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A. Significance

*Introduction* – Challenger Center for Space Science Education (Challenger Center), a nonprofit organization, will partner with regional LEAs to develop and implement classroom-based learning simulations in science, technology, engineering, and mathematics (STEM) to address **Absolute Priority 7—Effective Use of Technology, Subpart (b) Technology-enabled solutions.** These dynamic and interactive simulations are ideal for teaching systems concepts with multiple interrelationships, cause and effect actions, and adaptable problem-solving situations (National Research Council, 2011). The Challenger model encompasses four innovations beyond other classroom simulations: (1) integration of simulations and problem-based learning; (2) real-time assessment of student progress integrated within the technology platform; (3) strong professional development to ensure teacher understanding of content, technology, pedagogy, and efficacy; and (4) combined virtual and hands-on experiences to reinforce learning. In this development phase, Challenger Center will produce evidence supporting a classroom-based simulation that aligns with national Next Generation Science Standards (NGSS), Common Core State Standards (CCSS), and Virginia, West Virginia, and Pennsylvania state standards; enhances multidisciplinary competencies (science, mathematics, and language arts); teaches systems thinking; and strengthens 21st century skills in critical thinking, collaboration, and communication. The technology will be low-cost, adaptable, and scalable. This project is supported by **strong theory** (Appendix D).

*Background* – Challenger Center was founded in 1986 by the families of the space shuttle astronauts tragically lost in the Challenger “teacher in space” mission. Site-based programming is offered internationally through more than 40 regional Challenger Learning Centers that offer state-of-the-art educational simulations. During a two-hour “flight,” student
teams assume the roles of astronauts, scientists, and engineers. They conduct research, solve problems, make decisions, and communicate results related to spacecraft operations and space-based experiments. Teachers employ standards-aligned curricula in their classrooms to prepare students for the experience and many complete post-mission activities. This powerful role-playing involves a combination of simulation and hands-on manipulative activities that ignite the imagination, promote engagement, and build self-efficacy as students apply science and math knowledge and problem-solving skills in a real-world scenario.

Challenger Center’s existing site-based model serves more than 400,000 students and 40,000 teachers annually across 30 states. However, many students are unable to visit a Center. To significantly expand access, Challenger Center will develop, test, and formatively assess a cutting-edge simulation that can be experienced in a classroom or school computer lab. The classroom-based simulation project will serve 1500 5th grade students, many of them high-need.

**Development and Advancement in the Field** – Challenger Center’s simulation model engages students in guided problem-based learning as they respond to external information and practice solving problems collaboratively. Challenger Center will adapt its technology for the classroom and will create a simulation appropriate to 5th grade science learning objectives. Critical elements of the project are professional development modules that span pre- and post-classroom simulation activities, improved interfaces for students (as team members) and teachers (as simulation commanders), and real-time assessment of student understanding and progress. Several project elements based on strong theory (**Appendix D**) will advance the field:

1. Integration of *simulations* with *problem-based learning*. This will enrich the simulation as the students practice being scientists and collaborate to solve a real-world problem through research and experimentation.
Unobtrusive background assessments of student comprehension and participation, delivered to the teachers in real time in an understandable format. Automated analysis addresses the issue of scale in observations of student skills, as teachers otherwise could not keep track of a multitude of learning tasks and scenario elements. It is important that assessments in simulated environments not interrupt the experience in progress (Shute & Kim, 2013; Shute et al., 2009). Embedded assessments can test concepts beyond what can be measured in paper-based tests, such as student’s progress on problem-solving sequences (National Research Council, 2011) and students’ abilities to conduct inquiries, understand model behaviors, and determine roles and relationships. They can also be used post-simulation to further analyze student knowledge and to guide classroom lessons. However, despite its promise for use in formative classroom assessments (Brown et al., 2008), the use of embedded assessments within learning simulations is still in its infancy (Quellmalz et al., 2009). Thus, this project is exciting and cutting edge.

Research-based professional development (PD) that ensures that teachers understand the science concepts within the simulation and can use the provided technology to administer and assess the simulation and track student participation and learning. Elementary school teachers are not science or technology experts, so content knowledge is an essential component. Earlier studies have demonstrated the importance of teacher pre-simulation training on the effectiveness of the Challenger site-based model for conferring knowledge gains and influencing students’ future career choices (McLain, 2011). Teacher preparation is also essential to a classroom implementation in which the teacher acts as the simulation commander. The PD will be based on best practices of science teaching, supported by empirical evidence: engaging resilient scientific preconceptions; organizing knowledge around core concepts; supporting metacognition and student self-regulation; and cooperative learning (National Research Council, 2005a). The PD
design will apply simulation theory (National Research Council, 2011) within a community-of-practice framework (Barnett, 2002; Borko, 2004; Tytler et al., 2011).

(4) The integration of virtual and hands-on manipulative activities culminating in the production of a tangible, take-away learning object for the student. Real and virtual activities are mutually reinforcing (Harrington, 2011) and both are based on the application of classroom knowledge. Hands-on activities within a virtual simulation expand the context of the investigation into a real-world scenario, increase student engagement (Metz, 2008), and help teachers implement the inquiry-based instruction called for in national and state standards.

Outcomes – The project will adapt high-value elements of the site-based Challenger Learning Center experience to the classroom, resulting in improved student outcomes through activities that are cost effective, scalable, and aligned with standards. The simulation model can be implemented at any school with classroom computers or a computer lab and a local area network (future versions will be Internet-based). Simulations will increase engagement, motivation to pursue STEM studies, and gains in content knowledge, critical thinking, and communication skills (as demonstrated through a matched comparison between classes who experience the simulation and control classes). These mediators will lead to the project outcomes of improved student achievement in mathematics and science. Additional benefits are improved teacher preparation for teaching science and using technology within the classroom, and improved abilities to rapidly respond to student learning needs. Student skills can be improved by repeating variations of the simulation with the students taking on new and different roles.

B. Quality of the Project Design

Effective Use of Technology – Challenger Center’s simulation model addresses Absolute Priority 7—Effective Use of Technology; Subpart (b), Technology-enabled solutions.
Challenger Center will create a classroom-based simulation that can be completed in one to two hours by classes of up to 30 students, divided into teams with 1–3 students on each team. Based on its successful site-based “missions,” the classroom simulation will immerse these student teams in a virtual situation, assign them with roles and responsibilities (e.g., navigation, life support, medical, communications, planetary science, and engineering), provide them with reference materials and tasks (delivered via computer using multimedia), and set up problems to be solved. The teams will collaborate in person or through text-based chat, audio, or video communication links. The teacher guides the simulations as the commander.

**Project Goals** – There are six project goals: *(1) Adapt Challenger Center’s technology platform to work in a classroom or computer lab.* *(2) Develop and implement a classroom-specific simulation appropriate to 5th grade science objectives.* *(3) Improve data flow from the learner interface to the simulation commander interface, and enable the commander (teacher) to assess student understanding and progress in real-time.* *(4) Produce and evaluate professional development (PD) modules that ensure that teachers understand the science concepts, can effectively direct a simulation and the hands-on student activities, and can react appropriately to student actions and learning (pre- and post-simulation activities).* *(5) Deliver and evaluate the simulation-based learning at partnering LEAs.* *(6) Produce moderate evidence that participating students achieve significant gains compared with non-participating students.* Challenger Center’s plan to achieve its goals is summarized in the following abbreviated *logic model* (full model provided in Appendix D):

| **ASSUMPTIONS:** | Students are engaged and inspired through immersive educational simulations and problem-based learning. Technology solutions can deliver these experiences to classrooms with little or no investment by schools. Appropriate professional development is key to effective simulations. Assessments must be in real-time, non-disruptive, and manageable. |
| **INPUTS:** | Funding and project staff; partnering LEAs, university, and consultants; national curriculum standards, client/server software and server technology |
**ACTIVITIES:** Technology transition to classroom platform; updated learner and commander interfaces; simulation development; teacher professional development; technology-based real-time assessment development and implementation; evaluation plan

**OUTPUTS (Key Offerings):** Educational simulation experience delivered to classrooms; professional development for participating teachers and curriculum for expansion; embedded real-time assessments; ongoing problem-based learning in classrooms

**MEDIATORS:** Teacher knowledge, skills, capacity, and efficacy; student knowledge, skills, engagement, efficacy, and motivation

**INTERMEDIATE-TERM OUTCOMES:** Improved student achievement in mathematics and science as measured by standardized test scores

**LONGER-TERM OUTCOMES:** Increased enrollment and achievement in STEM courses at secondary level; increased enrollment and achievement in STEM courses at post-secondary level; increased student entry into STEM careers

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**Participating LEAs** – Challenger Center will work with its three confirmed partner LEAs (Hanover County Public Schools and Frederick County Public Schools in Virginia, and Mars Area School District in Pennsylvania, with percentages of high-need students ranging from 10% to 34%), as well as additional LEAs in Virginia and West Virginia, to be determined. The additional LEAs will be selected with guidance from the Virginia and West Virginia Departments of Education, as well as the partnering Challenger Learning Centers in those states, both of which have experience working with high-need schools. The LEAs will be selected based on 5th grade enrollment of a large percentage of high-need students, according to student poverty levels, number of English language learners, and/or high-minority school designations.

**Project Activities** – The primary activities in this project are described below.

**Technology Platform** – Challenger Center will adapt its existing client/server simulation platform, Sim3, to run on a local area network in a classroom. Sim3 uses web and media services and Extensible Markup Language (XML) for overall data management. Sim3 also provides an integrated authoring solution for creating and customizing scenarios, while also allowing educators to make content edits according to local needs. The participating schools will be provided with the server (hardware and proprietary software) and client software for their
existing computers (future versions will be cloud-based and delivered over the Internet).

Modifications to the existing simulation platform include:

(1) Updating the Learner Interface (the students’ side of the simulation) to improve classroom usability (Figure 1). The updates will enable real-time presentations through an added multimedia layer, improve the abilities for multiple team members to perform useful tasks, adapt and adjust the mission roles to allow all teams to be in the same room, modify the system tools to make them classroom-specific, and log additional user transactions.

Figure 1. Sample screenshot of the current Learner Interface.

(2) Enhancing the Simulation Commander Interface (used by the teacher) to improve data flow from the Learner Interface and to make it more user friendly. The teachers start and end the
simulation, set off “emergencies” for the students to respond to, send messages to students, and direct and redirect the students’ learning experiences by modifying the storyline. The updates include overhauling the interface to streamline and simplify general simulation operations and available options, incorporating an expanded and enhanced status display so the teachers can better interpret student progress and potential obstacles in real time, and incorporating a streamlined method for on-the-fly simulation content adjustments.

(3) Adapting the back-end software to update the web services, real time message protocol services, and authoring. This includes updating the web services for better assessment parsing, improving the data and protocols communications among modules, streamlining the connection sub-systems, and updating the authoring environment to allow for local editing.

Simulation Experiences – The simulation will build upon one of Challenger’s proven missions that aligns with 5\textsuperscript{th} grade standards, such as the Encounter Earth mission which focuses on Earth systems and how they impact and are impacted by humans as well as space systems (i.e., gravitational force and the relationship of the Earth and moon to the sun). Educators from the partnering LEAs will work with the Challenger Center in the creation of a defined classroom-based storyline, student responsibilities, and learning objectives that align with national and state standards. The educators and development team will also develop hands-on interactive activities based on common classroom materials that will align with the students’ roles within the simulation. The development will be collaborative and team-focused, and the educators and the Challenger Center team will meet regularly by teleconference, as well as in-person at least twice per year during the development period.

The simulation will use accurate and up-to-date content presented through high-definition multimedia. The students will use models to represent Earth’s systems and natural events,
analyze and interpret data on the ocean and atmosphere, make predictions, and design solutions to problems. The simulated and hands-on activities will provide the teams with information and knowledge which they will use in additional tasks, share with other teams, and help them achieve the mission objectives. The simulation commander (teacher) will monitor class, team, and student progress and determine the students’ understanding of specific concepts. In response, the teacher will adjust the experience by changing the mission information, adding or subtracting mission emergencies and events, and modifying the task flow in the simulation.

With each virtual or hands-on experiment or activity, the students practice being scientists by analyzing, interpreting, and extracting data that they will share with other teams to help meet the goals of the mission. For example, a hands-on activity could be creating a tornado-type funnel in a bottle of water driven by gravity. The decisions require problem solving, analysis, prioritizing, and compromise. The students will also design and produce a physical learning object as a culminating take-away project. Examples could be a papier-mâché or origami model of the Earth and its moon, or a functional model of an earth-observing satellite made with recycled materials or LEGO® kits.

**Real-Time Assessment** – The user interface and background analysis will allow the teachers to follow the class’ progress and individual student achievement using *dashboards* (a graphical representation of a performance indicator, which is used to enable a real-time, informed decision). Software tools will store data from the log file in a structured format using data warehousing, extract trends from the data warehouse, and display this information in a user-friendly format (dashboard). Essential elements of this task are the development of the tools and processes for data storage, management, analysis, and reporting; and development of the data relationships and processes for automatically identifying trends from the database system.
The teachers will make decisions regarding simulation control based on the displayed dashboards and reports. The goal is for the teachers to track student use, time on task, acquisition of content knowledge and correlation to learning standards, acquisition of intended skills and processes, and learning efficacy. For example, a dashboard can visually show the length of time students are spending on a task compared to an expected time for that task, and where in a process any delays are occurring. Another dashboard can show specific questions and whether they have been answered correctly, or whether teams are including all relevant information when they communicate with other teams during a critical task. Reports post-simulation could cover topics such as how many critical questions were answered correctly, how long the simulation took, and comparisons between teams or between simulations. The software will include the ability to share user progress data with Challenger Center. Challenger Center will then use this feedback to enhance the user experience/simulation and for overall system improvement.

The software updates will be developed by Challenger Center, the Redmon Group (a software consultancy firm), and the University of Virginia (UVA). Challenger Center will work with Redmon to update the backend of Sim3, and will work with the educators from the partnering LEAs to refine the interface and obtain feedback on its ease of use and functionality. Redmon will update the client and server software and develop new simulations tools.

The UVA Department of Systems and Information Engineering will contribute software developed by undergraduates in their capstone course. Beginning in Fall 2014, the UVA student team will meet with Challenger Center staff and the educators to better understand the information and data of interest to the project. The focus will be what students understand and learn from the simulation, and how the students comprehend the content and apply that
knowledge. The UVA students will then work closely with Redmon to ensure the software is refined and designed in a way that supports the necessary collection, warehousing, and retrieval.

In the first year (Fall 2014), the UVA team will develop a prototype dashboard that will display assessment data. A second UVA team, beginning in Fall 2015, will update the prototype to make it user friendly. This second team will also meet regularly with the Challenger Center staff and the test educators to improve functionality, and will meet with Redmon to ensure any changes to the dashboard or the information retrieval requests are captured in the software program design. Once the software is completed, the Challenger Learning Centers will work with the national office to test the software within their facility, using staff and volunteers (students and adults) to identify problems. Classroom tests of the simulation will occur during the educator professional development, described next.

**Professional Development** – Research-based professional development (PD) will ensure that participating teachers understand the science concepts and use of technology, can use the capabilities of the simulation tools, can command the simulation, and can track student participation and learning through the embedded assessments (i.e., integrated dashboards).

Three professional development phases will enable Challenger Center to determine the best methods for improving the educators’ understanding, abilities, and comfort in teaching 5th grade STEM content and incorporating the simulations into their lessons. The first phase will include the entire team of educators and will focus on STEM content. Teachers will work in groups during activities that familiarize them with the content and allow them to practice teaching these concepts using a hands-on, collaborative, and interdisciplinary approach that models best practices for classroom teaching. As a group, they will provide feedback and
suggestions for strengthening the lessons and methods. The teachers will also explore and
discuss how the concepts align with CCSS and NGSS as well as state curricula.

The second phase will focus on the simulation. Challenger Center has extensive
experience in simulation training, and will expand on this capability. Challenger staff will lead
simulations with educators serving as students. Educators will then alternate into the simulation
commander role, while other educators act as students. The Challenger staff will facilitate the
process and provide coaching to ensure fidelity, with a particular focus on the real-time
assessment data. Using a proven professional learning community (PLC) model (DuFour et al.,
2006), teachers will analyze the assessment data and discuss student learning and next steps for
science instruction.

The third phase will be at the schools. Educators will review the simulation, procedures,
assessment tools, and PLC data analysis protocol with Challenger coaches. Teachers will then
command the simulation with their students, while the Challenger staff monitors and provides
coaching. Afterward the teachers and students will debrief the experience and review the results
of the student data. This phase will be repeated as necessary. After PD, Challenger will staff a
telephone helpline to assist teachers as needed.

To develop and implement these training elements, Challenger Center will define the
educators’ needs and current level of understanding, and identify any impediments that need to
be removed or mitigated to ensure individual achievement. Lessons will be created and taught by
Challenger Center and Challenger Learning Center staff. Also, subject matter experts will
evaluate the content, and participate in training when appropriate. Formative assessment will be
administered by the project team and coaches at the end of each day and phase of training.
Additional components will be considered based on best practices for adult learners: overcoming/contesting hegemony; building a sense of self-efficacy, empowerment, and success, particularly in a subject where many elementary teachers lack confidence; and understanding and leveraging the rich background knowledge and experiences brought by each individual. Thus, PD will focus on the key factors that motivate adult learners: (1) the need to relate what is being learned to reality and how it can be applied; (2) an emphasis on problem solving and the need for experiential learning and exploration, reasoning, and reflection; (3) the use of internal factors for motivation and readiness to learn; (4) the desire to acquire new skills in addition to increasing knowledge; and (5) the need to retain new facts and methods for access at a later date.

At the end of the PD process, Challenger Center will have a detailed understanding of teacher learning needed to enable them to become effective simulation commanders and will use this understanding to produce online PD modules to be used during the subsequent scale-up implementation to a large number of schools and classrooms. The online PD will include both synchronous (hosted webinar) and asynchronous (independent use) elements.

The formative assessment will identify the PD content that is most efficacious for teaching the science content and preparing teachers for their roles as simulation commanders. This formative assessment will be used within a design-based research process (Sandoval and Bell, 2004) to ensure that the simulation platform functions as intended and can be used effectively by teachers when implemented in a school setting.

**Potential Challenges** – The primary technical challenge is ensuring that teachers can make the best use of the rich stream of data and complex patterns generated by student actions and stored in the simulation logs. The automated assessment system needs to extract information and trends from these data streams using reliable and valid interpretations. This is a key
challenge, as the use of learning analytics to extract information from large datasets is a relatively new field. To mitigate this risk, Challenger Center and UVA will adopt industry best practices and will incorporate feedback from educators and subject matter experts.

An implementation challenge is ensuring that teachers use the simulation as designers intended, so as not to undercut student learning (National Research Council, 2011). To address this issue, Challenger Center will involve the regional Challenger Learning Centers, the local educators, and subject matter experts in developing a PD program. Educator PD will ensure that student learning is the focus of the simulations and that the simulations are used for maximum benefit. A second issue is that students often find inquiry-based learning to be difficult (National Research Council, 2005b). To assist them, teachers need deep content knowledge and effective teaching strategies. To meet this need, Challenger Center’s extensive PD will enhance teachers’ knowledge and comfort with science content and technology in general, as well as its classroom application. A third issue might be a lack of technological infrastructure in schools. Challenger Center will provide the server hardware and software, as well as technical support to ensure the participating schools can implement the simulation platform. In future work, the simulation will be cloud-based and will work on any Internet-enabled computer.

C. Quality of the Management Plan

The overall project management will be provided by the national Challenger Center, with participation by multiple LEAs, two regional Challenger Learning Centers, the Redmon Group, and the University of Virginia. The independent evaluation will be conducted by The Policy and Research Group (see Section E).

The Project Director will be Kathleen Meehan Coop, Vice President of Education at the Challenger Center. Under direction of Ms. Meehan Coop and Mr. Muhammad Shazlee, Director
of Education Technology, Challenger Center will have responsibility for the project oversight, including development of the education technology components, testing, implementation, and functionality; and lead responsibility for professional development. Ms. Meehan Coop would oversee the entire project, and will share responsibility for coordination, management, and enhancement of the education technology components with Mr. Shazlee. Both Ms. Meehan Coop (overall program, professional development, educational content) and Mr. Shazlee (software development, implementation, and testing) will work closely with the external evaluator.

Challenger Center will also devote an Education Manager and an Education Technology Manager to the project (to be determined, see Section D). Carlos Nunez, Mission Specialist at Challenger Center, will assist the Education and Education Technology Managers. He will help coordinate meetings, travel, and the shipping and purchasing of materials. Mr. Nunez will also assist with authoring the content of the new simulation into the Sim3 platform and preparing PD material. Challenger network support will be provided by Bill Seilnacht, Manager of Technical Support, and Jason Ketter, Technology Support Specialist. They will work closely with the Challenger team to ensure that any materials, equipment, or hardware used in schools meets all applicable standards. They will serve as technical support (help desk) for educators and school IT staff. The project will also receive extensive support from other Challenger Center departments, including Communications and Donor Relations.

The lead personnel at the confirmed participating LEAs are Kim Dye (Hanover County, VA), Jeri Swogger (Frederick County, VA), and Matt Friedman (Mars, PA). The responsibilities of the LEAs are to work with Challenger Center and the evaluator to support the program and randomly select the educators who will participate in either the test group or control group. The educators will advise on content development, the storyline, and the development of the
culminating tangible project and the hands-on manipulative tasks. They will also serve on the program’s advisory panel to ensure that the project meets their districts’ needs. The Virginia Department of Education will contribute to the project by ensuring the new classroom simulation is aligned to Virginia state standards and is relevant to the state’s education priorities.

Two regional Challenger Learning Centers (CLCs) are partnering in this project: Challenger Learning Center in Wheeling, WV (Jackie Shia, Director) and the MathScience Innovation Center in Richmond, VA (Dr. Hollee Freeman, Executive Director). These two Centers were selected due to the variety of programs they offer, including a transition model that includes elements of both the traditional Challenger Learning Center mission and the proposed classroom-based mission. The Wheeling CLC provides expertise in program evaluation, and the Richmond CLC has experience working with a diverse consortium of schools. These CLCs will work closely with Challenger Center staff and educators on the creation, review, and edit of the new classroom simulation, including the content, storyline, hands-on manipulative tasks, and the culminating physical project. These CLCs will upgrade their facilities to the new Sim3 platform so they can test and run the new simulations before deployment in the schools. They will also assist with training the educators at the test schools and will participate in the development and implementation of the professional development tools.

The University of Virginia (UVA) Department of Systems and Information Engineering, directed by Dr. Reid Bailey, Associate Professor, will contribute to the software development and prototyping of the user interface, data warehouse, and dashboard components as described in Section B. Dr. Bailey will (1) provide oversight and coordination of UVA’s role in the project; (2) develop, advise, and support capstone project students who will be developing software components; (3) develop assessment tools and dashboards with Challenger Center and the
Redmon Group, (4) attend all planning, development, and advisory meetings, (5) assist as needed in school site visits and teacher PD; and (6) document all contributions.

The Redmon Group, led by Kenneth Cline, will update the mission and data log functions, provide back-end systems to accumulate and aggregate the response data, provide web services supporting the real-time assessment capabilities, and create methods to trigger changes in the learning environment. Redmon will contribute design, artistic, and programming staff.

**Communications** – Given the diverse physical locations of the project team, much of the daily communication will occur through email, teleconferences, and webinars; however, in-person meetings and site visits will also be arranged to facilitate project coordination as needed. Regular meetings will be scheduled so that key members of each team receive updates and can effectively coordinate next steps. Depending on the phase of the project, meetings will occur daily, weekly, or monthly, and involve a small group or multiple stakeholders. The internal Challenger Center team will meet weekly to ensure continued progress on program milestones.

An Advisory Committee, consisting of the Project Director and key personnel from Challenger Center (Muhammed Shazlee, the Education Manager, and the Education Technology Manager); the two regional Challenger Learning Centers (Jackie Shia and Dr. Hollee Freeman); the LEAs; the Virginia Department of Education (Eric Rhoades, Science Coordinator); the University of Virginia (Dr. Reid Bailey; Dr. Gregory Lewin, Lecturer in the Department of Systems and Information Engineering; and Dr. Jennifer Maeng, Assistant Professor, Science Education); and the Redmon Group (Ken Cline), will be formed and will meet quarterly.

**Partner Relationships** – Contractual relationships will be established with each of the partnering institutions, software developers, the evaluators, advisors, and the schools. These
contracts will outline expectations and specific dates for deliverables as appropriate. Challenger Center staff will also conduct regional site visits.

**Timeline** (CC: national Challenger Center; CLC: regional Challenger Learning Center; Q1-Q2: spring of each project year; Q3-Q4: fall of each project year)

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<td>Content, software updates (Redmon, CC, CLCs)</td>
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<td>Beta software/content testing in classrooms (CC, CLCs, educators)</td>
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<td>Classroom implementation (CC, educators)</td>
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<td>National conference, dissemination (CC, Evaluator)</td>
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**D. Personnel**

The Challenger Center has assembled a strong team with complementary expertise. The Project Director, Kathleen Meehan Coop, has nearly 20 years of experience in education and project management. As the Vice President of Education, Ms. Meehan Coop oversees education product development at Challenger Center. Prior to joining Challenger she was the Director for the National Ocean Sciences Bowl at the Consortium for Ocean Leadership, where she managed...
the operations and provided the strategic vision for a national high school STEM program on marine science. She also served as a Senior Program Manager at the U.S. Civilian Research & Development Foundation where she managed international grant competitions. During her time at the Tennessee Aquarium, she developed and implemented teacher professional development programs. Ms. Meehan Coop has an MBA from University of Tennessee at Chattanooga and an M.Ed. from Slippery Rock University. She also holds a bachelor’s degree in environmental studies from Sonoma State University and acquired certification to teach from Loyola Marymount University.

Muhammad Shazlee is Director of Technology at Challenger Center for Space Science Education. He has more than 16 years’ experience in information technology (IT) leadership and design, development, and implementation of complex IT and education technology solutions. Mr. Shazlee has a proven record of managing teams from concept to delivery, and is currently leading the update of the Challenger Center’s site-based simulation platform to enhance experience, delivery, and usability. He is versed in IT architecture, systems administration, network engineering, databases, and enterprise-level hardware, including servers, networking, and security equipment. He has a bachelor’s degree in computer systems engineering.

Challenger Center will hire an Education Manager and an Education Technology Manager for this project immediately upon grant award. If necessary, Meehan Coop and Shazlee will manage their responsibilities (with assistance from Mission Specialist Carlos Nunez) until these positions are filled. These managers will handle the daily operations of project implementation, including the coordination of program meetings, management of the development sessions for content and software, creation of the trainings materials for the PD programs, implementation of site visits, and coordination of testing activities. The Education
Manager will also review and edit all the content and scenario materials and will work closely with the Education Technology Manager to author those materials into the Sim3 software platform. The Education Technology Manager will test all upgrades before release for external testing, and will coordinate activities and meetings with Redmon and UVA to ensure that embedded evaluation tools integrate seamlessly into the Sim3 upgrades. The Project Director, in coordination with the Education Manager, will work closely with the external evaluator.

Dr. Reid Bailey, Associate Professor in the Department of Systems and Information Engineering, University of Virginia, will direct the UVA software development. Dr. Bailey joined UVA in 2006, after holding faculty posts at the University of Dayton and the University of Arizona, where he was the Lockheed Martin Assistant Professor of Engineering Design. He has been involved in engineering design education in all three positions, including teaching capstone courses in which more than 150 capstone design teams (most with industrial sponsorship) completed projects; he personally mentored more than 20 teams. Industrial clients have included people with special needs, nurses at the UVA Hospital, the Cavalier Daily, and the Virginia Discovery Museum. He also co-authored the only design-centered textbook written specifically for first-year engineering students, *Becoming a Technical Professional*.

E. **Quality of Project Evaluation**

*Introduction* – The external evaluation will include a formative evaluation for continuous improvement and a summative evaluation to systematically study the project outcomes. The logic model (see Appendix D) outlines relationships that hypothesize (based on strong theory) how the project will use technology-enabled solutions to build elementary students’ motivation, engagement, content knowledge, and self-efficacy in STEM subjects, improving academic achievement in these domains. The logic model specifies a causal relationship between necessary
program elements (inputs, activities, and key components), possible mediators, and the expected intermediate- and long-term impacts. The formative evaluation will collect data on program components and the mediating factors annually to assess progress towards meeting project goals. As evaluation resources permit, qualitative data will be gathered in the form of focus groups and interviews to provide further formative feedback. The summative evaluation will test the project hypotheses by conducting: (1) an impact study to draw causal inferences about the effects of the intervention on relevant outcomes (defined as academic achievement in math and science); and (2) an implementation fidelity study that measures if the intervention thresholds were met and documents the experiences of comparison participants to contextualize impact findings. Mediating factors, such as student engagement, will be analyzed by specific exploratory research and examined with a pre/post design, which is acceptable for development grants under National Evaluation of i3 (NEi3) guidelines (Abt Associates, 2012, p. 17). Details of the exploratory study will be provided in the comprehensive evaluation plan to be completed upon award.

**Impact Study Research Questions** – The confirmatory research questions that will direct the impact study are: (1) *Do 5th grade students who receive the Challenger Center intervention demonstrate greater achievement in math after one year than equivalent students who have not received the intervention?* and (2) *Do 5th grade students who receive the Challenger Center intervention demonstrate greater achievement in science after one year than equivalent students who have not received the intervention?* These research questions are important, measurable, and address a key funding requirement of the i3 program.

**Methods for Impact Study** – The evaluation will focus on the intermediate outcomes of math and science achievement (evaluating the logic model’s longer-term outcomes is not feasible in the grant time frame). To investigate the above research questions, the analysis will employ a
cluster Randomized Controlled Design, in which 5th grade teachers will be randomly assigned to provide the treatment or control conditions to students. The impact of the intervention will then be assessed by comparing science and math achievement for treatment and control students. A regression-based analysis will estimate these impacts while statistically controlling for relevant covariates, as well as the baseline measure of the outcome variables. A difference-of-means analysis should provide unbiased estimates of the treatment effect; however, a multi-level modeling approach is proposed as it will increase the precision of those estimates (thereby increasing the minimum detectable effect size) and account for the nested structure of the data (Murnane & Willett, 2011).

**Measure of Academic Achievement and Data Collection** – Math and science achievement will be operationalized as rank-based z-score transformations of individual-level student-scaled scores on standardized state tests in math and science, as required by each state. These transformations are necessary since state tests are differentially scaled (re-scaling student data into a common metric is an appropriate analytical approach, as outlined by May et al., 2009). The evaluation will use individual-level post-intervention observations (i.e., spring of the intervention year) as the outcome measure, as state tests meet the NEi3 (Abt Associates, 2012, p. 12) criteria for outcome variables (face validity, reliability, consistency, and lack of over-alignment). Tests are taken in participating states at the end of each school year in grades 3 or 4 (depending on state testing schedules) (pre-intervention) and 5 (post-intervention). Data collection procedures will be identical for treatment and comparison conditions. All academic outcome data collection will be administered by the schools under the responsibility of the state and each school district. The evaluator will acquire individual-level test datasets from each state’s Department of Education.
**Sample Identification/Selection, Sample Size, and Minimal Detectable Effect Size** –

Within the participating LEAs in Virginia, West Virginia, and Pennsylvania, 30 5th grade teachers will be randomly selected to provide the treatment condition, and 30 will be selected to provide the control condition (treatment as usual) in Year 3 of the project. Pairs of 5th grade teachers will be recruited from participating districts and randomized into control/treatment pairs within the school. The analytic sample is thus expected to be balanced within schools, districts, and states. This will occur over two consecutive years (i.e., again in Year 4). Treatment and control students will thus be cluster randomized into either condition. Crossovers and no-shows will be minimized and tracked, and retention will be maximized through data collection procedures. Consistent with the What Works Clearinghouse and i3 evaluation guidelines, if attrition is high, baseline equivalence will be established with pre-intervention observations of outcome measures (state test scores in math and science). The treatment is a year-long STEM intervention built around a highly-immersive experiential core. Although the literature provides no benchmarks for expectations of effectiveness for such an intervention, the typical elementary student intervention effect size provided in the published research is approximately .23, for studies that use narrow subject-matter standardized tests as outcomes and compare treatment conditions to “treatment as usual” for mainstream students (effect sizes are presented as standardized mean differences between control and treatment groups, based on Hedges’ g formulation; statistics on mean effect sizes come from Hill et al., 2008). The evaluation as proposed—with 15 sites, 2 treatment/2 control classes of 25 students per site per year (a sample size of 1500 treatment and 1500 control students over two years), and based on a number of standard expectations—should yield a Minimal Detectable Effect Size (MDES) of about .17 to
after two years of data collection.\footnote{Effect size estimates are calculated with Optimal Design and reflect the following basic expectations: power ($\gamma$) = .80, significance ($\alpha$) = .05, and intra-cluster correlation coefficient ($\rho$) = .20. The first two are standard, and the third is empirically-based on research in education (e.g., see Hedges & Hedberg, 2007). Estimates vary based on the projected variation explained ($R^2$) by the model and whether models are estimated with fixed or random effects. Pre-test data are usually highly predictive, so it is anticipated that the smaller effect size is more accurate.} This study design will meet the “moderate evidence” criteria for an i3 validation grant, as it will meet WWC standards with reservations (QED), examines a relevant outcome, has a large sample size, and is a multi-site sample.

**Analytic Approach** – For both research questions the proposed analytic approach will be to regress post-test scores (outcome measure) on pre-test scores (baseline observation of outcome measure), a treatment/comparison indicator variable (treatment=1, control=0), and relevant student- and site-level covariates. Covariates are included to increase the precision of the estimates. The model will be estimated with a multi-level structure using HLM or Stata. The coefficient for the treatment indicator should be an unbiased estimate of the treatment effect of the Challenger Center intervention or the regression-adjusted mean difference in post-test scores between treatment and control students. Statistical significance will be based on test statistics produced by Stata for the coefficient using a two-tailed test, with $p < .05$.

**Key Components and Outcomes** – As described above, the key components and intermediate- and long-term outcomes, as well as the theoretical link between the two (mediators), are shown in the logic model (provided in Appendix D).

**Measurable Threshold for Implementation** – As per the NEi3 analysis and reporting guidance, annual thresholds (see below) are set for each key component as depicted in the logic model.
model. If the fidelity measure is greater than or equal to the threshold, the key component will be judged to have been implemented with fidelity; if it is less than this threshold, the key component will be judged to have not been implemented with fidelity. (1) Professional Development: 90% of the 30 treatment teachers attend the three PD phases as measured by attendance logs maintained by the Project Director. (2) Educational Simulation Experience: 85% of the 1500 treatment students participate in the classroom simulation as measured by the electronic student activity log. (3) Embedded Assessments: 90% of the 30 treatment teachers use the real-time dashboard data to make decisions about simulation control as measured by the data generated by student and teacher actions within the simulation software. (4) Ongoing Problem-based Learning: 90% of the 30 treatment teachers refer back to the simulation during the school year and use hands-on labs learned at the PD to teach science, including a hands-on culminating activity, as measured by a teacher survey. The full threshold rubric will be provided in the comprehensive evaluation plan; for each key component, specific indicators will be operationalized, including the data source, scoring, and threshold level. The implementation findings will provide context for the impact findings. Data will also be collected on control students’ experiences to ensure they do not have similar experiences to treatment students.

Evaluation Resources and Evaluator Qualifications – The project has allocated sufficient resources (10.7% of the budget) to the evaluation proposed. The evaluators (The Policy & Research Group) are well qualified, having led over 30 federally-funded evaluations. The PI, Dr. Eric Jenner, oversees the evaluation of a current i3 Development grant, has over 10 years’ experience in supervising rigorous evaluations, authors evaluation reports, continues to publish, and serves as a peer reviewer for the Journal of Education for Students Placed at Risk.