Data Adventures

Education Innovation and Research Program - Early-Phase Grant

Santa Clara County Office of Education

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Data Adventures: A Mobile Makerspace to Promote Data Literacy, Digital Storytelling, and Interest in Data Science

The Santa Clara County Office of Education (SCCOE), San Jose State University (SJSU), WestEd, and The Policy & Research Group (PRG) propose an early-phase Education Innovation and Research (EIR) project to develop and experimentally test an innovative intervention to improve data fluency among high-needs students – English Language Learners (ELL), students with disabilities (SWD), students from limited income communities, and students in rural communities. SCCOE is ideally situated to be a first-time partner with EIR as a leader in educational reform and innovation. It is recognized as the geographic lead for the Bay Area and the California lead for equity & learning acceleration lead within the State System of Support. SCCOE provides instructional support to the 31 school districts of Santa Clara County (SCC). These districts serve 267,224 students from rural areas (Gilroy) to urban centers (San Jose). It serves a diverse population, 40% LatinX, 31% Asian, and 41% low income. Despite living in or near Silicon Valley, these high-need students frequently have limited access to interactive and meaningful data literacy, digital storytelling, and data science experiences. *Data Adventures* will (1) build students' 21st century skills in data fluency and digital storytelling; (2) increase student excitement for Science, Technology, Engineering, Art, and Mathematics (STEAM) through immersive, authentic experiences and cross-age tutoring with SJSU students; (3) incorporate student identity, voice, and choice through digital storytelling while reducing burdens on teachers; and (4) provide these as mobile experiences which can make them available to a much wider range of high-need communities. By working with the teachers and students in SCC, we will co-design a series of customizable, authentic, interdisciplinary adventures that incorporate data fluency, making, and digital storytelling that can be easily integrated into classroom communities. This project addresses **Absolute Priority 1 -**

Demonstrates a Rationale**, Absolute Priority 3** - Field Initiated Innovations - Promoting Equity in Student Access to Educational Resources and Opportunities: STEM, and **Competitive Preference Priority 1** - Partnership with entities underrepresented in EIR**.** San Jose State University - CommUniverCity (SJSU) is a key partner and a minority serving institution (MSI). *Data Adventures* will engage 10 teachers/100 high-need students across SCC & rural communities during the co-design and pilot phase, and 40 teachers/ 3,650 6th-7th grade students in 20 high-need SCC schools & rural communities during the evaluation study. This project's multidisciplinary team will create authentic and engaging data science experiences that integrate data storytelling & cross-age tutoring. Thematic units and lessons will be co-designed to appeal to diverse students, support the formation of student identities in STEAM, & reduce teacher implementation barriers. Our goal is to make *Data Adventure* innovations available to student populations countywide to expand meaningful engagement for students in STEAM education.

A. Significance: Importance of STEM: The success of the U.S. STEM education system is vital to our economic, cultural, and political systems. However, the most recent NAEP shows that only 35% of 4th graders and 34% of 8th graders are proficient in science (NCES, 2019), leaving many students ill-prepared for tomorrow's science and engineering-based economies (Marginson, et al., 2013; OECD, 2019). These gaps in STEM access and achievement are even worse for students from historically marginalized groups; Black, Indigenous, and People of Color (BIPOC); SWD; emerging multilingual learners; and/or diverse socio-economic backgrounds (Noguera, et al, 2015; Reardon, et al, 2019). Our inability to address this gap has frightening repercussions. As a society, we are unable to meet the demand for skilled workers in STEM fields (e.g., technology, engineering, healthcare; Carnevale, et al., 2011), impacting our nation's economy and leading to recruitment of individuals outside of the U.S. to fill STEM-related occupational vacancies. For individuals, historically disenfranchised students like SWD are underrepresented in STEM classes, majors, and careers, depriving them of access to high demand jobs with growth opportunities and depriving STEM fields of the numerous and powerful benefits a diverse STEM workforce brings. It is urgent that we develop innovative and engaging solutions in K-12 settings to develop a diverse and STEM-literate next generation.

The Data Explosion and the Emergence of Data Science. A growing area of instructional need is data science - the field of producing, understanding, and communicating the implications of the data that surround us. Our information-driven economy generates vast amounts of data: in the last two years 90% of all data in the world was generated (Hariri et al., 2019). While this has had a positive effect on many things (e.g., ability to understand natural phenomena and conduct research quickly), it has also created data overload and made it possible to manipulate people and advance misinformation (Raine & Anderson, 2017). Data science is an approach to solving real world problems that are an amalgamation of technical, programming, analytic, communication skills, and roles (Kolassa, 2016). It is important for all community members to be knowledgeable about data, its role in human affairs, and how it can help us understand the world. Social media accounts place the burden of data protection and privacy on the user and whether rural or urban, 1 in 5 teenagers report using social media accounts all day (Vogels et al., 2022). Teenagers report shaping their public persona and data through the removal of negative comments, dislikes, or friends, and only 40% are concerned about third-party companies accessing and using their data (Madden et al., 2013). While the future workforce need not all be data scientists, they must be data literate and have the ability and confidence to make sense of and use data and be able to understand and critically analyze stories told about and with data.

STEAM, Making, and Makerspaces. Historically, the practice of the STEM fields, including data science, and the arts were considered to be separate and frequently incompatible ways of knowing and engaging with the world. In recent years, the two fields are seen as compatible and synergistic and have included an ‘A’ to STEM to form STEAM. STEAM education builds critical thinking skills by breaking down barriers between disciplines and is a promising method for making materials more socially and culturally relevant (Kant et al., 2018). STEAM provides students with engaging content, hands-on and product-oriented activities, and engages student creativity. One of the overarching aspirations of STEAM is to motivate students to transition from being consumers of science and technology into being designers and skilled storytellers who use data and art to explain and understand the world (Honey & Kanter, 2013) and eventually to meet the increasing demand for workers (CompTIA, Inc., 2021). STEAM activities, too, can be a vehicle for storytelling. Whereas STEM education has been criticized for not attracting diverse students (Vossoughi et al., 2016; Barton et al., 2017), STEAM has demonstrated tremendous potential for attracting and retaining a diverse set of students, including Black (Allen-Handy et al., 2020), LatinX (Lindberg et al., 2020), and Native American (Kant et al., 2018) students. These interventions lead to meaningful and lasting interactions with both STEM and art (Peppler & Wohlwend, 2018). One of the most promising implementation models for STEAM has been makerspaces that use 3D printing, sensors, VR/AR tools to introduce students to alternative narratives of what counts as math or science.

Factors Impacting STEAM Trajectories. Despite the growing demand and importance of data science, access to STEAM and high-quality data science instruction is distributed inequitably (Dorn et al., 2020). The COVID-19 pandemic highlighted the dramatic and pervasive inequities that have existed for generations between rural/urban districts and high/low poverty districts (USDOE, 2021). These inequities in access and subsequent lack of diversity are reflected in the demographics of employees and management in technology fields, where white men are welcomed and promoted and nearly all other demographic, racial, and cultural groups are either excluded or marginalized (Greenfield, 2012). Additionally, many young people do not see individuals they identify with in technology leadership positions or depictions of technology fields in popular culture (Gallup, Inc., 2020), discouraging members of these groups from entering the STEM pipeline (Smith et al., 2017). This ongoing pattern creates a feedback loop resulting in poor outcomes for individuals and industry, depriving companies of the benefits of a diverse workforce and further widening the digital divide (Gallup, Inc., 2020, Google LLC & Gallup, Inc., 2016a. Google LLC & Gallup, Inc., 2016b).

Our Solution: *Data Adventures.* Our proposal, *Data Adventures*, will create 4-6 units to address each issue - inequities in access to data science instruction, inequities in access to emerging technologies and tools, a lack of diversity in STEM fields, & a lack of relevant learning experiences for high need students - by integrating innovative, accessible, and culturally relevant data science content into STEAM offerings centered on authentic, immersive experiences using technology and tools delivered by a mobile data makerspace and supplemented with cross-age tutoring to increase student excitement for STEAM and incorporate student identity, voice, and choice through digital storytelling.

Taking STEAM on the Road: Mobile Education. Mobile data makerspaces overcome inequities in access to emerging technologies and tools. There is considerable variation in the technological and device infrastructure across schools, students in high need communities are at a disadvantage. A robust body of spatial analysis research highlights the value of examining education phenomena from a community perspective (Butler & Sinclair, 2020; Cobb, 2020). In STEM, there is most definitely a geography of opportunity when it comes to funding and accessing technology, critical tools, and learning opportunities. Not all communities can afford new technologies(high speed computers, 3D printers, and VR/AR headsets) nor do students have access to data collection and representation technologies. These communities are geographically distant from urban areas which limits access to informal settings and existing infrastructure. Our mobile data makerspace delivers data collection, representation and storytelling experience and materials to school sites. A vehicle delivers classroom kits to encourage engineering, artistic expression, and the use of new technologies and collaboration along with introduction to cross age peers from the community. *Data Adventures* will bring the infrastructure and experiences to communities in the form of a mobile data makerspace outfitted with tools otherwise unavailable locally. Similar offerings have been implemented in Brownsville School District, Killeen Independent School District, Seattle Public Schools, Claflin University, San Jose Public Library, Pullap School District, Poudre School District, and Georgia O'Keefe Museum.

Cross Age Tutoring and Mentoring. These kits and adventures will be used in tandem with cross-age tutoring, a mentoring approach where older students (mentors) assist and support younger students (mentees) in their learning process. It involves pairing students from different age groups to facilitate academic and social development, promoting a positive learning environment, and building meaningful connections between peers. Cross-age tutoring offers a reciprocal benefit for both mentors and mentees, including academic and social benefits for high need mentees such as SWD and BIPOC (Alegre, et al., 2020; Morano & Riccomini, 2017). Further, serving as a mentor to other potential first-generation students has demonstrated academic growth and college retention for mentors from minoritized groups as well (Yeager, et al, 2016). In *Data Adventures*, we will recruit a diverse population of undergraduate mentors from SJSU to help implement robust data learning opportunities at school sites and ultimately support students in demonstrating their findings at data science fairs.

Data Adventures will use community mentors and mobile data makerspaces to deliver STEAM opportunities to diverse communities and create meaningful onramps for middle school students into data science. These engaging experiences will (a) introduce students to data inquiry experiences, a foundational instructional approach commonly found in data science in combination with the creativity and collaboration of makerspaces (Bybee, 2009); (b) provide contextual real world experiences to apply quantitative reasoning (e.g., measures of center or describing variability within data); (c) opportunities to work with data to draw conclusions, argue from evidence, and justify conclusions; and (d) increase excitement as they tell their stories using data and art with community partners (e.g., libraries, makerspaces, universities).

B. Quality of the Project Design: Our Approach/**Conceptual Framework**: *Data Adventures* will support student growth in STEAM, including data literacy which is crucial to data science, by delivering highly-engaging, accessible, hands-on data experiences with little teacher preparation time. Within this project, a Data Adventure is a short thematic unit (e.g., sneaker culture, gamer speed runs, community service in parks) that begins within an immersive STEAM experience with the arrival of the mobile data makerspace bringing data, cross-age tutor mentors, and materials to the school. The immersive experience connects students to three major components of each Data Adventure*:* (1) data science, (2) introduction to the data collection materials (e.g., surveys, sensors, thermal cameras) and, (3) digital data storytelling. The kickoff brings cross-age tutors (SJSU) and the mobile makerspace to reduce preparation time for teachers, catalyze the student data inquiry process, and leave tools (kits; see Figure 1) for the adventure to continue at the school (see Logic model in Appendix G). Each Data Adventure contains digitally delivered lessons called *Quests* designed with Universal Design for Learning (UDL) and Culturally Sustaining Pedagogy (CSP) principles (described below) and tools to pursue pathways of learning and expression with data. Participants culminate with the *Quest Fair,* where students, community members, and cross-age mentors come back together at the school site or at SJSU with the mobile data makerspace to share and honor each other's digital data stories. An example is provided in Table 1.

Table 1: Example Data Adventure

Sixth Grade Data Adventure: When is it too hot for PE?	
Standards	Science - ETS 1-3 Analyze data from tests to determine similarities 6 RP.A.1 and A.3 Ratios, proportions,and rate reasoning
Kick-off	Kickoff introduces students to SJSU campus, mentors, and STEM experience in college (*community, cross-age tutoring*) through multiple engagement and representation options within the quests (*UDL*). Students also learn to use infrared cameras and laser thermometers from the kits (*data collection materials*) and collect data and examine variability in surface temperatures (*data science*). Teachers receive classroom makerspace kits with data cards, pedometers, and construction and art materials.
Quests 1-3	Students (1) conduct or listen/watch interviews of community members that work outside (*data collection materials, community*) and (2) use Fitbits to monitor heart rate and O2 while exercising on school grounds (*data collection materials*).
Quests 4-5	Students examine surface temperature phenomenon by examining data in CODAP (free online data visualization tool), document reflections after completing data science simulations (*data representation*, *math and science practices*).
Quests 6-8	Students explore thermal data collected by connecting with their community (*community*). SJSU students investigate a similar problem on campus and watch short interviews of STEM students investigating regions of the campus that have radiant heat issues similar to the middle school (*cross-age tutoring*).
Quests 9-10	Students create digital or physical data stories to share what they learned about surface heat (*digital data storytelling*). Projects range from using maker kit materials to 3D print a cooling device for laborers outside, designing stickers to raise awareness, uniform color guidance for the local soccer team, to recording a spoken word performance piece to accompany a data plot (*UDL, CSP*).
Quest Fair	Students visit SJSU campus with family and friends to share their data story to college students, faculty and staff (*community, cross-age tutoring*)

Our target audiences are middle school students from historically marginalized groups (e.g., Black, Indigenous, BIPOC, SWD, emerging multilingual learners, and/or diverse socio-economic or geographical backgrounds). Research suggests these students experience substantial gaps in STEM access and achievement (Noguera, et al, 2015; Reardon, et al, 2019), are more likely to experience decontextualized learning experiences (Bannister, 2016; Lambert & Tan, 2017), and are less likely to have access to creative STEAM learning opportunities and enter STEAM-related fields. Middle school STEM classes often lack the curricular and material resources necessary to incorporate data literacy that addresses these gaps.

Project Design:

Instructional Design. Instructional design will draw on three evidence-based principles: (1) standards-aligned, rigorous content; (2) flexible implementation; and (3) authentic, engaging driving questions. *Standards-aligned, rigorous content* will align with NGSS Science and engineering practices that explicitly call for collecting and modeling (via data), analyzing and interpreting data, and using technology and engineering (NGSS Lead States, 2013). Additionally, the *Quests* build and develop statistical and mathematical thinking through developmentally appropriate lessons. *Flexible implementation* plans help teachers adjust to their local scope and sequence by offering two different pacing approaches delivered via CORGI (a google app designed to support higher order thinking through graphic organizers; www.corgi2.cast.org, Blackorby et al., 2018): either a stretched (one day a week over a quarter) or compressed (two week unit) format. Flexible implementation also includes disciplinary connections to math and science standards, UDL supports for data collection, representation and storytelling, thereby increasing the likelihood that the adventures are relevant and reducing the minimum data science expertise required for teachers. *Authentic, engaging driving questions* will produce lessons that leverage high-interest contexts drawing on data examples that are either based on real-world datasets curated or generated through participatory sensing campaigns (e.g., recycling, music, sneaker shoe color). Compressed units rely more heavily upon data collection tools and materials from the mobile data makerspace whereas the stretched units are built upon data types and methods students are familiar with but perhaps did not directly contribute to.

Figure 1: Tools Provided in Data Makerspace Kits

DATA MAKERSPACE PROVIDES

Engagement	Representation	Storytelling & Expression
Laser thermometer **collect surface temperature**	***CODAP*** **explore and represent data**	***360 digital camera and sensory table tools*** **to help audience connect to the place where data were collected**
Pedometers and Fitbits **document steps to a trash cans and recycling**	***3D printers*** **to model favorite data plot or space**	***Audio booth*** **to record and collect data stories**
Participatory sensing **apps collect survey data about when folks are distracted**	***Corgi*** **to encounter and document data in different forms**	***VR headset*** **to virtually walk through the data**
3D scanners **collect volumetric data of crowding in school hallways**	***Art station*** **clays, foam board, paint, beads**	***Laser cutter*** **to make stickers as a call to action as a result of datastory**
	Microbits **assemble sensor to collect/represents data live**	

Universal design for learning (UDL). UDL is a goal-driven instructional framework that brings together proactive and iterative cycles of instructional planning, proven educational practices, data collection and decision-making, and continuous improvement across a learning environment (Basham et al., 2020; Meyer et al., 2014). The premise of UDL is that barriers to learning occur in the interactions among learners' strengths, challenges, and preferences and the characteristics of curricula and that barriers are not solely inherent in the capacities of the learner. Three principles, based on neuroscience and educational research, underlie the framework of UDL: (a) multiple means of engagement, (b) multiple means of representation, and (c) multiple means of expression and action (Meyer et al., 2014). UDL is noted in the ESSA (2015), IDEA (2004), HEOP (2008), the Perkins CTE (2006), and the 2012, 2016, and 2020 National Education Technology Plans (U.S. Department of Education, 2017). UDL has been applied to a wide range of education challenge areas ranging from reading instruction for struggling readers and English learners, writing, mathematics and science, and diverse age ranges (King-Sears, et.al., 2023).

Culturally Responsive and Sustaining pedagogy (CRSP). Scholars have problematized the ways that individual educational frameworks have siloed the approaches to addressing student variability (Cruz, et al., 2022). As a project, *Data Adventure*s recognizes the potential in "cross-pollinating" Culturally Sustaining Pedagogy (CSP) and UDL (Waitoller & King Thorius, 2016), and articulating theory from various sectors of emancipatory education to realize critically inclusive STEM learning. CSP emphasizes the importance of sustaining linguistic, literate, and cultural pluralism to realize social transformation within schools (Alim et al., 2020; Ladson-Billings, 1995). This paradigm emphasizes four components of culturally responsive pedagogy—caring, communication, curriculum, and instruction (Gay, 2018)—to conceptualize the classroom as a site of co-constructed knowledge, in which pedagogy must speak to students' cultural realities. From this perspective, differences are viewed as part of the human condition and strengths to be built upon rather than assimilated (Paris, 2012). Educators' understanding of students' culture holds consequences for students' access to learning, as overlooking its influence disadvantages some while privileging others (Kirkland, 2020). A sustaining approach requires educators to move beyond surface-level curricular adjustments toward deeper practices that leverage not only the students' cultural and community assets but also expand this conception of identity-sustainment to include neurodiversity. As the field acknowledges the need to achieve inclusive, high-quality learning for all students, systems of education must shift toward related understandings of students' intersectional identities, which include but are not limited to race, gender, language, and learning preferences (Collins, 2019; Crenshaw, 2017). The utilization of UDL and CSP in the design and delivery process emphasizes students' identities as multifaceted and dynamic, and—based on an intersectional understanding—that each student brings unique strengths, experiences, and preferences to learning.

These approaches will collectively result in learning sequences that engage 6-7th grade students in innovative, accessible, and culturally relevant data science content through authentic, immersive STEAM experiences supplemented by a mobile data makerspace and cross-age tutoring, increasing data literacy, student excitement, and career interest in STEAM. *Data Adventures* celebrates and welcomes the whole student by incorporating student identity, voice, and choice through digital data storytelling. It is responsive and relevant, usable and accessible to all students, and integrates community assets. *Data Adventures* low preparation time for training and teaching will increase teacher interest, implementation, and integration of data scienc. The mobile data makerspace kits, cross-age tutors, and community partners will help students & families connect with local STEAM agencies for possible future participation.

Phases: *Data Adventures* will accomplish these goals through three separate, but distinct phases: Phase 1: Develop and Pilot; Phase 2: Evaluation; and Phase 3: Disseminate.

Phase 1: Develop and Pilot (Years 1-2). In Phase 1, we will co-design the *Data Adventures* thematic units with middle school students and teachers by employing a systematic iterative approach from improvement science. Using Plan, Do, Study, Act (PDSA) cycles (Bryk, 2015), we collaborate with teachers and strategic community partners to: (1) ***Plan***, includes defining the objectives, identify data topics, design lessons and materials; (2) ***Do***, includes implementing the approach with small numbers of students (mini-pilot); (3) ***Study***, includes using data to evaluate the practicality, resonance, and effectiveness of the approach (responsive revision following another mini-pilot round); and (4) ***Act***, includes using the observed process and outcome data to improve overall design. By revisiting the co-design process frequently, we can leverage real feedback data to build, mockup, and iterate *Quests* together. *Quests* are designed for teachers to implement with minimal training and will be tested in the co-design phase. We will collect quantitative and qualitative data to understand the feasibility, acceptability, and potential impacts of each *Quest* within the Data Adventure, and to ensure that variabilities in learner characteristics are addressed. The two years of co-design will result in the development of 4-6 adventures.

Phase 2: Evaluation (Years 3-4). To evaluate the efficacy of *Data Adventures* to improve students' data literacy skills, attitudes, and aspirations to engage in STEAM careers, PRG will lead Phase 2. Described in detail below, the evaluation will use a school-level cluster randomized controlled trial design (RCT), plus an implementation evaluation to understand the degree to which *Data Adventures* is implemented as intended.

Phase 3: Disseminate (Years 1-5). This phase will occur throughout the life of the project. Our dissemination plan is based on a multipronged approach with these main goals: (1) add to the scholarly and practice discourses, (2) share findings with community and schools involved, and (3) provide easily accessible, evidence-based, and highly-engaging data science and makerspace experiences. To achieve the latter goal, *Data Adventures*' materials, processes, and products will be disseminated widely to reach the many audiences (e.g., students, educators, curriculum designers, entities with existing makerspaces) interested in *Data Adventures* and in replicating it elsewhere. SCCOE will maintain an active social-media presence (e.g., Instagram, TikTok) that will support broader dissemination of products from the project (e.g., student work, student postings, and practitioner briefings) and include local community centers and libraries. We will also share our work at national conferences and submit journal manuscripts to practitioner and research journals (e.g., *Journal of Research on Educational Effectiveness*, *Middle School Journal)*. Finally, an important principle for our work will be a collaboration between the project team, teachers, students, schools and mentors.

After the evaluation process, the materials will be manualized via videos, how-tos, and online resources hosted on a webpage to support teacher adoption as well as train local community partners to sustain both the mobile data makerspace and the implementation of *Data Adventures*. The guiding principles in its design will be: (1) non-technical ease of use; (2) support for a wide range of teachers (e.g., experience with technology), (3) low onboarding and preparation time, and (4) facilitation of an open and inclusive environment.

Project Plan: Goals, Objectives, Activities, and Outcomes. Table 2 specifies the five project goals and associated objectives, activities, measures, and outcomes. Goal 1 is to improve access to, achievement in, and interest in data science and STEAM among high need students. Goal 2 is to develop, collaboratively co-design and refine interdisciplinary content from data science, data literacy, and STEAM to increase rigor and relevance in preparation for implementation. Goal 3 is to create professional development materials to support implementation and increase teacher self-efficacy, knowledge, and practice in data science. Goal 4 is to conduct an experimental evaluation of *Data Adventures'* effects on student knowledge, self-efficacy, and practice in data science and data literacy. Goal 5 is to support dissemination and scaling of *Data Adventures* for use in other high need communities.

Table 2. Goals, Objectives, Activities, and Outcomes

Goal 1: Improve access to, achievement in, and interest in STEAM among high-need students.		
Activity	**Measure**	**Outcome**
Objective 1.1: Increase instruction of data literacy in middle schools		
1.1.1 Analyze implementation data	Mobile Data Makerspace Vehicle Designed and Outfitted # *Data Adventures* taught # middle school sites implementing	Increased access to high-quality data literacy lessons and resources
Objective 1.2: Increase data literacy		
1.2.1 Analyze data literacy assessment	(LOCUS) 6/7th grade assessment	Improved data literacy
Objective 1.3: Increase student interest in pursuing STEM knowledge/careers		
1.3.1 Improve attitudes toward data science and STEM	STEM Career Interest Scale; Middle School Attitudes Toward STEM Scale	Increased representation of target populations in STEM fields
Goal 2: Develop and collaboratively co-design and refine interdisciplinary content from data science, data literacy, and STEAM to increase rigor and relevance in preparation for implementation.		
Activity	**Measures**	**Outcome**
Objective 2.1: Build and test *Data Adventures* lessons, including kits, content, procedures, and implementation supports.		
2.1.1 Recruit teachers for co-design	# of teachers participating in co-design	Teacher consent received
2.1.2 Conduct data science and data literacy survey	# teacher surveys of existing data science and/or data literacy	Complete scan of curriculum and resource coverage
2.1.3 Co-design PDSA cycles	# *Data Adventures* identified and developed, including resources and materials	4-6 *Data Adventures* designed, refined, and tested
2.1.4 Pilot test design and data collection procedures of co-designed PDSA cycles	# *Data Adventures* designed # *Data Adventures* piloted # of surveys # of observation protocols # of procedures documents # Mobile makerspace sites visited	Pilot includes *Data Adventures*, process, workflow, and procedures tested Surveys created, tested, and entered into Qualtrics
2.1.5 Analyze pilot test results and revise process	See *Data Adventures* Measures in Appendix J	Procedures, assessments, protocols revised based on pilot
Goal 3: Create teacher onboarding materials to support implementation and increase teacher self-efficacy, knowledge, and practice in data science.		

Activity	Measures	Outcome
Objective 3.1: Create professional development (PD) materials		
3.1.1 Create implementation and training resources	# of *Data Adventures* with PD materials	Draft *Data Adventures* implementation guides for teachers, partners, administrators
Objective 3.2: Increase teacher confidence in implementing data science and data literacy lesson		
3.2.1 Analyze teacher self-efficacy	Teacher Efficacy and Attitudes Toward STEM	Increased teacher data science self-efficacy
Goal 4: Conduct experimental evaluation of *Data Adventures*' effects on student knowledge, self-efficacy, and practice in data science and data literacy.		
Activity	**Measures**	**Outcome**
Objective 4.1: Conduct experimental evaluation		
4.1.1 Recruit schools and teachers for experimental evaluation	# of schools/teachers in treatment condition # of schools/teachers in control condition	Teacher consent forms signed
4.1.2 One day teacher orientation prior to implementation	# of teacher attendees to session	Teachers have background knowledge, practice, and technology skills to implement *Data Adventures*
4.1.3 Implementation in partner schools	# of *Data Adventures* implemented # of schools Mobile data makerspace visited # cross-age tutors from SJSU	Teachers implement at least one Data Adventure
4.1.4 Teacher and student survey, observation, and performance data	# onsite observations conducted % response rate on surveys of attitudes, reactions, and recommendations # of student outcome assessments completed	50% response rate. Data exists on implementation, self-efficacy, and knowledge. Performance data exists. Data shared.
4.1.5 Analyze data	# of analysis, tables, and visual displays	Implementation, impact, mediation, moderation analyses conducted. Implementation fidelity and outcomes available.
4.1.6 Evaluation report	# of evaluation reports submitted	Formal summative report of evaluation findings submitted
Goal 5: Support dissemination and scaling of *Data Adventures* for use in other high-need communities.		
Activity	**Measures**	**Outcomes**
Objective 5.1: Build knowledge, evidence, and practical tools needed to support dissemination and further scaling of *Data Adventures* in high-need middle schools.		

5.1.1 Sustainability strategy development	# of cost effectiveness analyses # of updated PD resources # of online resources developed	Cost information available. Online resources created.
5.1.2 Creation of kits and PD resources to facilitate scaling	# of kits and PD resources created # Community partners incorporating resources	Resources exist to support schools interested in adoption or experimentation
5.1.3 Dissemination	# social media posts; one-pagers, videos, how-to guides; conference presentations and journal articles	A rich array of information is available for different audiences and applications

C. Quality of Project Personnel: The project director is [redacted], MA, Director of the Inclusion Collaborative, SCCOE. She has over 15 years of experience in implementing innovative programs for high need learners in SCC. She will be responsible for the overall design, implementation, analysis, reporting, fiscal management, and dissemination required for this project. She will be assisted by [redacted] who is a national expert in instructional design and UDL. *Data Adventures'* work will be carried out by the teams described in Table 3 (Resumes are in Appendix B). Collectively, the team has extensive experience in educational innovation, design thinking, UDL, CSP, curriculum design, and implementation.

Table 3. Data Adventure Teams

The **Leadership Team** will formally convene bimonthly and includes [redacted] M.Ed, SPED (SCCOE), [redacted] (SCCOE), [redacted] (WestEd), [redacted] (WestEd), [redacted], PhD (WestEd), [redacted], PhD (WestEd), and [redacted], PhD (PRG). [redacted] has expertise in cultural & systems change for Gen. Ed and SPED. [redacted] is an expert in data science and data visualization. [redacted] is an expert in UDL, with experience in designing and evaluating education technologies. [redacted] is an expert in inclusion education implementation and is a national expert in instructional design and UDL.
The **Co-Design and Professional Development Team** will formally convene weekly via zoom and includes [redacted], PhD (WestEd), [redacted] (WestEd), [redacted], PhD (SJSU), [redacted] (SCCOE), [redacted], PhD (WestEd), [redacted], PhD (WestEd), and [redacted], PhD (WestEd). This team will be led by [redacted] and will co-design and develop *Data Adventures* lessons, materials, procedures and formative research efforts, as well as professional development materials and sessions for teachers to implement the *Data Adventures*.
The **Evaluation Team**, led by [redacted], PhD (PRG), includes [redacted] (MPH, MSW), [redacted] (MPH), & a Junior Research Analyst. This team will conduct an independent evaluation, including instrument design, procedures, data collection, impact analyses, & reporting.

D. Quality of the Management Plan:

Management Plan and Project Timeline: The following timeline of activities and milestones, assigned personnel, and responsible personnel (in parentheses) is listed below (Table 4; see Gantt chart in Appendix G for more detail). Our team is experienced in collaborative and agile project management. We will meet regularly to review progress, examine qualitative and quantitative data, identify challenges and barriers, and make timely changes when necessary.

Table 4: Management Plan

Activity	Milestones	Y1	Y2	Y3	Y4	Y5	Personnel
Goal 1: Improve access to, achievement in, and interest in STEAM among high-need students.							
1.1.1	Analyze implementation data				√	√	1, 2, 3 (JB)
1.2.1	Analyze data literacy assessment				√	√	3 (EJ)
1.3.1	Improve attitudes toward data science and STEM				√	√	1, 2, 3 (LP, EJ)
Goal 2: Develop and collaboratively co-design and refine interdisciplinary content from data science, data literacy, and STEAM to increase rigor and relevance in preparation for implementation.							
2.1.1	Recruit teachers for co-design	√	√				1, 2 (SL)
2.1.2	Conduct data science and data literacy survey	√					1, 2 (SL)
2.1.3	Co-design PDSA cycles	√	√				1, 2 (SP, ML)
2.1.4	Pilot test design and data collection procedures of co-designed PDSA cycles		√	√			1, 2 (SP, ML)
2.1.5	Analyze pilot test results and revise process		√	√			2 (LP, ML)
Goal 3: Create teacher onboarding materials to support implementation and increase teacher self-efficacy, knowledge, and practice in data science							
3.1.1	Create implementation and training resources	√	√	√			1, 2 (SW, LP)
3.2.1	Analyze teacher self-efficacy			√	√		2, 3 (NG, EJ)
Goal 4: Conduct experimental evaluation of *Data Adventures*' effects on student knowledge, self-efficacy, and practice in data science and data literacy							
4.1.1	Recruit schools and teachers for experimental evaluation			√	√		1, 2 (SL)

4.1.2	One day teacher orientation prior to implementation			√	√		1, 2 SL/SP
4.1.3	Implementation in partner schools			√	√		1, 2 (SL, SP)
4.1.4	Teacher and student survey, observation, and performance data			√	√		3 (EJ)
4.1.5	Analyze data			√	√	√	3 (EJ)
4.1.6	Evaluation report					√	1, 2, 3 (EJ)
Goal 5: Support dissemination and scaling of *Data Adventures* for use in other high-need communities.							
5.1.1	Sustainability strategy development		√	√	√	√	1, 2 (LW, SW)
5.1.2	Creation of kits and PD resources to facilitate scaling	√	√	√			1, 2 (SP)
5.1.3	Dissemination	√	√	√	√	√	1, 2, 3 (SL)

1 = Leadership Team; 2 = Co-Design and PD Team; 3 = Research and Evaluation Team

Organizational Infrastructure and Strength of Partnerships: The *Data Adventures* organizational partners (Table 5) share a mission of improving outcomes for all learners and have collaborated on multiple projects. Partner staff will work in interdisciplinary teams to ensure that project activities are completed. The organizational partners, working alongside the community groups who have offered letters of support, will ensure that the human capital, professional learning support, and programmatic design elements can be sustained and scaled.

Table 5. Organizational Partners

Santa Clara County Office of Education (SCCOE) will oversee *Data Adventures*. SCCOE is a comprehensive regional education service agency delivering outstanding services to over 240,000 students and 31 districts. The SCCOE has expertise in data literacy, data science, and digital storytelling. The SCCOE is conducting an NSF: Computer Science for All project.
San Jose State University (SJSU) is a minority-serving institution (MSI) as both an Asian American and Native American Pacific Islander-Serving Institution (AANAPISI) and a Hispanic Serving Institution (HSI). SJSU ranks 15th in the number of Baccalaureate and 20th for Master's degrees awarded to minority students. Money Magazine ranked SJSU as #1 Most Transformative College in the U.S. (2020).
WestEd is a preeminent educational research, development, and service organization with 13 offices nationwide. WestEd is home to multiple national centers, two IES Regional Education Labs, and multiple EIR projects in design and evaluation roles.
The Policy & Research Group (PRG) will oversee the external evaluation activities throughout the project. PRG is an independent research organization known for conducting experimental

studies and evaluations in education, including NSF and i3/EIR projects.

Cost. The proposed budget, $4,000,000 over five years, is reasonable and adequate to support the efforts of *Data Adventures* staff and partners to fulfill project goals and objectives. The project will leverage existing SCCOE & WestEd assets, including SCCOE's strong partnerships with surrounding counties of education and role as the geographic lead, to maximize the value of the EIR investment. PRG will lead a cost effectiveness study at the end of the project.

E. Quality of the Project Evaluation: Policy and Research Group (PRG) will lead an independent evaluation (see LOC in Appendix. C) of *Data Adventures*. The PRG Principal Investigator, [redacted] has led over 100 evaluations, including 18 randomized controlled trials (RCTs), and has What Works Clearinghouse (WWC) Certification for Group Design Standards (see CV in Appendix B). The logic model (Appendix G) hypothesizes that a digital storytelling and data investigation curriculum and data makerspace grounded in UDL will promote and improve middle school students' 21st century skills in data fluency and increase students' STEM self-identity, engagement, and interest, and improve achievement in science and mathematics. PRG will conduct a school-level cluster RCT to assess confirmatory and exploratory research questions (RQs; see below) as well as an implementation evaluation to assess the degree to which *Data Adventures* is implemented as intended. Data sources, collection methods, timelines, and analytic approaches by research question are summarized in Appendix J.

Methods of Evaluation: Evidence for Project Effectiveness

Table 6. Research and Evaluation Questions

Confirmatory Research Questions	Data Sources
What is the intent-to-treat (ITT) impact of *Data Adventures* (treatment) relative to business as usual (control) on 6/7th grade students': **1)** Interest in STEM classes and careers? **2)** STEM engagement?	● STEM Career Interest Survey (Kier et al, 2013) ● Middle School Student Attitudes Toward STEM (FIEI, 2012)

3) Data literacy?	● Levels of Conceptual Understanding in Statistics (LOCUS) assessments
Exploratory Research Questions	
4) What is the impact of *Data Adventures* relative to the control on 6/7th grade students' achievement in science and math, as defined by end of course grades?	● School records
5) Does *Data Adventures'* impact on student outcomes vary by students' baseline science and math achievement and/or demographic and socioeconomic characteristics?	● Student demographic and achievement data collected from districts
6) Do components of fidelity of implementation (i.e., adherence, including dosage, quality, experiences of control group, and context) influence the effect of *Data Adventures* on students' outcomes?	● Fidelity monitoring logs, observation logs
7) What is the impact of *Data Adventures* on teachers' self-efficacy related to STEM?	● Teacher Efficacy and Attitudes Toward STEM (T-STEM) Survey (FIEI, 2012)
Implementation Evaluation	
8) To what extent is *Data Adventures* implemented with fidelity and what are the success factors and/or obstacles that affect fidelity?	● Teacher surveys and interviews, fidelity monitoring logs

Evaluation Will Meet WWC Standards Without Reservations: PRG will execute a school-level cluster RCT that will meet **WWC standards *without reservations*.** The target population is students enrolled in 6th - 7th grade at study schools during the fall semester of the implementation year. 6th - 7th graders will be enrolled in the study at 40 partner schools across two cohorts: 20 schools in the first cohort (2026-27 SY) and 20 schools in the second cohort (2027-28 SY). Schools will be randomly assigned to either the treatment (*Data Adventures*) or control (business as usual) condition at a 1:1 ratio. Random assignment will be blocked by district and cohort to ensure an approximately equal assignment ratio within each district. Based on annual enrollment numbers by grade level across schools located in SCC and rural communities, we approximate that the 40 participating schools will have a combined 4,800 6th grade students (average of 120 per school) and 3,840 7th grade students (average of 96 per school). We estimate an 85% consent rate for the study, resulting in a total ITT sample of approximately 40 schools and 7,344 students.

The evaluation is sufficiently powered. Across 2 cohorts, SCCOE expects to recruit 40 schools. Based on standard assumptions & reasonable expectations (Appendix J), the assumptions that schools will be assigned to treatment and control at a 1:1 ratio, and that each school will have, on average, 180 students enrolled in 6th & 7th grade, this study should yield a Minimal Detectable Effect Size (MDES) of approximately 0.25 (Hedges' g). The applicant research team has generated promising evidence to suggest that active and engaging problem-based learning activities can have positive impact on STEM engagement and interest, as well as achievement, with effect sizes ranging from 0.28 on achievement to 0.83 on measurements of interest (Israel et al, 2015; Yu, et al., 2020; Jaciw et al., 2018). We will estimate impact within an ITT framework so the contrast we are investigating is the effect of the offer to participate in *Data Adventures* (treatment) program relative to the offer to participate in the business-as-usual programming, regardless of actual program exposure. Since this is a school-level cluster RCT, we do not anticipate cross over or contamination to be a significant threat to the study's internal validity, however the ITT analysis will maintain the integrity of random assignment regardless.

PRG will implement and monitor all random assignment procedures. At the start of each school year, school officials will send PRG a roster of 6th and 7th graders who are enrolled at the school and eligible for the study. PRG will randomize study schools to implement *Data Adventures* (treatment) or business as usual (control), blocked by district and cohort year, using the random allocation (ralloc) command in Stata 17 (StataCorp, 2021). Students who enter the school after the point of randomization (i.e., joiners) may participate in the *Data Adventures* program, but will not be enrolled in the study. (See Appendix. J, Gantt Chart).

Outcome measures and data collection. To measure the impact of the intervention, PRG will collect outcome data from 3 sources: 1) student-level administrative data from each partner school or LEA for two full academic years (RQs 4, 5); and 2) a *Student Outcome Assessment* to collect self-reported data directly from study participants (RQs 1-3); and 3) a *Teacher Survey* to collect self-reported attitudes and self-efficacy around STEM topics (RQ 7). All items and scales used for outcome measurement have been validated in educational research (see Appendix J for details of proposed measures listed in Table 6). The same questionnaire will be administered by PRG at the beginning of the fall semester (baseline) and again at the end of the same semester after the program ends (post-program). Data collection procedures will be identical for both treatment and control conditions. Academic records for the previous school year will be requested by PRG from all partner schools in the fall of each grant year; data-sharing agreements with all study schools and/or LEAs will be formalized prior to collecting any academic records.

Analytic approach. This is a cluster-RCT where the level of assignment is the school and the level of analysis is the student. For all confirmatory research questions, the proposed analytic approach will be to regress student-level post-intervention outcome measures on a treatment/control indicator and relevant individual-level covariates and blocking variables, including the baseline measure of the outcome. Estimates will be produced using a multi-level model with both fixed and random effects in Stata. Statistical significance will be inferred at $p < .05$, using a two-tailed test. To monitor the quality of the random assignment and data collection procedures, senior analysts at PRG will conduct **baseline equivalence** testing on demographic and baseline outcome data (baseline questionnaires and prior-year academic records). Whether or not baseline equivalence is achieved, we will include the baseline outcome and covariates in the analytic model. If attrition rates exceed the WWC's cautious boundaries and baseline equivalence is not achieved, we will use propensity score weighting or matching to produce balanced analytic samples. Diagnostics on the complete baseline sample will be a useful monitoring tool for the verification of randomization procedures; baseline diagnostics on the analytic samples (those who have provided follow-up data) will monitor for imbalance (**differential attrition**) between study groups. **Overall attrition** will be closely monitored and analyzed routinely. PRG staff have previously achieved extremely low overall and differential attrition of students (9% and 2%, respectively) on an i3 cluster RCT that enrolled 2,500 students in 30 elementary schools across four school districts in Virginia; no schools were lost to attrition. Additionally, because SCCOE is a geographic leader for partnering LEAs, we are confident that we will be able to maintain low attrition of clusters (schools) enrolled in the ITT sample.

In addition to examining average treatment effects, we will examine whether *Data Adventures'* effect varies across students and schools by conducting subgroup analyses among students of different demographic characteristics (e.g., race/ethnicity, ELL status, IEP status) and prior educational achievement (i.e., math and science scores). Additionally, we will employ exploratory analyses for students that attend schools that met adequate implementation fidelity thresholds. By identifying whether effectiveness varies across groups of students or in different implementation contexts, we can inform efforts to further develop and scale *Data Adventures*.

Performance Feedback and Periodic Assessment of Progress Toward Project Outcomes

PRG will design and conduct an implementation evaluation to understand variation in how *Data Adventures* works in practice, interpret the efficacy of the intervention, provide feedback for program improvement, and identify features and conditions necessary for sustainability and replication. The implementation evaluation will assess and report on: adherence, quality, comparison group experiences, and contextual factors. PRG will host bi-weekly project monitoring calls with the *Data Adventures* leadership team, which will include discussion of any potential challenges identified through PRG's ongoing review of implementation data. A more detailed analysis of implementation data will be shared with the *Data Adventures* team annually as formative feedback and to identify potential modifications to improve program fidelity. Annual thresholds will be set for each key component depicted in the logic model (see Section E.3 below). Fidelity measures will include: program dosage, observations by trained observers of the intervention, fidelity monitoring logs, and teacher and student feedback forms and structured focus group discussions. We describe each implementation element, data used to assess each element, frequency of data collection, and responsible party in the *Implementation Evaluation Summary Table* in Appendix J. Quantitative data, such as dosage and observation rating data and close-ended questions from questionnaires, will be analyzed descriptively. To analyze qualitative data gathered in interviews and open-ended questionnaire items, the evaluators will use a grounded theory approach. This approach allows the evaluators to conduct flexible yet focused qualitative analysis through a systematic coding process to identify emergent themes and meaningful patterns of ideas in the data (Charmaz, 2006; Guest et al., 2021).

Evaluation Plan

Cost Effectiveness. PRG will conduct a cost analysis based on the Resource Cost Model (Levin & McEwan, 2002) to provide information about the cost of implementation, including associated teacher onboarding, and whether it is cost effective relative to the BAU condition. Costs will be identified in both the project and BAU conditions using the "ingredients method" (Levin et al., 2017). Analyses will identify the costs associated with each component, distinguish start-up costs from ongoing costs, and convert total costs to per-teacher and per-student costs. The cost information and effect size estimates will be combined to describe the impact on a per dollar basis following the most up-to-date recommendations for cost analyses (Hollands et al., 2021).

Key Components, Mediators, and Implementation Thresholds: As depicted in the logic model (Appendix G), *Data Adventures* posits that if the four key components (i.e., Data Adventure Quests, PD materials, mobile data makerspace and kits, immersive experiences) are well implemented, the program will lead to improvement in students' STEM interest, engagement and data literacy skills. These changes in mediators, including attitudes towards STEM, will result in better educational outcomes, as demonstrated by higher achievement in STEM, measured by end of course grades. Ultimately, the *Data Adventures* team hypothesizes that exposure to the intervention in middle school will lead to increased enrollment in high school STEM courses and postsecondary STEM majors.

PRG and the *Data Adventures* team will work together during the co-design and pilot phases to identify measurable thresholds for acceptable implementation. Preliminary thresholds include: **1) Data Adventure Quests:** the co-design team will finalize 4-6 *Data* Adventures, comprised of a set number of *Quests* (or lessons) to be taught in 6th and 7th grade science and mathematics class over the course of two weeks (condensed option) or once per week over a quarter (stretched option); **2) PD materials:** the PD will design professional development materials to support implementation and increase teacher self-efficacy, knowledge, and practice in data science, as well as offer a 1-day teacher orientation to be completed before implementation; **3) Mobile Data Makerspace:** project staff will bring the data makerspace to each school at the start of programming and will supply each school with a classroom kit to provide students with access to materials to design and create alternative representations to accompany their data; **4) Immersive Experiences**: project staff will host an *immersive kickoff experience* at SJSU campus at the start of each data adventure to introduce students to cross-age mentors, participatory sensing campaigns, and relevant data collection tools and data storytelling; project staff will also host the *Data Adventure Quest Fair* at the conclusion of each implementation period where students, mentors, and community members visit SJSU campus together to experience each others' stories. Implementation elements, data used to assess each element, frequency of data collection, and responsible parties are described in *Implementation Evaluation Summary Table* in *Appendix. J.*

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