education needs, and existing LSU training, as well as help ensure BBI third-party assessors are trained to perform rigorous evaluations of micro-credential portfolios. **Dr. Frank Neubrander**

(D.D. Smith Alumni Professor of Mathematics, Interim Executive Director of the Cain Center, and Gordon A. Cain Chair for STEM Literacy) will lead the LSU project team with support from: **Dr. Jesse Allison** (Associate Professor with a joint appointment at LSU's School of Music and the Center for Computational Technology), who leads the curriculum development and teacher training for the DDEM Pathway; **Mr. Fernando Alegre** (Research Associate, Computational Thinking and Coding Education and Training Coordinator and Lead Curriculum Writer); and **Ms. Vanessa Begat** (instructor in the College of Engineering and Associate Director in the Cain Center at LSU), who is the lead curriculum writer for the Pre-Engineering Pathway courses and the primary Pre-Engineering trainer for the intensive summer training.

In consultation with LDOE and LSU, BBI will develop and refine the micro-credential content; train participants to use the BBI platform; train, calibrate, and manage the expert assessors and facilitators; and train the project team to use the BBI platform reporting tools to monitor teachers. **Mr. Jason Lange** (BBI President and Co-Founder) will oversee the BBI team. **Ms. Kelly Montes De Oca** (BBI Chief Learning Officer) will oversee micro-credential development and refinement with **Mr. Jason Gordon** (Senior Learning Strategist) and will also develop and manage BBI's participant training program. **Dr. Allison Powell** (Senior Learning Strategist) will deliver BBI's training program to teachers and will also oversee the training and calibration of cohort facilitators. **Mr. Ed Vandenberg** (Senior Learning Strategist) will oversee the training and calibration of micro-credential assessors.

Lastly, researchers from RAND Corporation with considerable experience leading and coordinating evaluations of education policies at the state and district level and their implementation—as well as executing large-scale randomized control trials and outcomes analyses— will be responsible for evaluating key aspects of implementation and outcomes. **Dr. Julia Kaufman** (Policy Researcher) will be Primary Investigator for the evaluation, overseeing

all aspects of the study, leading the evaluation of implementation and facilitating design-based implementation work. **Dr. Christopher Doss** will serve as Co-Primary Investigator and will lead the impact portion of the evaluation. **Monica Mean** (Policy Analyst) will serve as a project coordinator, as well as a researcher on the project.

Potential for Continued Support of the Project after Federal Funding Ends

This micro-credential program will be likely to continue after federal funding ends for several reasons. First, upon testing the program with an initial cohort of teachers, LDOE intends to formalize the program through BESE approval as an ancillary certificate program required for teachers who teach in the Pre-Engineering and DDEM Pathways. As with the ELA and Math Content Leader and Mentor Teacher ancillary certificates, we expect that these micro-credentials will support career ladders for current teachers who will have demonstrated expertise in advanced science subjects, and may also account for a percentage of the experiential requirements for an Educational Leadership Certificate. Teachers who wish to teach in these pathways—and the schools who wish to hire them—will thus be incentivized to support the monetary costs of the micro-credential program. We will also estimate per-student costs for the micro-credentials to support state planning for sustaining them. Lastly, LDOE plans to draw upon funding through Career Development Funds (CDF), which are intended to support students' access to high-value courses and training. Once the micro-credential program is developed and tested with this EIR grant, these funds can be drawn upon to support Jump Start Pathway teacher training at the cost of 6% on top of the Minimum Foundation Program formula administered for each student enrollment in qualifying courses (LDOE, 2018c).

Evaluation Plan

The RAND Corporation will lead an independent, third-party, rigorous mixed-methods evaluation of the micro-credentials. The evaluation will include: (1) a study of the development

and implementation of micro-credentials as intended; and (2) a study of the outcomes of micro-credentials. Together, the two components of the study will provide a rich understanding how micro-credentials can be developed and instituted across a diverse set of schools, and will produce data on the effects of micro-credentials on teaching practice and student outcomes **designed to meet What Works Clearinghouse standards without reservations**. Table 4 below presents the research questions that will guide the implementation and impact evaluations.

Table 4: Research Questions

Implementation Research Questions
RQ 1. How are micro-credentials developed and what lessons learned about the development process can be shared for replication?
RQ 2. How are micro-credentials implemented across partner districts and are they implemented as intended and reflected by fidelity measures?
Impact Research Questions
RQ 3. What is the effect of teacher micro-credentials on teacher retention, opportunities for learning they provide in their instruction, and attendance? How do the effects vary by teacher characteristics such as gender, ethnicity, age, years of experience and courses taught?
RQ 4. What is the effect of teacher micro-credentials on student academic, behavioral, and STEM engagement outcomes? How do effects vary by high-needs status, ethnicity, and baseline academic performance?

Evaluation to Provide Guidance about Effective Strategies Suitable for Replication

In Year 1, RAND will gather data to document the development of the micro-credentials (RQ1), using design-based implementation research lens to inform design iterations and solutions to challenges that arise over the course of the development process. Starting in Year 2, RAND will gather implementation data on fidelity measures that reflect the intended implementation of the micro-credential model (see Table 5), which can inform decisions on course corrections that could lead to improvements in outcomes and program sustainability. The implementation data will also provide information regarding the potentially effective strategies or mechanisms tied to findings from any outcomes analyses and can serve as an essential resource for other states and districts exploring whether to try out or replicate aspects of the micro-credentials in their context.

RAND will gather data on the development and implementation of the micro-credentials through the following activities: (1) documentation regarding content of the micro-credential content and performance assessments, in comparison with LSU training materials and Pathway

Table 5. Fidelity Measures for Micro-credential Implementation in Year 2

Fidelity Measures	Data Sources	Thresholds for Implementation
Micro-credentials are sufficiently aligned with LSU training and what students are intended to learn through Jump Start STEM Pathway courses	Documentation; Stakeholder meetings and interviews	100% alignment between micro-credential content for specific courses, Pathway curricula for those courses, and main foci of LSU training
Teachers progress through micro-credentials at the intended pace	BBI micro-credential platform data	# of teachers who progress through micro-credentials as intended (target=47 teachers) and complete them (target=45 teachers)
Teachers complete performance assessments and create portfolios of work that demonstrate engagement in cycles of inquiry through job-embedded tasks	BBI assessment scores Teacher surveys	# of teachers who received "Demonstrated" scores for each micro-credential (target=47 teachers) # of teachers report engagement in cycles of inquiry (target=47 teachers)
Teachers who complete micro-credentials report high feelings of preparedness to teach STEM courses	Teacher surveys	# of teachers who report high feelings of preparedness upon completing micro-credential (target=40 teachers)
Teachers who complete micro-credential demonstrate that they have integrated opportunities for students to learn key Pathway content into their instruction	Teacher logs Student surveys	# of teachers who report integrating key curricular content into their instruction (target=40 teachers) # of students who report teachers provided challenging and engaging instruction (target=1,500 students)
Stakeholders—including higher education, workforce and school system leaders—perceive micro-credentials as providing a useful signal regarding teachers' readiness to teach STEM Pathway courses	Stakeholder interviews	Proportion of stakeholders who perceive micro-credential as useful signal of preparation (target=90% of stakeholders)

curricula; (2) ongoing partner meetings and feedback provided by stakeholders during annual briefings; (3) phone and/or in-person interviews with key stakeholders—including project partners, workforce/higher education partners, district/school leaders, and a subset of participating teachers—in the spring of Years 1-4; (4) surveys of teachers participating in micro-credentials in the spring of Year 2-3; (5) teacher daily instructional logs (short surveys) to both participating and non-participating teachers of engineering and computer science courses in the fall of Year 2-3; (6) surveys to students of both participating and non-participating teachers of engineering and computer science courses in the fall of Year 2-3.

In Years 2 and 3, proposed stakeholder interview and teacher survey protocols will be guided by fidelity of implementation measures and will take place both during in-person site visits to 2-3 school systems to gather data from both leaders and teachers in the same schools. The study team will also utilize the implementation measures to guide the a priori coding schema applied in any qualitative analysis, although additional inductive coding will also document any emerging themes (Miles and Huberman, 1994; Strauss and Corbin, 1994). Researchers will conduct periodic inter-coder reliability checks to ensure consistent coding processes are followed and meet to discuss major discrepancies in coding. The surveys to participating teachers will include measures regarding the extent to which they engaged in micro-credential activities and feel prepared to teach engineering and computer science courses, drawing upon items from the Teacher Efficacy and Attitudes toward STEM (T-STEM) Survey, which was developed and validated by the Friday Institute at North Carolina State University (2012). More information about the teacher logs and student surveys is included in the next section.

Evaluation Methods to Provide Valid and Reliable Performance Data

Table 6 below presents the valid and reliable measures that will be used in the impact analysis. To answer research question 4, primary measures will be teacher logs and student surveys completed at baseline in fall 2020 and endline in fall 2022. Both the logs and surveys will be intended to measure teachers' coverage of Pathway curricular content and instructional quality, which is a primary outcome for this study. Through logs, teachers are typically asked, at the end of each day for a period of days (usually 5-20), to record aspects of their daily instruction. Studies indicate high correlations between teachers' log reports and independent classroom observations (Hill, 2015; Walkowiak, 2018), and log data on teachers' coverage of curricular content have significant relationships with student achievement (Kurz, Elliott, Kettler & Yei, 2014; Kurz, Elliott & Roach, 2015). Student survey measures of extent to which teachers provide engaging and

challenging instruction also have strong relationships with student achievement (e.g., MET Project, 2012). Some log and survey items will necessarily need to be developed to measure coverage of key content from within Pathway curricula. To provide validity evidence for the logs and surveys, RAND will consult with LSU partners to ensure the instruments address necessary Pathway curricular content, as well as pilot logs and surveys with, respectively, a small number of teachers and students to refine them before implementation to the entire cohort of treatment and control teachers.

Table 6 presents each measure connected to evaluation research question and outcomes included in the project logic model. Micro-credentials will affect the primary outcomes directly through improved teaching or by increased student learning that results from improved teaching. More student and teacher success will then improve the distal outcomes, which are exploratory analysis. All assessments and survey instruments in Table 6 have been validated through piloting and consultation with experts, and they have been found to predict external student outcomes.

Table 6: Valid and Reliable Outcomes

Research Question	Type of Outcome	Measure [Validity and Reliability Information When Available]
RQ 4	Primary Outcome	Teacher logs and student surveys [drawing upon existing valid/reliable items]
	Exploratory Outcomes	Teacher attendance, teacher retention [Considered valid outcomes in the WWC teacher training protocol (WWC, 2016)]
RQ 5	Primary Outcomes	End of course tests in Algebra I and Geometry, ACT (math and science), [alphas from 0.84-0.88 for Algebra I and 0.85-0.88 for Geometry (Data Recognition Corporation, 2017); alphas from over 0.8 to over 0.9 for listed domains (ACT, Inc., 2017)]. Math and Science Engagement Scales (MSES) [alphas of 0.75-0.89 (Wang et al., 2016)] and Panorama Surveys [alphas of 0.70 (Panorama, 2015).] Number of pathways courses taken
RQ 6	Exploratory Outcomes	Completion of basic and higher-order industry-approved credentials, on-time promotion, student attendance, suspensions, graduation, College type, enrollment and retention [Obtained through National Student Clearinghouse (NSC), which covers 97 percent of all enrollments in Title IV degree-granting institutions (Dundar and Shapiro, 2016)]

Evaluation Methods Designed to Meet WWC Standards Without Reservations

RAND will field a blocked, cluster randomized controlled trial **designed to meet What Works Clearinghouse standards without reservations**. After the micro-credentials are initially

developed in Winter 2019-20, the micro-credentials will be piloted with 10 teachers in Spring 2020. These teachers will not be included in the randomized controlled trial. At the start of the 2020-2021 school year LDOE anticipates that 106 other teachers across 50 schools will be teaching engineering and computer science courses in the Jump Start Pathways. These estimates are reasonable considering that 56 teachers across 30 schools are currently teaching in the pathways and the pathways are experiencing exponential growth. A substantial number of schools have two or more teachers leading pathways courses and these teachers often share students across courses and teach them multiple times as students progress through the pathways. Thus, teacher randomization within a school is not possible. RAND will randomly assign schools to either receive an offer to enroll in micro-credentials (treatment) or to teach in the "business as usual" condition (control). Spillover effects, or control group contamination, is much less likely to occur across schools. Teachers within a treatment school can discuss micro-credentials and how to build the required performance portfolios within the context of the pathway, which is likely to occur if the micro-credentials are eventually a state requirement. In order to increase statistical power, four schools will be placed in blocks by baseline academic performance and school composition (proportion of races/ethnicities and free or reduced priced lunch eligible). Half the schools within a block will be randomly assigned to the treatment condition and half to the control condition.

As discussed in the project design section, we are confident that teachers will elect to participate in the randomized trial for several reasons, including that Jump Start Pathway teachers have already voluntarily attended trainings to teach in the pathways and they will be offered a $1,000 stipend to participate. Furthermore, LDOE will emphasize that this is an opportunity to be an early adopter of a program in which *all teachers may eventually be required to participate.* The future of the micro-credentialing program is not dependent on the $1,000 incentive because LDOE eventually intends to integrate the micro-credentialing into the pathways program and make future

teacher participation mandatory. Randomization will occur in the summer of 2020. Teachers in treatment schools will complete the micro-credentials during the 2020-2021 school year, starting in October 2020 after all Pathway teachers and students have completed teacher logs and surveys intended to gather baseline instructional and engagement measures. Teachers in the control schools will only complete the baseline logs and surveys, not the micro-credentials in any grant year. Thus, we can analyze effects of micro-credentials up to two years after their completion.

Analysis of Randomized Controlled Trial. RAND will gather individual student and teacher data from LDOE, including baseline measures of outcomes, to estimate the effect of micro-credentials on student and teacher outcomes (RQ 4 and 5). The following model will be used:

$$Y_{ist} = \beta_0 + \beta_1 Micro_{st} + \boldsymbol{X_{ist}\beta_2} + \boldsymbol{T_{ist}\beta_3} + \alpha_b + \varepsilon_{ist} \quad (1)$$

where Y_{ist} is the student or teacher outcome measure in Table 6 of student or teacher, *i*, in school, *s*, in year, *t*; $Micro_{st}$ is an indicator for whether a school was randomly assigned the offer of micro-credentials; $\boldsymbol{X_{ist}}$ are student level covariates including race/ethnicity, gender, specialized program participation, free or reduced priced lunch status, grade level, and baseline measures of the outcome where appropriate; $\boldsymbol{T_{ist}}$ is a vector of teacher level covariates including race/ethnicity, gender, years of experience, certifications, and baseline measures of the outcome where appropriate; α_b are block randomization fixed effects; and ε_{ist} is a student or teacher level idiosyncratic error term. Standard errors will be clustered at the school level to account for the nesting of students and teachers in schools.

RAND will obtain data on all 9th through 12th grade students in pathways in treatment and control schools from LDOE. RAND will ensure balance on all student and teacher characteristics listed above, as well as baseline measures of the outcome, where appropriate. For end-of-course tests, RAND will obtain individual 8th grade mathematics standardized test performance. RAND

will obtain teacher attendance and student attendance and disciplinary data from LDOE from the year prior to randomization. Further, RAND will administer baseline teacher logs and student STEM engagement surveys the fall prior to micro-credential implementation.[3]

RAND will also look for differential treatment effects by select teacher and student characteristics. As one of the goals of the pathways program is to improve the participation of high needs and underrepresented students in STEM, RAND will look at differential effects on underserved students, including minority students and high-need students. RAND will also look at differential effects in teacher-level variables, including teacher experience, gender, ethnicity, age, and courses taught. In each case analogues of equation 1 will be used where an interaction term between $Micro_{st}$ and the student or teacher characteristics of interest is included. The coefficient on the interaction term is the estimate of the differential for the characteristic of interest.

Finally, the student and teacher level data will allow RAND to track student and teacher mobility and attrition. As required by WWC, RAND will consider the primary population of interest the students and teachers in school in the fall of 2020, immediately after randomization and exclude "joiners." RAND will follow any of these teachers and students that leave the pathways after randomization or leave any LDOE affiliated school ("attrition"). In addition to intent-to-treat estimates RAND will calculate complier average causal effects per WWC guidelines to estimate the impact of micro-credentials on teachers who complied with random assignment.[4]

[3] The remainder of the student and teacher measures do not have baseline analogues. As required by WWC, RAND will ensure balance on grade level, baseline test scores, race/ethnicity, and free or reduced priced lunch participation for students outcomes. RAND will ensure balance on teacher experience and the achievement, race/ethnicity, and free or reduced priced lunch status of students taught by the teachers in the year prior to randomization.

[4] As a secondary analysis RAND, will look at cohorts of students who enter schools after randomization. It is unlikely the random assignment of micro-credential offer will affect enrollment patterns. However, per WWC requirements, RAND will check for baseline equivalence on the aforementioned outcomes and demographic variables. If baseline equivalence is achieved, these exploratory analyses will meet WWC Standards with reservations.

Power Calculations. LDOE projects that 4,000 students will be enrolled in Pre-Engineering and DDEM Pathways in the 2020-2021 school year. They will be taught by 106 teachers in 55 schools with an average of 72 students, taught by 2 teachers, in each school. The analytical sample will contain 3,640 students and 106 teachers in 50 schools. The minimum detectable effect size (MDES) is 0.13 standard deviations (SD) for student outcomes and 0.41SD for teacher outcomes.[5] These effect sizes are reasonable given that teacher logs have been used to measure "opportunity to learn" or the degree to which teachers dedicate instructional time to cover the intended curriculum and effects have been as large as 0.50 SD (Kurtz et al., 2015). A meta-analysis of professional development found that studies of nine WWC compliant studies of professional development programs that provided intensive, continued support and feedback improved student test outcomes by an average of 0.54 SD (Yoon et al., 2007). Micro-credentials will be a year-long continuous process with ample support. Though less intensive, we are powered to detect effects one-fifth the size of the aforementioned professional development programs.

Project Components, Mediators, Outcomes, and Measurable Implementation Thresholds

Our evaluation plan notes research questions by key project goals and has established mediators and outcomes included in our logic model. In addition, our fidelity of implementation measures highlight key thresholds for acceptable implementation, which are aligned with key outcomes listed in Table 1 that provides an overview of project goals, objectives and outcomes. RAND will make a composite measure of these fidelity measures (in Table 5) and correlate it to outcomes in Table 6 to understand how fidelity measures mediate student and teacher outcomes.

[5] *PowerUp!* (Dong and Maynard, 2013) was used to calculate minimum detectable effect sizes. For student outcomes we assume a two tailed test, with 80% power, 5% probability of Type I error, an intraclass correlation of 0.05 (Hedges and Hedberg, 2007), 50 percent of student assigned to treatment group, 50% of variance in the outcome is accounted for by covariates at the student level and 60% at the school level, 76 students per school, 4 schools per block, and 13 blocks. An intra-class correlation (ICC) of 0.05 is typically seen in standardized tests (Hedges and Hedberg, 2007). For teacher outcomes, all parameters remained the same except 76 students per school was replaced by 2 teachers per school and the ICC was assumed to be 0.15 (Kelcey and Phelps, 2013).

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