

WBL4CS: The Effectiveness of Work Based Learning in Computer Science Education

A. Significance

A1 Contribution

Currently there are over one half million unfilled jobs in the field of computer science (CS) nationally (1). Although recently there has been a substantial effort to increase CS education in the nation, this movement has almost exclusively been focused on traditional academic settings, such as new classroom computer science courses (2) Several studies have found that work-based learning (WBL), which encompasses activities that provide high school students with real-life or simulated work experiences, is highly effective in increasing student engagement in learning, particularly among high need students (3). However, there has been limited research done connecting these core areas of educational interest, leaving the field to wonder, “What is the potential impact of WBL on CS education?” And/or “What is the effectiveness of WBL in attracting more students from traditionally underrepresented groups to pursue a CS career?”

In response to this understudied area, the Rhode Island Department of Education (RIDE) proposes the “***WBLACS: The Effectiveness of Work-Based Learning In Computer Science Education***” project. This project is designed to address *EIR Early-Phase Absolute Priority 3: Field-initiated innovations -- Promoting STEM education, with a particular focus on computer Science*, and the *Early-Phase Competitive Preference Priority: Computer Science*. It will leverage a quasi-experimental study to explore the impact of a structured industry project in CS on students who take *AP Computer Science Principles (APCSP)* in their junior year of high school. This effort will be statewide and will focus on expanding the evidence base of the effectiveness of WBL to determine if WBL can be a significant benefit to CS education,

particularly for underserved student populations. Activities to achieve improved CS outcomes for high-need students include commitment to having at least half of the schools in the study be schools with large high-need student populations, and an activity devoted to training educators in broadening participation in computing (BPC) to help recruit, retain, and better educate underrepresented groups of students in CS.

In addition to expanding the research surrounding WBL and CS education, it is expected that this project will also produce theories and techniques for linking CS instruction at the secondary level to computer science industry. The project has been developed to be cost effective and practical for both schools and employers, so that it has the potential to be more easily scalable to the national context of CS learners. RI's successful initiatives in CS education and in WBL (see Section A2), coupled with promising early research on the effectiveness of WBL, provide a strong rationale for the likelihood of measurable and positive student impacts through this project.

The project will be led by RIDE, which will conduct the project using the Rhode Island Technology Enhanced Science and Computing (RITES+C) Research-Practice Partnership (RPP) structure (4). RITES+C is a 12 year RPP that includes RIDE, Rhode Island College, The University of Rhode Island, and many LEAs in RI that have worked together on large federally funded projects in science/CS education (5). The external evaluation for this project will be conducted by the Education Development Center (EDC). We are confident that this dynamic interdisciplinary team is well suited to meet the rigorous expectations of an EIR early phase project.

A2 New Strategies For CS Education Based on Work-Based Learning

This section describes our promising new strategies for improving CS education through WBL that build on RI's existing WBL and CS successes. **WBL Nationally:** WBL is a pedagogical strategy by which students are taught about a core content area by engaging directly with real-world projects and industry mentors within a specific field. Over the past thirty years, much research has been done to study the impact of this type of academic venture. It has been found that when well connected to traditional academic study, WBL helps students to understand the relevance of what they are learning in school. In linking students with mentors and other caring adults, WBL also offers young people opportunities to gain confidence and to understand the impact they may have in the world they will enter following school (6).

The theory of action posited by this proposal is also grounded in the recommendations from the What Works Clearinghouse (WWC) *Educator's Practice Guide on Dropout Prevention*, which codifies strong evidence that engaging students by offering curricula and programs that connect schoolwork with career success is a meaningful tactic to lower rates of high school dropout and promote student engagement (7). "Students are engaged in school when they are interested in their classes and see them as important to their future, and when they feel they belong in school. Engaged students have good attendance, come to class prepared, and are able to navigate daily challenges in and out of school (8). These behaviors, in turn, improve course pass rates and help students establish positive relationships with teachers and peers, reinforcing students' sense of belonging in school (9)."

However, not all WBL is created equal. In 2009, for example, WestEd and the James Irvine Foundation released a comprehensive report which studied the implementation of WBL in California and provided policy recommendations for increasing access to, and improving rigor

of, WBL activities (10). This report urges those setting policy around WBL to focus on student, teacher and employer engagement and provides strategies for engaging each of these central parties. The report also encourages the use of third party connectors, and codified state-wide policy for advancing WBL practice.

WBL in RI. The state of RI, through its PrepareRI program (11) at RIDE (12), is already engaged in implementing many aspects of high quality WBL, tailored to its local context. It has committed to the ambitious goal of providing high-quality WBL opportunities in every high school by 2020. Through its Governor's Workforce Board, RI has established statewide standards for WBL that govern all WBL activities (13) using a flexible definition that includes:

- *Internship:* A position for a student or trainee to work in an organization, sometimes without pay, to gain work experience, satisfy requirements for a credential, and/or gain course credit.
- *Apprenticeship:* Highly-formal job training experience that involves studying with a master of the trade on the job.
- *Service-learning:* A program or project which combines community service with an outside organization with a structured opportunity for reflection about that service, emphasizing the connections between service experiences and academic learning.
- *School-based enterprise:* Students produce and sell goods or services in the school and learn about business skills and entrepreneurship. This may be part of an entrepreneurship course, and a business professional may serve as a mentor and advisor for the enterprise.
- *Industry project:* Individual, group, or class-wide projects in which students address a real-world, industry-focused question or problem with the guidance of industry

professionals. This is the most scalable form of WBL and is the format that will be used on this Early Phase EIR project, as described in Part B1.

PrepareRI WBL opportunities are designed to be:

- *Rigorous*: Skill-based, and tied to measurable outcomes
- *Relevant*: Connected to a student’s interests and to the real world of work
- *Reflective*: Engage the student in reflection and analysis
- *Interactive*: Provide multiple and extended opportunities for students to interact with industry professionals
- *Integrated*: Connected with the student’s school-based curriculum and for academic credit

RI has had success in implementing WBL in Career and Technical Education (CTE) programs (14) both in CTE Regional Centers, and recently in CTE Programs in comprehensive high schools. The state has also built WBL into its standards for CTE program approval at the state level, which now mandate at least 80 hours of WBL for all students in order for them to be considered CTE completers. State standards that govern CTE and WBL are further differentiated by industry cluster and/or project type, including specific standards for high-quality, industry-informed, CS programming (15).

CS Nationally. In 2016 the federal government launched its CS4All initiative, calling for the rapid expansion of CS coursework in schools across the country (2). This initiative called CS a “new basic skill” for the next generation of workers in America’s economy, and called for both private and public sector investment in preparing the nation with this competency. In response to this call to action, many new investments in CS were made nationally, including several that were extended to Rhode Island. The most tangible of these impacts in our state was the

establishment of CS4RI, detailed below.

K-12 CS Education in RI. In 2016 RI Governor Raimondo launched the state’s CS4RI (16) initiative, which is now part of the PrepareRI program at RIDE. Before the launch of CS4RI, the landscape for CS education in Rhode Island left much to be desired:

- Only 9 public high schools, and no Title I schools, offered any form of AP CS course.
- Only 1 percent of RI public high school students were enrolled in CS courses.
- Only 42 Rhode Island public high school students took any CS AP exam in 2015 (16).

From this bleak starting point, CS4RI has quickly propelled RI to a position as a national leader in establishing K-12 computer science education. In 2018 RI passed its state standards for K-12 CS Education (15), and its CS CTE standards (17). CS is currently being taught in 100% of RI public schools (16), and RI has the highest percentage in the nation of high schools offering AP CS courses (1).

Rationale. This project demonstrates a rationale, as required in *EIR Absolute Priority 1*, based on high-quality research findings on the positive effects of WBL, that CS WBL is likely to improve student outcomes in CS. The theory is based off on evidence codified by the WWC that high quality career-focused programming can lead to higher student engagement, which in turn, can lead to other improved student outcomes. Our rationale is further codified in the Logic Model of Appendix G.

B Project Design

B1 Goals, Objectives, Measures, and Activities

The following table shows the project goals, objectives, from the Logic Model, and measures of success from Appendix G. Following this table, the activities to achieve the

objectives of the first two goals are described; the WWC objective activity is described in Section D.

Table 1: WBL4CS Goals, Objectives, Measures	
Goal 1: Students, particularly high-need students, will be better able to apply CS concepts and practices	
Objective	Measures
RI Students with CS WBL will score 10% higher on the <i>APCSP</i> exam than students without WBL.	The average <i>APCSP</i> exam score of the treatment group with CS WBL compared to the average <i>APCSP</i> exam score of control group without CS WBL; including breakdown by gender, race, and income demographics.
RI Students with CS WBL will be significantly more engaged than students without WBL.	RI SurveyWorks student engagement data for the treatment group compared to the control group; including breakdown by gender, race, and income demographics.
	RITES+C CS attitude survey for the treatment group compared to the control group; including breakdown by gender, race, and income demographics.
Goal 2: More students, particularly high-need students, enter the CS workforce	
Objective	Measure
RI Students with CS WBL will be 10% more likely to intend to enter a career in CS than students without WBL.	RITES+C CS career intent survey results for the treatment group compared to the control group results; including breakdown by gender, race, and income demographics.
Goal 3: National improvement in CS achievement	
Objective	Measure
Produce WWC Moderate Evidence that WBL positively affects CS education, and documents to allow replication of CS WBL implementation by other LEAs.	WWC publication, documentation on RI's CS WBL implementation.

Activity 1: Establish High Quality CS Course In High Schools. In Year 1 of the project the RITES+C team will recruit 20 RI high schools who will offer the *APCSP* course to their students. At least half of these schools will be Title I schools with significant populations of high-need students. Some of these schools may already offer the course, and some may need to have one or more teachers take professional development (PD) training to be able to offer the course. The project will train at least 10 *APCSP* teachers and allows for up to 20 to be trained. Since the learning objectives of the *APCSP* course are uniform as prescribed by the College Board, it will be left up to the high school to choose between *APCSP* curriculum provided by Project Lead The Way (PLTW) (18) or that provided by Code.org (19) which are the leading national providers of CS curriculum and PD, and the two providers endorsed to deliver *APCSP* by CS4RI (16). In addition to AP credit, several PD providers have been approved by URI to have their students receive transcribed URI academic credit for its first CS major course; this credit will be provided free to the students on this projects through state funding and an in-kind discount by URI.

To ensure that classroom facilities are not a lurking variable in the study, each participating school will receive funds, as shown in the Budget and Budget Justification, to establish a classroom for *APCSP* that meets minimal standards for delivering the course. The *APCSP* exam will be taken by at least 1200 students, with at least half from URGs. The *APCSP* exam results will be the primary measure of CS achievement for the project's impact evaluation. The exam is based on learning objectives that cover a majority of the Computer Science Teachers Association Level 3A (high school) CS Education Standards, the standards that are the basis for the RI K-12 Computer Science Education standards (15), and for most of the

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state CS education standards in the country. This makes the exam a strong measure of learning CS concepts and practices, and one with national applicability that has been thoroughly tested.

Activity 2: Establish Uniform WBL Programs. Ten of the 20 high schools will constitute the treatment group. Prior to taking the *APCSP* course in 11th grade, their students will participate in at least 60 hours of WBL in 10th grade. This WBL will take the form of an Industry Project. We will base it on a model Industry Project that was designed by Andrea Russo, the Microsoft Philanthropies TEALS Regional Program Manager for New England. This Industry project is currently being piloted with 30 students from three schools in RI and has generated a great deal of student, teacher, and industry enthusiasm.

Of the five forms of WBL included in the approved RI Standards (Internship, Apprenticeship, Service Learning, School-based Enterprise, and Industry Project), Industry Projects combine quality industry exposure (School-based Enterprise and Service Learning do not have extensive industry participation or student exposure to careers and workplaces), and are able to scale to a large number of students (Internships and Apprenticeships tend not to be scalable due to limited availability of such positions with companies and the expense of paid employment for students).

The Industry Project that will be utilized for the WBL4CS project is a model that has the CS students take a series of six one-day site visits to six different local companies which have volunteered their staff to demonstrate the various stages of the software development process and engage students in activities related to each stage:

1. Ideation and requirement analysis for software products
2. Business analysis (cost, market analysis, etc)
3. Software design and prototyping
4. Coding and development
5. Quality analysis and testing, debugging
6. Software product marketing

Aligning to recommendations for best practice in WBL (10), the WBL4CS project will leverage an established intermediary, [REDACTED] to help establish the industry partnerships necessary to provide this experience to 600 students from 10 schools across the state, at least half of which will be students from URGs.

The designers of this career-aligned experience are additionally confident in its quality due to its alignment to the WWC recommendations for career-focused programs that target student engagement. These include:

- Learning materials are chosen and adapted to focus on an industry that is connected to regional workforce needs.
- The career coursework and experiences are aligned with industry standards.
- The academic curriculum enables students to learn skills related to the industry.
- Local community colleges or technical schools advise on the industry-related curriculum and relevant student outcomes.
- Students participate in work based learning that links classroom activities with work experiences, such as job shadowing and career mentoring.
- Counselors create an individualized graduation plan for each student based on students' career and education goals.
- The career coursework is regularly evaluated against student outcomes and the needs of local industry and partners (7).

In addition to the student site visits, the RITES+C team will enhance the academic rigor from the model originally piloted by TEALS by incorporating the site visits as part of a one semester CS course that students take in 10th grade as a follow-on to the one semester introduction to CS course that most schools with a CS pathway offer in 10th grade. This CS

WBL course will augment the one-day site visits with classroom learning about the software development process. The in-class material will follow Google/Udacity's (free) software development course (20). RITES+C partner URI will provide PD in this material to at least 10 teachers and up to 16 teachers to allow for one teacher per treatment school with some attrition. The final part of the course will be student presentations on their experience made to industry representatives.

The curriculum for this course, along with a toolkit to help establish the required industry participation, will be published by the RITES+C RPP as a product of this EIR project to allow other high schools to replicate the CS WBL model nationally.

The result of Activities 1 and 2 will be that treatment schools will offer:

10th Grade: *Intro to CS Semester 1, CS WBL Semester 2*

11th Grade: *AP Computer Science Principles*

Many schools have an *Intro to CS* course in place; those that do not will receive PD for a teacher to offer the course to ensure some CS exposure prior to the CS WBL experience. This will allow for up to another 23 teachers to be trained in CS education.

Activity 3: Ensure Support for Underrepresented Groups. In addition to thoughtful selection of treatment and intervention schools, each participating CS teacher (at least 30 teachers up to 59 teachers) will be required to take CS4RI's PD training in *Broadening Participation in Computing* (BPC). This will position the WBL4CS project to ensure the objective in the Competitive Preference Priority of better serving students from underrepresented groups in CS education is met. In the Summer of 2018, CS4RI piloted this BPC PD training, which was developed by WeTeach_CS at the University of Texas (21) under National Science

Foundation funding, to 12 RI CS teachers. The PD includes materials from the National Center For Women in Technology (NCWIT) (22) with specific modules on:

- How to define equity and the related issues that impact its realization in CS courses;
- How to develop the skills to advocate for CS;
- How to use CS as a vehicle for exploring issues of personal relevance and social justice
- How to explore and understand our own unconscious biases, beliefs, and stereotypes that can influence our teaching, student recruiting, and interactions with other stakeholders in CS education;
- How to navigate CS program and material selection, while using specific strategies to establish equity and self-esteem among different populations.

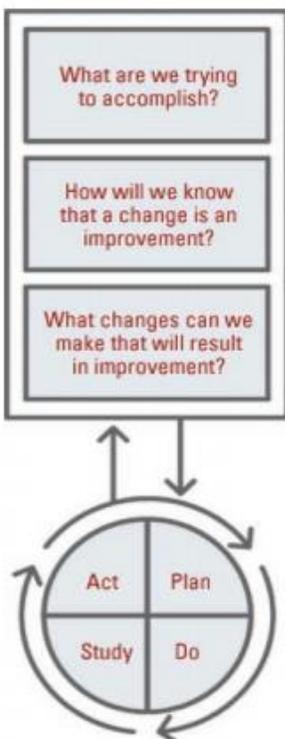
B2 Conceptual Framework

Appendix G provides our logic model that identifies key project components and describes the theoretical and operational relationships among the key project components and relevant outcomes. It includes the goals, objectives, measurements, outcomes, resources, and activities from the previous section. Building off previous research, our model posits that WBL will yield greater student engagement in learning. We further theorize that when paired with traditional CS learning, this heightened engagement can lead to greater student proficiency in the aligned academic content area.

B3 Feedback and Continuous Improvement

A focus on continuous improvement is integral to the design of this proposed project. In order to ensure that research and practice are intrinsically linked at each step of the grant's administration, the project will be organized within the existing RITES+C RPP structure. Leveraging a high quality, pre-existing, protocol for ensuring continuous improvement

will provide the grant management team with the advantage of a research-based structure and the many tools for organization in its widely-used RPP toolkit (23).



Researcher Practitioner Partnerships (RPPs) are intentionally organized to involve organizational personnel from the outset, benefit all parties, attend to their relationship, and support the use of what is learned from the research. Researchers who partner with practitioners are well equipped to understand local contexts, address pressing questions, and produce informative and actionable findings. They also gain access to policy insights and data that can facilitate rigorous and groundbreaking research. Likewise, practitioners can more easily access, interpret, and use research evidence when they collaborate with researchers and help. RPPs focus on a “problem of practice”, which for this proposed early-phase EIR project is: *Does work-based*

learning improve computer science achievement and other student outcomes? The RITES+C RPP will follow the *Model for Improvement* (24) (shown left) and its strategies for collective-impact, continuous improvement cycles.

To inform the general model, RITES+C will conduct monthly meetings of the core RPP members; an annual retreat of extended RPP members; an annual, one-day community gathering and sharing for teachers; and formal and informal feedback loops at each PD event and classroom observation. The external evaluators from EDC are a part of the RPP team to provide embedded evaluation, where the evaluators work in the RPP structure as part of the continuous feedback and improvement process.

An improvement cycle will occur every quarter: Starting with the current logic model

[**Plan**], data collected from enacting the activities [**Do**] will be analyzed and presented by RIDE staff to the RPP members at each quarterly meeting [**Study**]. Then corrections and/or reinforcements can begin quickly after [**Act**].

C Resources and Management Plan

C1 Management Plan

This proposed project will be managed by RIDE, through the facilitation of a full time Project Manager, in conjunction with two leadership subcommittees: an RPP Initiation Team that performs supervision of the project, and an RPP Research Team that performs the activities of the project.

RPP Initiation Team. The RPP Initiation Team will guide the partners through strategic actions, as suggested by both the American Institutes of Research (2017) and the Carnegie Foundation for the Advancement of Teaching (24). The Initiation Team will consist of: Spencer Sherman, RIDE PrepareRI Lead, who will be the Project Director; A RIDE staff member who will be the Project Manager (to be hired), Victor Fay-Wolfe, CS4RI Lead; Holly Walsh, RIDE Education Specialist and Logistics Manager for the CS4RI Core Team.

The RPP will use a framework with five *domains of activity* to attack the problem of practice (25): (1) develop a theory of practice improvement; (2) build a measurement and analytics infrastructure; (3) learn and use improvement research methods; (4) lead, organize, and operate the partnership; and, (5) foster the emergence of culture, norms, & identity consistent with the partnership aims. By attending to these domains of activity, initiation teams can catalyze the development of an organizational structure that allows educators to accelerate learning from practice and building a professional knowledge base that enables the field to tackle complex educational problems.

The RPP Initiation Team will be responsible for completing three key tasks (27) during the project's Year 1 planning stage:

1. Building a cohesive team with participants representing different types of expertise reducing uncertainty by clarifying what participation entails;
2. Building engagement by aligning work with ongoing efforts;
3. Using tools and resources from improvement science to identify a problem that is important and specific enough to be able to act on.

The RPP Initiation Team will convene quarterly meetings of the RITES+C RPP. Semi-annual meetings will be held for all stakeholders and interested policymakers, to keep abreast of the RPP's activities and achievements, and to offer their perspectives on how best to proceed with the work.

RPP Research Team. The RPP Research Team will use Design-Based Implementation Research (DBIR) that both structures the research approach and provides guidance for future projects based on the research results. The first DBIR principle is to incorporate RITES+C practitioners into the research process and to have practitioners support researchers' understanding the problems of practices being addressed. We will have researchers and practitioners working together throughout the project in monthly meetings. All members will help set and assess progress towards the research goals, help conduct the design part of the project, and provide feedback on research results that drive further design, implementation and research. This supports the second principle of DBIR in which research is collaborative in nature and equally values all participants' contributions to the iterative process of research and practice.

The third principle is that DBIR projects develop results that are applicable across a wide range of interests and settings. By having Research Team members that include teachers,

Rhode Island Department of Education 2019 Application to the EIR Early Phase Competition administrators, university faculty, graduate students, RIDE, and EDC, we will ensure a wide range of perspectives. Our target schools will include high schools from urban and suburban settings. Our use of the nationally implemented *APCSP* course, along with a structured yet flexible WBL model, supports the work’s applicability to a wide variety of settings.

The RPP Research Team will consist of: Dr. Fay-Wolfe, who in addition to being the CS4RI Lead on appointment at RIDE, is a URI CS faculty member with a specialization in CS Education research; Dr. Carol Giuriceo, the Director of the RI STEAM Center with a specialization in Broadening Participation in STEM research; Dr. Charles McLaughlin, a Rhode Island College faculty member with specialization in Career and Technical Education research; and Dr. Jacqueline DeLisi and Dr. Jessica Bailey from EDC. The practitioners in the DBIR group will include a CS teacher and administrator from each high school that participates in the study, and the RIDE staff member and Skills RI staff member who coordinate WBL. Monthly meeting notes from this group will be recorded in a shared document site.

Timeline. The activities and other performance tasks in this project are shown here on a timeline with grey cells indicating project work during a time period:

Tasks	Year 1			Year 2			Year 3			Year 4			Year 5		
	Semester 1 SY 19-20	Semester 2 SY 19-20	Summer 2020	Semester 1 SY 20-21	Semester 2 SY 20-21	Summer 2021	Semester 1 SY 21-22	Semester 2 SY 21-22	Summer 2022	Semester 1 SY 22-23	Semester 2 SY 22-23	Summer 2023	Semester 1 SY 23-24	Semester 2 SY 23-24	Summer 2024
Activity 1: PD in CS Courses															
Activity 2: Establish CS WBL															
Activity 2: Students Take CS WBL															
Activity 3: PD in BPC For CS Teachers															
Develop Data Collection Instruments															
Collect AP CS Exam and Survey Data															
Collect WBL Data															
RPP initiation, research, feedback															
Disseminate results															

The chart shows that in the first year the RPP project will be formed, it will establish CS WBL opportunities, create surveys, and establish data sharing agreements with schools. It will

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also help schools establish CS pathways and recruit students, and deliver PD for CS teachers in the Summer of 2020 in *CS WBL* (software development process material), *APCSP*, and *BPC*.

The PD will continue as needed in Summers of Years 2, 3, and 4. In Year 2 the first of the three cohorts of students will take the first offering of the *CS WBL* course as 10th graders in second semester of SY 2020-21 with similar cohorts formed in Years 3 and 4. The three cohorts are shown in Table 3 of Section D. The RPP evaluation, feedback, and improvement cycles will continue throughout the project.

C2 Personnel Responsibilities and Qualifications

As described in Part A, RITES+C will leverage the success that RI has had with its PrepareRI WBL (26) and CS4RI CS education (27) initiatives. The key personnel from those efforts are involved in this project. The following chart shows project personnel and their responsibilities for the activities (noted in the table) from the Logic Model described in Part B1, and their qualifications. Details on personnel qualifications are on their resumes in the Appendix. Asterisks denote that the person’s activities on this project is funded by this grant, lack of asterisks indicates that the person’s time is in-kind matching provided by RIDE.

Table 2: Project Personnel Responsibilities and Qualifications		
Person	Responsibilities	Qualifications
Spencer Sherman	RPP Initiation Team Lead. Overall project Lead.	RIDE PrepareRI Lead and Director of the Office of College and Career Readiness. Mr. Sherman holds a Masters of Public Policy from the Harvard Kennedy School of Government.
Victor Fay-Wolfe*	RPP Research Team Lead - CS education research. Initiation Team. PD coordination (Activity 1).	RIDE CS4RI Lead. URI CS Faculty. Code.org Regional Partner running all Code.org CS PD in RI. PhD in Computer Science. Professor Fay-Wolfe holds a Doctorate in Computer and Information

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		Science from the University of Pennsylvania.
Holly Walsh	RPP Initiation Team. Grant management and logistics.	RIDE CS4RI Core Team lead on logistics and budgeting. Ms. Walsh holds a B.A in Education from the University of Rhode Island and has served as the E-Learning and Instructional Technology Specialist at RIDE for over 10 years.
Master CS Teachers from high schools (20)*	RPP Research Team - practitioners. Deliver CS courses, coordinate CS courses in their school, administer data collection instruments to students.	Trained CS high school teachers.
LEA administrators from partner high schools (20)	RPP Research Team - practitioners. Establish CS programs in their high school (Activities 1 and 2) .	Experienced LEA administrators.
Carol Giuriceo*	RPP Research Team. BPC research.	Director of the RI STEAM Center. Dr. Giuriceo holds a PhD in Education offered as a joint degree from the University of Rhode Island and Rhode Island College .
Charles McLaughlin*	RPP Research Team - WBL research.	RIC Education Faculty member with WBL research focus. Dr. McLaughlin holds a PhD in Technology Education from the University of Maryland.
Jacqueline DeLisi*	RPP Research Team - evaluation. Develop data collection instruments. Embedded evaluation and feedback. Experiment design and management. WWC publication of research results support.	EDC researcher experienced in DoE evaluations and research. EdD in Education Administration, Training, and Policy Analysis from Boston University.
Jessica Bailey*	RPP Research Team - evaluation. Develop data collection instruments. Embedded evaluation and feedback. Experiment design and management. WWC publication of research results support.	EDC researcher experienced in DoE evaluations and WWC review and placement. PhD in Educational Research, Measurement, and Evaluation from Boston College.

In addition, the budget allocates a staff position at RIDE to manage the project including scheduling and conducting RPP meetings, the logistics of scheduling WBL experiences in the

Rhode Island Department of Education 2019 Application to the EIR Early Phase Competition treatment schools (Activity 2), managing data collection, and other logistics. The budget also allocates time for a graduate student to perform data collection and support data analysis. There is also a contract to [REDACTED] to support the WBL industry interactions (Activity 2), and to URI to provide PD in *APCSP* (Activity 1), *CS WBL* (Activity 2), and *BPC* (Activity 3).

C3 Continued Support

The project's establishment of CS WBL will continue beyond the period of this grant. As shown in the commitment letters in Appendix C, the RI Governor, our Institutions of Higher Education, Industry partners and our Congressional Delegation are committed to the WBL and CS education in the state. RIDE will seek to transition staff funding, particularly the CS WBL RIDE staff member who is fully funded on this project, to state funding once the effectiveness of CS WBL has been demonstrated on this project. Leveraging grant funding as a proof point for further investment in this manner is a common practice at the state agency, which faces an FTE cap and must provide an evidence-based rationale for each new state-funded position. The resulting CS sequence, credential of value (AP credit and URI academic credit), and the CS WBL outcomes together meet the RI CTE standards, which will help establish the CS WBL as a permanent part of the offerings in the state's high schools, which will be transitioned to LEA funding as the project ends. Rhode Island also provides state categorical funding to all CTE programs in high-growth, high wage industry areas, such as CS, which could be leveraged to continue this project at the LEA model after the close of the grant period. The State is also putting together its Perkins V plan, which is likely to yield additional investments in both CS and WBL.

Lastly, the project's use of the *APCSP* high school curriculum and assessment, which is

widely used across the country, and the project's flexible and scalable WBL model, will allow for scaling the research to a Mid-Phase CS WBL EIR project based on the moderate evidence achieved in this early-phase EIR project, and will ensure national relevance and applicability of the results in the priority area of improving CS education in the country.

D. Project Evaluation

D1. Evaluation Goals and Design. EDC will conduct the evaluation of this WBL4CS project to determine the extent to which the WBL initiative meets the program goals and objectives (see Table 1, page 7). The evaluation will provide formative feedback on the WBL4CS implementation and will use a quasi-experimental design to examine its impact on students' CS proficiency, engagement, interest in CS, and post-high school career intentions (see Appendix I for an overview of the outcomes, associated measures and data collection period). The evaluation questions include: 1) To what extent is the WBL4CS initiative being implemented as designed? 2) To what extent can the fully developed WBL4CS initiative be feasibly implemented within the requirements and constraints of the school, LEA, and state contexts? 3) To what extent does WBL impact students' CS proficiency? 4) To what extent does WBL impact student engagement? 5) To what extent does WBL impact students' intentions to pursue CS careers? 6) To what extent does WBL impact students' interest in C S? For evaluation questions 3-6 the impact on underrepresented groups will be examined descriptively and through moderator analyses.

EDC will conduct an **implementation study** in Years 1 and 2 to address Evaluation Questions 1 and 2. EDC will work with the RITES+C Team to identify a sample of schools, beginning with a subset in Year 1, and expanding to up to 10 schools with WBL in Year 2. Data sources will include surveys of WBL supervisors, students, and teachers of the CS courses.

These surveys will be developed in collaboration with the RITES+C RPP during Year 1 based on the project components articulated in the project logic model (see Appendix G). They will provide information about the WBL expectations for students, the components of the experience, and students' growth and performance through WBL. In addition, the evaluation team will conduct interviews with up to 10 WBL supervisors and up to two focus groups with students in each sample school to understand the components of high quality WBL experiences. These data sources will also inform continuous improvement cycles, detailed in section B3.

Data from the implementation study will be analyzed through iterative qualitative review cycles (28). Qualitative software will be used to code qualitative data and track the perspectives of participants through the iterations of WBL in Years 1 and 2. This analysis will result in descriptions of the components of high quality WBL implementation, and will result in a rich and contextualized understanding of factors that mediate the program's ability to affect its specific outcomes.

The **impact study** will address Evaluation Questions 3-6 using a propensity-score matching (PSM) quasi-experimental design (QED) that meets the **WWC standards with reservations** (Activity 4 in the Logic Model). The sample will consist of approximately 600 students from 10 treatment schools and a control group of at least 600 students from 10 schools with similar characteristics. All students in the study will take an intro to CS course and the *APCSP* course, while only students in treatment schools will experience WBL. A two-stage multilevel PSM procedure outlined by Zubizarreta and Keele (2014) (29) will be used to match students in treatment schools to students in control schools on student characteristics such as free or reduced price lunch status, English language learner status, race/ethnicity, and pre-intervention SAT or PSAT scores. To the extent possible, students will be matched within an

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LEA. Once all possible combinations of matched individuals are known, then schools will be matched on school characteristics. EDC will use an iterative matching approach to establish baseline equivalence acceptable to meet WWC standards with reservations. For instance, if the matched treatment and control group means for a measure included in the matching process are greater than 0.25 standard deviations of each other, then EDC will refine the matching approach.

The study will have outcome data for three cohorts of students (Table 3 below). The first cohort begins in the second year of the project (year one is dedicated to program refinement through continuous improvement). Outcome and performance measure data will be collected annually. By the fifth project year, outcome data will be available for all three cohorts (see Appendix I). Results will be pooled across cohorts and available for both treatment and control students--1,200 students total. For all outcomes, this study is powered for a **minimum detectable effect size (MDES)** in the range of 0.38 to 0.49, which is accounting for school level clustering and assuming power level of 0.8, an alpha of 0.05, intra-cluster correlations of 0.05 and 0.11, and a level 2 covariate that explains 0.18 to 0.33 percent of the between-school

Table 3. Cohort Activities By Project Year				
Project Year	Cohort Activities			
	10th graders take Intro CS course and WBL experience	11th graders take APCSP course and exam	12th grade	Employment or postsecondary enrollment
1 (2019-20)	N/A			
2 (2020-21)	Cohort 1			
3 (2021-22)	Cohort 2	Cohort 1		
4 (2022-23)	Cohort 3	Cohort 2	Cohort 1	
5 (2023-24)		Cohort 3	Cohort 2	Cohort 1

variance (Hedges & Hedberg, 2007). This is aligned with the average effect size of 0.41 reported from a meta-analysis of the effects of computer programming on cognitive outcomes (30).

Research Question 3, regarding student understanding of CS concepts and practices, will be examined using multilevel regression modeling to reflect the level of treatment assignment (school) and the nesting of students within schools. The outcome variable is students' APCSP exam score and measures the core competencies and practices aligned to the WBL intervention. The impact analysis will start with the simplest model (see Equation 1), in which the student outcome is a function of a school's treatment status (i.e., Treatment vs. Control), a pre-intervention/baseline school-level APCSP exam score, a series of cohort indicators, school random effect and student residual. Then additional covariates and interaction terms will be used to improve the impact estimate's precision and to enable nuanced interpretations.

Equation 1: $[\text{Outcome}]_{ij} = b_0 + b_1[\text{TRT}]_j + b_2[\text{Baseline}]_j + d(k)\text{Cohort}(k) + u_j + e_{ij}$

In order to estimate the impact of the treatment on student subgroups, the overall impact analysis will be followed by a corresponding moderator analysis. In this analysis, a series of indicator variables representing student demographic characteristics are entered into the analysis model, along with the treatment-by-demographic indicator interaction terms.

To analyze **Evaluation Questions 4-6**, regarding the impact of the WBL intervention on student engagement, intentions to pursue a CS career, and interest in CS, EDC will compare survey results, drop out rates, absenteeism rates, and CS credits earned for treatment and control students using multilevel models such as that in Equation 1. For each cohort, the data will be collected at baseline (either at the end of students' freshmen year or at the beginning of sophomore year) and at the end of junior year.

D2. Strategies suitable for Replication. Data from the implementation and impact study as well as performance measurement (see D3) will inform **continuous improvement cycles** outlined in section B3 which refine program components to produce robust outcomes in multiple

Rhode Island Department of Education 2019 Application to the EIR Early Phase Competition settings. As program components are improved upon through iterative cycles of Plan/Do/Study/Act, they are also scaled to new schools, providing new settings that program strategies must also adapt to. This process leads to robust program components that are successful in multiple settings.

D3. Providing Performance Data on Relevant Outcomes. Evaluators will work collaboratively with the RITES+C RPP team to develop annual and cumulative performance measures aligned with the logic model. Performance data will include the numbers of students who are being served, including the numbers of students who are high needs. The evaluation will collect project specific performance data that will contribute to understanding the project design and student outcomes, including proficiency in CS concepts and practices, interest in CS, and student engagement. The performance measures and targets are described in Appendix I.

D4. Articulating Project Components. The Logic Model (see Appendix G) articulates the proposed components, including mediators, inputs, and outputs, and describes measurable thresholds for acceptable implementation. Throughout the project, EDC will work closely with the RITES+C Team to refine and further articulate the project components and logic model.

Qualifications: EDC is well-qualified to conduct the evaluation and performance monitoring given the organization's and team's experience designing, delivering, and evaluating programs in education, including i3 and EIR programs. Dr. Jacqueline DeLisi has led multiple research and evaluation projects funded by the National Science Foundation and NASA and has expertise in instrument development, including determining psychometric properties, to describe the implementation of educational interventions and measure student outcomes. Dr. Makoto Hanita has more than ten years of experience leading the design, execution and analysis of large-scale RCTs in education settings including four such studies funded by IES. Dr. Jessica Bailey

will also serve as a project analyst and has 10+ years of analysis and project management experience.

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