Student's Full Name
Samuel Severance

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School of Education

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I'm applying for funding for:
Summer 2014
Fall 2014
Spring 2015

By submitting this application, I confirm that, if selected to receive a Chancellor's Award for Excellence in STEM Education, I will:

- ✓ Attend and be recognized at the annual Symposium on STEM Education (fall 2014).
- ✓ Give a brief introduction (~10-15 min) to my project at DBER in fall 2014.
- ✓ Actively engage in the CU-Boulder STEM education community by attending Chancellor's Fellow events.
- ✓ Present my work to the STEM education community by giving at least one DBER seminar, OR, if that is an impossibility, I will give a talk that the CU-Boulder STEM education community is invited to attend.
- ✓ Submit a 1000 to 3000-word report detailing the outcomes of the project at the end of the funding period.

Shifting Teacher Practice to the Next Generation Science Standards through Professional Development

Samuel Severance
Combined PhD Student
Educational Psychology & Learning Sciences | Cognitive Science
School of Education
Institute of Cognitive Science

Faculty Advisors:

Dr. William Penuel
Professor
School of Education

Dr. Tamara Sumner
Associate Professor
Institute of Cognitive Science
Department of Computer Science

Problem

Currently, several states, including Colorado, are debating whether to adopt new, ambitious standards in science, the Next Generation Science Standards (NGSS). The NGSS, released in 2013, are standards grounded in research on how students learn science that aim to prepare students for participation in science and engineering practices. They differ from previous standards in that they are organized around a small, carefully chosen set of disciplinary core ideas and integrate those core ideas with science practices (such as argumentation and modeling) and crosscutting concepts in science (such as scale). These standards are based on the recommendations of an expert panel convened by the National Research Council (2012) regarding the need for more focused, coherent standards in science.

While nine states have already adopted the new standards, policymakers in remaining states continue to debate whether to adopt the NGSS. In the meantime, individual school districts, such as Denver Public Schools (DPS), have decided to forge ahead with adopting the NGSS. This study seeks to answer how a large urban school district, DPS, helps teachers to understand the shifts called for in the NGSS through their participation in an NSF-funded professional development course, the Next Generation Science Exemplar (NGSX).

This will be no easy task, as some of these shifts are significant. First, integrating practices and content knowledge poses significant challenges for teachers, who often focus on them separately or use one as a context for teaching the other rather than teaching them in an integrated fashion (Davis, Petish, and Smithey, 2006; Furtak & Alonzo, 2010). This is understandable, since the first generation of science standards produced separate guidance to teachers for teaching content and for teaching inquiry (NSES, 1996, 2000). Second, teachers often do not have a deep understanding of the practices that the standards focus on. For example, instead of viewing the science practice of *developing and using models* as requiring students to construct, use, and evaluate scientific models to explain and predict phenomena as the standards call for, past research indicates teachers tend to view models as primarily helpful for making abstract ideas concrete or as tools they can use to demonstrate phenomena to students (Crawford & Cullin, 2004; Smit & Finegold, 1995). In addition, they are less likely to view models as supports for explanation or prediction in the context of question-driven inquiry (Van Driel & Verloop, 1999; Windschitl & Thompson, 2006). These problems are likely to be significant in Denver's adoption of NGSS, particularly as Colorado did not participate in developing the NGSS, and therefore has little institutional capacity in terms of accessible resources or knowledge from which to develop resources.

In response to the new standards and the demands they pose for teacher learning, there has been a proliferation of professional development offered by researchers, informal education institutions, and districts. The NGSX professional development that DPS has subscribed to using is one such example. While there is some research underway on the NGSX professional development course that DPS will be using, the NGSX developers are conducting this research and there are not yet findings to report. Therefore, there is, to date, little research on how teachers make sense of the new standards and what models of professional development can best support change in individuals', schools', and districts' science teaching practices in relation to the shifts required by the NGSS.

To address this deficiency, my colleagues and I plan to study the implementation of the NGSX with a group of DPS teachers, seeking to understand how teachers make sense of the professional development, as well as whether, and how, the structure of the professional development supports them to change their instructional practice. The members of this research team have conducted professional development in other districts related to NGSS and studied teachers' responses to it (Allen Bemis, Penuel, & Jones, 2013). The findings from our professional development confirm past research showing that a key challenge is developing teachers' understanding of science practices emphasized in the standards, particularly *developing and using models*.

The current study will examine how the NGSX does or does not facilitate teachers' understanding of the NGSS, with an emphasis on teachers' conceptions of modeling, by employing analytical frames from sensemaking theory (Weick, 1995). When confronted with uncertainty, individuals engage in processes to develop new understandings that can result in changes to their future practice. The large shifts called for in the NGSS have created no small measure of uncertainty in science educators' understanding around expectations for their future instruction. Examining teacher sensemaking in the context of the structured design of the NGSX may provide insights into how to systematically support science teachers in surmounting the uncertainty of these new standards and, as predicted by sensemaking theory, determine how their instructional practice may change as a result.

Determining how the NGSX facilitates changes in the practice of science teachers addresses analysis at the teacher and classroom level. The implementation of the NGSX professional development program in DPS, however, offers other important levels of analysis for study. As teachers grapple with the shifts called for in NGSS, district administrators, professional development designers, and researchers, are grappling with how to build systems that support teachers. Specifically, this study will also examine how DPS administrators, NGSX designers, and our own research team jointly negotiate the implementation of the NGSX professional development for teachers as learners. One of the main challenges of adopting the NGSS centers on how to go about educating teachers in enacting the NGSS on a large scale given that specific needs and constraints may vary greatly from district to district and school to school. New initiatives that do not adapt to the needs and constraints of the local context of implementation often fail to achieve their desired impact (Fishman & Krajcik, 2003; Penuel & Fishman, 2012).

The largest school district in Colorado, DPS presents unique and challenging contexts that previous limited implementations of the NGSX have not had to contend with in other locales. Part of the challenge of adapting an initiative to the local context centers on participants arriving at a shared understanding of the problem-space, the nature of the actual context for the initiative (Penuel, Coburn, & Gallagher, 2013). Although DPS administrators, NGSX designers, and our own research team may all share the long-term desire of meaningful adoption of the NGSS across the district beginning with science teachers' participation in the NGSX, each group brings their own expertise and sense of the constraints to the implementation of the NGSX. It is a challenging problem of practice at this level of organization to negotiate how best to serve the needs of the local enactors while maintaining the integrity of the professional development design and the validity of data from which conclusions can be drawn and shared by researchers (LeMahieu, 2011). Understanding how organizers jointly navigate these tensions to make decisions about NGSX implementation could have important implications for how to effectively structure future research-practice partnerships in science education and professional development research.

Methodology

Research Questions

The research will address four main questions:

1. How are the NGSX professional development (PD) sessions implemented in a large, urban district?
2. How do NGSX PD tools and activities build a deep understanding of NGSS, particularly in relation to the integration of core ideas and practices in instruction?
3. How do teachers make sense of the NGSS in relation to their own current and future teaching practice?
4. What new practices do teachers introduce into their teaching from the PD?

Research Methodology

The NGSX study is a case study and will apply ethnographic qualitative research methodology in order to answer the research questions. Included in this approach will be observations of participants' activity within the context of the NGSX PD. In addition, all participants will be interviewed by researchers in order to better understand their thought processes in relation to behaviors observed within the NGSX PD and thoughts in relation to the NGSS in general.

Sample

A total of 35 participants will be invited to join the study. Of these participants, five will be district administrators who will help to organize and enact the NGSX PD, five will be the designers of the NGSX PD, five will be researchers supporting the NGSX PD, and twenty will be DPS teachers from the elementary and secondary levels. The sample size of 20 teachers was selected to include all teacher participants in the PD. Of the twenty participating teachers, at least three teachers each from the elementary, middle, and high school levels will serve as focus teacher participants. This distribution of focus teachers will provide coherence in data collection as well as allow for more rigorous comparative data analysis.

Sources of Data

There will be six main sources of data for the study. I will lead a team of researchers in developing protocols and collecting data for the study, and I will lead analysis of these data with guidance from two faculty members, Professor Bill Penuel (my advisor and mentor for the project) and Assistant Professor Eve Manz. Also supporting data collection will be a postdoctoral researcher, Dr. Heather Leary, who brings expertise in instructional design and teacher professional development.

Observational data of NGSX planning meetings. We will audio-record meetings between district administrators and researchers and create field notes from the original media. Focal topics for field notes will be (1) a general outline of topics discussed; (2) issues and concerns that are raised by each of the participant groups; (3) deliberation and suggested pathways addressing how to help teachers understand and implement NGSX and (4) any statements about plans regarding whether and how to implement NGSS.

Observational data of PD Sessions. Each NGSX PD session will be video recorded and fieldnotes will be created from the original media. Focal topics for field notes will be: (1) topics discussed in each study group session; (2) issues and concerns of teachers raised in the context of study group sessions; (3) deliberation and suggested pathways to addressing issues and concerns identified by district leaders and teachers; and (4) any statements about plans regarding whether and how to implement NGSS.

Observational data of Classroom Teaching Practices. In addition, we hope to visit the classrooms of 9 focus teachers to understand how they are implementing NGSS and related teaching practices into their practice. Only teachers who agree to be focus teachers will have their classroom observed. These observations of classroom applications of NGSX PD practices will be recorded as fieldnotes and will not be video recorded. These observations will focus on understanding: a) which of the eight NGSS practices teachers engage students in and how they support students' participation in those practices, with a particular interest in modeling, b) what content knowledge is the target of instruction and how it relates to the core ideas in NGSS, c) if and how practices and content knowledge are integrated. We plan to use open-ended fieldnotes, not a structured protocol, because appropriate structured protocols aligned to NGSS do not yet exist in the field.

Interviews. Interviews with focus teacher participants will occur either over the phone or in person and will be audio recorded. The audio recordings will be transcribed verbatim. The interviews will follow a

structured protocol. Protocol topics will include: (1) teachers' ideas about developing and using models in learning science; (2) teachers' use of ideas and tools from the PD in adapting or designing instructional materials; (3) issues or concerns that prompt individual or collective sensemaking about NGSS; (4) perceptions of the gap between current and NGSS-aligned practice; and (5) plans to implement instruction aligned to NGSS.

Surveys. All teachers participating in PD will be asked to complete a survey designed by the NGSX developers, both before the PD begins and after it finishes. The survey assesses their understanding of the NGSX content and asks questions about their teaching practices (e.g., how well prepared they feel they are to assess student thinking or support classroom discussion).

Artifacts. During each NGSX PD session as well as activities outside of the PD sessions, teachers will create artifacts that relate their understanding of the NGSS as well as artifacts that serve as reflections on their teaching practices. Additionally, the DPS district administrators have created a wiki website that will serve as a hub for the NGSX PD team, including handouts, directions and templates for activities, and logistical information. Researchers will have access to and will analyze these artifacts in order to provide another means of triangulating and supporting any potential findings.

Data Analysis

All sources of data, once formatted into text, will be coded using both inductive and deductive techniques with Dedoose software. Inter-rater reliability tests on portions of the data will also be performed using Dedoose. With the data coded, patterns that provide insight into answering the research questions will be sought and explicated.

Metrics of success will include analysis of organizers' responses to questions on the efficacy of the joint effort during structured interviews, observations of the level of application of NGSS concepts and ideas from the NGSX in focus teachers' classroom instruction, as well as analysis of teachers' responses on surveys regarding their assessment of changes to their own understanding of the NGSS as a result of their participation in the NGSX.

Project Timeframe

The duration of the proposed study is two semesters (see Table 1). IRB approval has already been granted and initial data collection has already begun. Thus far, my colleagues and I have collected fieldnotes from initial professional development sessions with teachers and planning sessions with organizers. Additionally, recruitment of focus teachers has commenced. With nine NGSX professional development sessions scheduled in DPS, data collection will need to continue into the Fall 2014 and Spring 2015 semesters. Given the time necessary to develop a valid coding scheme with high inter-rater reliability and the time and effort required in applying this system, as well as quantitative analysis of survey data, data analysis will occupy much of the Spring 2015 semester. At the conclusion of the analysis of all data, final evaluations of the NGSX PD in relation to the research questions posed here will be completed and reported.

Table 1. Proposed Timeframe for Study.

Task	Apr	May	June	July	Aug	Sep	Nov	Dec	Jan	Feb	Mar	Apr	May
Observe PD sessions	X	X			X	X	X	X	X				
Observe Planning Meetings	X	X			X	X	X	X	X	X			
Conduct Interviews		X								X			
Observe focus teachers		X				X	X	X	X	X			
Develop coding scheme			X	X	X	X							
Apply coding scheme							X	X	X	X			
Analysis of survey data										X			
High-level analysis of data									X	X	X		
Report findings to partners											X		
Write paper for JSTE[1]											X		
Hold joint seminar meeting											X		
Submit to JSTE												X	
Write paper for JRST[2]												X	
Submit to JRST													X

[1]Journal of Science Teacher Education, [2]Journal of Research in Science Teaching

Evaluating the Project's Success

Reflecting the research-practice partnership structure of this study, its success should be measured in terms of the partnership's success. Adhering to an interventionist research frame, I see this study as not only about understanding the processes of NGSX implementation in DPS and its impact on teachers' practice, but about making sure that the effort contributes to the capacity of the research-practice partnership between CU and DPS to use evidence from the research to inform its joint work and to each partner's goals for participation. To these ends, the key metrics for success will be:

1. Significant changes to teachers' practices
2. Consensus from district science leaders that the research is of high value and relevance to them, obtained through interviews
3. At least 2 first-author manuscripts for publication to peer-reviewed journals (e.g., *Journal of Research in Science Teaching*)

Benefits

Furthering My Development

Addressing the gap between educational research and practice remains one of the greatest challenges facing the field of education. After having taught science at the secondary level and now training for a

career as a researcher, one of my long-term career goals has always been to develop research and design techniques that foster new, sustainable, mutually beneficial ways of practice between educational researchers and practitioners that in turn enhance learning for students. This study supports this long-term goal. In seeking to understand how various groups—teachers, DPS administrators, NGSX developers, and researchers—with their own expertise and needs interact around the common goal of successfully bringing the NGSS to DPS, I will have the opportunity to develop and delineate practical principles for research-practice partnerships in regards to facilitating NGSS adoption through professional development.

Supporting STEM Education in CU's School of Education

This study contributes to ongoing research within the School of Education (SOE), specifically, work on learning environments that engage students in scientific practices, the use of modeling in science instruction, and research on NGSS and NRC Framework professional development. Results from this study will be shared through the Design-Based Implementation Research (DBIR) group at the SOE and through a joint seminar between the Educational Psychology & Learning Sciences and the Curriculum & Instruction programs.

In addition, this research provides insights to the SOE's teacher education program into how to prepare teachers for the unique situation of teaching science in Colorado, where teachers are increasingly asked to use both the Colorado Academic Standards and aspects of the NGSS and NRC framework. Understanding how teachers navigate these different frameworks will allow us to revise how we introduce and support these different sets of standards in the teacher education program.

Finally, the proposed study furthers a central goal of the DBIR group and the Center for STEM Learning, that of bridging the research-practice divide and developing partnerships between researchers and practitioners to make deep and lasting changes in STEM education. In recent semesters, DBIR seminars have focused on issues central to NGSS; however, there has been less emphasis on the challenges that these standards pose for teachers and effective means of leveraging partnerships to meet those challenges. I look forward to furthering these conversations.

Benefits to CU Community

A key role of the Center for STEM Learning at the University of Colorado Boulder is to "serve as a state, national, and international resource" for efforts to improve STEM education. The *Framework for K-12 Science Education* and *Next Generation Science Standards* embody the vision of countless scientists, engineers, educators, and science education researchers for how to improve STEM education. NGSX is perhaps the most well known PD initiative related to NGSS in the country, owing to the expertise of its developers. As a primary research partner both for the NGSX team and Denver Public Schools, CU-Boulder enhances its capacity and reputation to serve as both a local and national resource for improving teachers' readiness to implement the NGSS.

References

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Windschitl, M., & Thompson, J. (2006). Transcending simple forms of school science investigation: The impact of preservice instruction on teachers' understanding of model-based inquiry. American Educational Research Journal, 43(4), 783-835.

SAMUEL J. SEVERANCE

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OBJECTIVE

Develop research and design techniques for organizing sustainable research-practice partnerships in order to effectively implement educational interventions grounded in research on learning and cognition at scale

EDUCATION

2012-present Student in combined PhD for Learning Science and Cognitive Science
University of Colorado Boulder, May 2017 projected graduation date
Advisors: William Penuel, School of Education
Tamara Sumner, Institute of Cognitive Science

2005-2007 M.A.+ Instruction and Curriculum with Secondary Science Licensure
University of Colorado Boulder

2002-2003 B.A. Fine Arts with emphasis in Studio Art
University of Colorado Boulder

2000-2002 B.A. Neuroscience and Behavior
University of California, Santa Cruz

HONORS AND AWARDS

Miramontes Scholar Fellowship (2012-2016)
Outstanding Master's Plus Graduate Award (2007)
Hach Scientific Foundation Chemistry Teacher Scholarship (2005-2007)
ETS Recognition of Excellence (PRAXIS General Science: Content Knowledge Exam) (2007)
International Invitational Exhibition: National School of Fine Arts, Mexico City (2003)
Undergraduate Research Assistantship Grant (2002-2003)
Highest Honors in Major from Biology department (2002)
Kresge College Honors (2002)
Campus Merit Scholarship (2000-2002)

RESEARCH POSITIONS HELD

2012-Present Graduate Research Assistant / Research Manager
School of Education & Institute of Cognitive Science
University of Colorado Boulder
"INDP: Inquiry Hub"
NSF Award #1147590

2013-2014 Professional Development Consultant
CREATE for STEM Institute
Michigan State University
"NSF-RAPID: Model for Implementing the Next Generation of Science Standards"
NSF Award #1225661

2013 Graduate Research Assistant
School of Education
University of Colorado Boulder

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"Synergies: Understanding and Connecting STEM Learning in the Community"
Funder: Noyce Foundation

2005-2007 Professional Research Assistant / Student Hourly Employee
Institute for Behavioral Genetics
University of Colorado Boulder

2002-2003 Research Assistant
Barth Neuroscience Lab
University of Colorado Boulder
Funder: Howard Hughes Medical Institute

TEACHING POSITIONS HELD

2013 Co-Instructor / Graduate Teaching Assistant
Course: Educational Psychology for Secondary Schools
University of Colorado Boulder

2011-2012 Science Department Coordinator
Prairie Middle School, Aurora, CO
Cherry Creek Schools

2007-2012 Science Teacher
Prairie Middle School, Aurora, CO
Cherry Creek Schools

2007 Chemistry Teacher / Adjunct Faculty
New Vista High School, Boulder, CO
Boulder Valley School District

REFEREED CONFERENCE PROCEEDINGS

Severance, S., Leary, H., & Johnson, R. (2014, June). *Tensions in a Multi-Tiered Research-Practice Partnership.* Paper to be presented at the 11th International Conference of the Learning Sciences, Boulder, Colorado.

REFEREED CONFERENCE PAPERS

Severance, S., Penuel, W.R., & Leary, H. (2014, April). *Negotiation of Joint Work in a Research-Practice Partnership.* Paper to be presented at the annual meeting of the American Educational Research Association, Philadelphia, Pennsylvania.

PRESENTATIONS

Leary, H., Severance, S., Johnson, R., Penuel, W. R., Sumner, T., Devaul, H., Dibie, O., & Danesh, S. (2013, September). *Customizing Curriculum and Digital Resources for STEM Educators.* Poster presented at the 5th Annual Symposium on STEM Education, Boulder, CO.

Severance, S., & Penuel, W. R. (2013, April). *The Inquiry Hub as an exemplar of Design-Based Implementation Research.* Presentation to the Educational Psychology and Learning Sciences Program, University of Colorado, Boulder, CO.

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PROFESSIONAL SERVICE

2014-Present Student Ambassador for the Educational Psychology & Learning Sciences Program
University of Colorado Boulder
School of Education

2013-Present Institute of Cognitive Science Graduate Student Committee
University of Colorado Boulder
Representative for School of Education

MEMBERSHIPS

American Educational Research Association
International Society of the Learning Sciences
National Science Teachers Association
Phi Delta Kappa

Student's Full Name
Samuel Severance

Adviser's Full Name
William Penuel

Adviser's Home Department
School of Education

Adviser's Email Address
william.penuel@colorado.edu

By submitting this application, I confirm that, if my advisee is selected to receive a Chancellor's Award for Excellence in STEM Education, I will:

- ✓ Attain a GRA salary match (25% during the academic year, and 50% during the summer) from my own funding sources or from my department.
- ✓ Attend the annual Symposium on STEM Education (fall 2014).
- ✓ Actively engage in the CU-Boulder STEM education community by attending the weekly DBER Seminar Series when possible.

University of Colorado Boulder

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March 26, 2014

Dear Chancellor's Award Committee Members:

It is with pleasure that I write this letter of support for Sam Severance's application for the Graduate Chancellor's Award for Excellence in STEM Education. Sam is a second-year doctoral student in the Educational Psychology and Learning Sciences program at the School of Education and is my advisee. He has great potential as a leader in the field of science education research whose work sits at the intersection of learning sciences and policy.

Below, I address each aspect of the advisor application for this award:

Mentoring
This project is a collaborative project to be led by Sam, and his project collaborators bring a wealth of experience in designing and conducting studies of teacher professional development in science. My own research focuses on how both formal teacher professional development and informal interactions among colleagues supports implementation of programs and policies. Assistant Professor of Science Education Eve Manz, another collaborator on the project, is expert in the study of children's learning with models in science and is part of the School of Education's elementary science teacher education program. Postdoctoral researcher Heather Leary is expert in instructional design in science and has conducted research on how teachers use technological platforms to support instructional planning. We will meet every two weeks as a team to discuss data collection and analysis and to develop papers from the research

I view this opportunity as one in which Sam will have the opportunity to *lead*—and not just participate—a team of researchers in a significant study of teacher learning in science. I already meet with Sam on a bi-weekly basis to discuss a mix of project- and career-related goals and activities. We will incorporate regular check-ins regarding this study into our meetings, specifically focused around Sam's leadership of the project. Sam has already shown significant promise in being able to manage both relationships and data; his growing edge to be explored here will be to develop skill in leading analysis and writing of results. To support Sam in analysis and results, I will co-develop outlines with him, help him select a journal and review criteria used for that journal, and guide the selection of data analysis techniques for integrating our multiple methods.

Departmental Mechanisms for Including Research
There are two ways that Sam can earn credit for his leadership of this research. First, and in order to build an appropriate literature review for publications that is grounded in the data, he can enroll in an independent study class with me, his advisor. The focus of such a study would include not only a review of the relevant literature, but also an analysis of articles on

the topic from the selected journal. A second way for Sam to earn credit is by selecting this study as the context for his dissertation context. He would still need to develop a prospectus for the study that was approved by a committee in the School of Education, but it is possible this dataset would yield answers to a question of interest to Sam related to teacher learning in science.

Matching Funds
Sam is funded 25% during the academic year for the research-practice partnership with Denver Public Schools through a separate NSF grant. Though that grant does not cover work on this study (hence the application for iSTEM funding), it does support his continuous engagement with partners in Denver at the district level who are involved in science work. In fact, it will allow him to investigate how teachers who are involved in the proposed study study and who also participate in designing a biology unit aligned to the *Next Generation Science Standards* use the ideas they learn as part of *NGSX* in design.

Advancing My Development, STEM Education in the School of Education, and the CU-Boulder Community as a Whole
My goal as a mentor for doctoral students is to prepare them for interdisciplinary design work at scale. This presents challenges both to me and to students, because the academy tends to reward deep work in a single area. But to have broad impact in science education, I believe students need not only to understand science learning, but also science teaching, professional development, and organizational change processes. This funding will provide me with the occasion to mentor a student in all three areas and provide him with the time and support to "go deep" in all of these areas. In addition, it will provide him (and me) to discover ways to support interdisciplinary *writing* for science education journals. Sam has shown success already in this regard, having a solo-authored paper accepted as part of the upcoming ICLS conference in Boulder. The paper is a study of tensions in a multi-tiered partnership, and it is an example of the kind of interdisciplinary writing at the boundary between policy and learning sciences research I hope my students can do.

The efforts will assist our own School of Education as well, in developing the kinds of long-term partnerships with districts that are part of our long-term strategic plan. The DPS collaboration with CU from which this project grows is already six years old. It survives and thrives because we are responsive to the district's needs and goals, and the proposed study of NGSX grows out of a specific *request from the district* to our team at CU. This kind of responsiveness is a model form of partnership, and allows us to grow in terms of our understanding of what it means to organize research around problems of practice. As Sam notes in his proposal, there are multiple venues for sharing what we learn with our colleagues in the school, including regular seminars of the learning sciences and curriculum and instruction programs, as well as regular meetings of our cross-program Design-Based Implementation Research group.

It goes without saying that project like this one also helps to enhance our own—and CU's—reputation in the community. DPS is a large district, and our responsiveness signals a willingness on CU's part to be disciplined by a district's chief concerns and needs. The

NGSS is a high-profile, cross-state initiative to enhance STEM learning. CU's contribution to that can only help to solidify CU's position as a leader in STEM education.

Sincerely,

William R. Penuel

William R. Penuel
Professor of Educational Psychology and Learning Sciences

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EDUCATION

1993-1996 **PhD in Developmental Psychology**
Clark University
Dissertation: *Communicative Processes in Cultural Identity Formation: A Mediated Action Account*

Chair: James V. Wertsch
Committee Members: James Paul Gee, Nancy Budwig

1991-1992 **EdM in Counseling Processes**
Harvard Graduate School of Education

Master's Project: *An Ethnographic Evaluation of an HIV/AIDS Prevention Program*

Advisor: Robert Selman

1988-1991 **BA in Psychology**
Clark University

Bachelor's Thesis: *Animals as Objects of Moral Concern: A Narrative Approach*

Advisor: Bernard Kaplan

HONORS AND AWARDS

Jacob Hiatt Fellow in Psychology (1994-95)
Phi Beta Kappa (1991)
Graduated Summa Cum Laude from Clark University (1991)
Outstanding Undergraduate in Psychology (1991)

POSITIONS HELD

2011-present **Professor of Educational Psychology and Learning Sciences**
School of Education
University of Colorado-Boulder

POSITIONS HELD (Cont'd)

2006-2011	**Director of Evaluation Research** Center for Technology in Learning SRI International
2000-2006	**Senior Education Researcher** Center for Technology in Learning SRI International
1998-2000	**Research Social Scientist** Center for Technology in Learning SRI International
1997-98	**Program Evaluator** San Francisco Unified School District
1996-97	**Program Evaluation Coordinator** Metropolitan Nashville Public Schools

COURSES TAUGHT

Seminar in Human Development, University of Colorado
Adolescent Development and Educational Psychology, University of Colorado
Learning with Technology in and out of School, University of Colorado
Contexts that Promote Youth Development, Stanford University
Technology in Science Education, University of South Carolina
Assessment of Student Multimedia Projects, Foothill College

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Penuel, W. R., Phillips, M., Toyama, Y., Vahey, P., Hafter, A., & Peck-Theis, L. (2004). *Mathemagica summative program evaluation: Final report.* Menlo Park, CA: SRI International.

Penuel, W. R., Korbak, C., Yarnall, L., Lewis, A., Toyama, Y., & Zander, M. (2004). *GLOBE Year 8 Evaluation: Understanding diverse implementation contexts*. Menlo Park, CA: SRI International.

Roschelle, J., Abrahamson, A. L., & Penuel, W. R. (2003). *CATAALYST: Towards scientific studies of the strategic integration of learning theory and classroom network technology to improve teaching and learning*. Menlo Park, CA: SRI International.

Penuel, W. R., Korbak, C., Lewis, A., Shear, L., Toyama, Y., & Yarnall, L. (2002). *GLOBE Year 7 evaluation: Exploring student research and inquiry in GLOBE*. Menlo Park, CA: SRI International.

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Penuel, W. R., Kim, D. Y., Michalchik, V., Lewis, S., Means, B., Murphy, B., et al. (2001). *Using technology to enhance connections between home and school: A research synthesis*. Menlo Park, CA: SRI International.

Penuel, W. R., Michalchik, V., Daniels, M., Jennings, P., Stites, R., Yarnall, L., Hawkins, K., Pacpaco, R., & Kim, D. Y. (2001). *Community technology centers case study report: Learning with technology in six communities.* Report submitted to the U.S. Department of Education. Menlo Park, CA: SRI International.

Murphy, R., Penuel, W. R., Means, B., Korbak, C., & Whaley, A. (2001). *E-DESK: A review of recent evidence on the effectiveness of discrete educational software*. Menlo Park, CA: SRI International.

Penuel, W. R., Korbak, C., Daniels, M., Kim, D. Y., Yarnall, L., Hawkins, J., & Pacpaco, R. (2000). *Community technology centers program findings summary: A review of FY99 grantees' annual performance reports.* Report submitted to the U.S. Department of Education. Menlo Park, CA: SRI International.

Penuel, W. R., Golan, S., Means, B., & Korbak, C. (2000). *Silicon Valley Challenge 2000: Year 4 report.* Report submitted to the San Mateo County Office of Education. Menlo Park, CA: SRI International.

MAGAZINE ARTICLES

Penuel, W. R., (2008). Preparing teachers to teach for deep understanding: A curriculum-based approach. *The Earth Scientist,* 27 (2). 21-24.

Penuel, W. R., & Riel, M. (2007). The new science of networks and the challenge of school change. *Phi Delta Kappan, 88* (8), 611-615.

Penuel, W. R. (2005). Implementing a handheld program: Lessons from a district-level initiative. *Learning and Leading with Technology, 32* (6), 2-6.

Roschelle, J., Penuel, W. R., & Abrahamson, A. L. (2004). The networked classroom. *Educational Leadership, 61* (5), 50-54.

Penuel, W. R., Korbak, C., & Cole, K. A. (2002). Designing assessments for student multimedia projects. *Learning and Leading with Technology, 29,* 46-53.

Penuel, W. R. (2001). Designs for learning: Structuring opportunity in community technology centers. Retrieved June 4, 2004, from http://www.techsoup.org/howto/articlepage.cfm?ArticleId=331&topicid=12

Penuel, W. R., Yarnall, L., & Simkins, M. B. (2000, Sept./Oct.). Do technology investments pay off? The evidence is in! *Leadership*, 30(1): 18-19.

Penuel, W. R., Means, B., & Simkins, M. B. (2000). The multimedia challenge. *Educational Leadership, 58,* 34-38.

BOOK REVIEWS

Penuel, W. R. (2000). Little faith: A book review of *Ordinary resurrections: Children in the* years of hope, by Jonathan Kozol. City Limits. Available online at: www.citylimits.org/content/articles/viewarticle.cfm?article_id=2602.

Crawford, V. M., & Penuel, W. R. (1997). Review of *The Dialogical Self. Mind, Culture, and Activity.*

INVITED PRESENTATIONS

Penuel, W. R., Falk, J., & Dierking, L. (2013, December). *The* Synergies *Agent-Based Model: Preliminary work, challenges and opportunities.* Invited presentation to the Seoul National University, Seoul, South Korea.

Penuel, W. R., & Fishman, B. J. (2013, November). *Design-Based Implementation Research: Working in partnership to transform the relation of research and practice.* Webinar presented through MSP Net to the NSF Math and Science Partnership community.

Penuel, W. R. (2013, October). *Developing and using implementation evidence in research and development efforts.* National Science Foundation, Washington, DC.

Penuel, W. R. (2013, September). *Improving implementation of innovative teaching practices: From fidelity to principled adaptation of curricula.* Invited presentation at the University of Twente, the Netherlands.

DeBarger, W. R., Penuel, W. R., & Harris, C. H. (2013, September). *Designing NGSS assessments to evaluate the efficacy of curriculum interventions.* Invited presentation for the Joint meeting of the Council of Chief State School Officers and the State Collaborative on Assessment and Student Standards, Washington, DC.

Penuel, W. R. (2013, August). *Introduction to the Next Generation Science Standards.* Invited presentation to the Boulder Valley School District, Boulder, CO.

Penuel, W. R. (2013, August). *Designing for change in complex educational systems.* Invited presentation to Waterbury Summit, Pennsylvania State University, State College, PA.

Penuel, W. R. (2013, July). *Design-Based Implementation Research: Working in partnership(s) to transform the relation of research and practice.* Paper presented at the Maine Physical Science Partnership, University of Maine, Bangor, ME.

Penuel, W. R., & Fishman, B. J. (2013, May). *Design-Based Implementation Research: Working in partnership to transform the relation of research and practice.* Presentation to the Northwestern University Multidisciplinary Program in Education Sciences, Evanston, IL.

Penuel, W. R. (2013, March). Invited presentation to the National Center for Quality Teaching and Learning, University of Washington, Seattle, WA.

Penuel, W. R. (2012, September). *Planning for change: Issues of implementation and scale.* Keynote address presented at the Nevada STEM Smart Workshop, Las Vegas, NV.

Penuel, W. R. (2009, January). *Organizing, leading, and sustaining innovation in professional learning communities.* Keynote address presented at the Microsoft Innovative Schools Conference, London, England.

SELECTED RECENT PRESENTATIONS

Penuel, W. R., DeBarger, A., Kim, C. B., Moorthy, S., Beauvineau, Y., Kennedy, C. A., . . . Allison, K. (2013, April). *Improving learning by improving classroom assessment in Earth science: Findings from the Contingent Pedagogies project.* Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Juan, PR.

Penuel, W. R., York, A. J., Kirshner, B., Falk, J. H., Dierking, L. D., Haun-Frank, J., . . . Bailey, D. (2012, April). *Youth participatory research as a boundary practice in place-based partnerships for expanding learning opportunities in communities.* Paper presented at the Annual Meeting of the American Educational Research Association, Vancouver, BC.

Penuel, W. R., & Means, B. (2010, November). *Using large-scale databases in evaluation: Advances, opportunities, and challenges.* Paper presented at the Annual Meeting of the American Evaluation Association, San Antonio, TX.

Penuel, W. R. (2010, October). *Leveraging student interest and choice in designs for STEM learning in formal and informal contexts.* Paper presented at the Principal Investigators Meeting of the National Science Foundation's Science of Learning Centers, Arlington, VA.

Stevens, R., & Penuel, W. R. (2010, October). *Studying and fostering learning through joint media engagement.* Paper presented at the Principal Investigators Meeting of the National Science Foundation's Science of Learning Centers, Arlington, VA.

Penuel, W. R. (2010, September). *The role of intra-organizational processes in mediating institutional diffusion.* Paper presented as part of the IES Lecture Series at the University of Pennsylvania, Philadelphia, PA.

Penuel, W. R., Frank, K. A., Sun, M., Kim, C., & Singleton, C. (2010, August). *The role of intra-organizational processes in mediating institutional diffusion.* Paper presented at the Annual Meeting of the American Sociological Association, Atlanta, GA.

Penuel, W. R., Cheng, B., Harris, C. J., & Phillips, R. (2010, April). *Translating design principles into practice: A comparative case study of three design-based research projects in the LIFE Center.* Paper presented at the Annual Meeting of the American Educational Research Association, Denver, CO.

Penuel, W. R., Bates, L., Townsend, E., Gallagher, L. P., Pasnik, S., & Llorente, C. (2010, March). *A media-rich curriculum for improving early literacy outcomes of low-income children: Evaluation results for the Ready to Learn Initiative.* Paper presented at the Annual Conference of the Society for Research on Effectiveness in Education, Washington, DC.

Phillips, R. S., Harris, C. J., Penuel, W. R., & Cheng, B. (2010, March). Teachers managing students' ideas, questions, and contributions in the context of an innovative inquiry-based elementary science unit. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Philadelphia, PA.

Gallagher, L. & Penuel, W. R. (2009, April). *Preparing teachers to design instruction in middle school Earth science: Impacts of three professional development programs on student learning.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Penuel, W. R. (2009, April). *Evaluating the DELTA Project.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

O'Connor, K., & Penuel, W. R. (2009, April). *Organizing as a metaphor for learning and research on learning.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Fishman, B. J., Penuel, W. R., Hegedus, S. J., Tatar, D., Dickey, M., Moniz, R., et al. (2009, April). *What happens when the research ends? Factors related to the sustainability and scalability of a research-based innovation.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Penuel, W. R. (2009, January). *Organizing, leading, and sustaining innovation in professional learning communities.* Keynote Presentation at the Microsoft Innovative Schools Conference, London, England.

Fishman, B. J., Penuel, W. R., Gallagher, L. P., Lopez-Prado, B., & Korbak, C. (2008, June). *The mediating role of coherence in curriculum implementation.* Paper presented at the 8th International Conference of the Learning Sciences, Utrecht, the Netherlands.

Rafanan, K., Roschelle, J., Bhanot, R., Gorges, T., & Penuel, W. R. (2008, June). *Measuring mathematics discourse in technology-supported collaborative activities.* Paper presented at the 8th International Conference of the Learning Sciences, Utrecht, the Netherlands.

Penuel, W. R., & Gallagher, L. P. (2008, March). *Comparing three approaches to preparing teachers to teach for deep understanding in Earth science: Short-term impacts on teachers' instructional planning and practice.* Paper presented at the Annual Meeting of the American Educational Research Association, New York, NY.

Penuel, W. R., McWilliams, H., & McAuliffe, C. (2007, December). *Investigating the role of the teacher in science curriculum: New evidence for an old debate.* Paper presented at the American Geophysical Union Fall Meeting 2007, San Francisco, CA.

Penuel, W. R., Riel, M., Frank, K. A., & Krause, A. (2007, April). *Teacher networks and the diffusion of innovations.* Paper presented at the 4th Lake Arrowhead Conference on Human Complex Systems, Lake Arrowhead, CA.

Joshi, A., & Penuel, W. R. (2007, April). *The role of institutionalized norms of autonomy and equality in shaping interactions of teachers.* Paper presented at the 4th Lake Arrowhead Conference on Human Complex Systems, Lake Arrowhead, CA.

Penuel, W. R., Riel, M., & Sussex, W. (2007, April). *A network perspective on teacher collaboration: Teachers' social capital and the enactment of curricular reforms.* Paper presented at the American Educational Research Association Annual Meeting, Chicago, IL.

Penuel, W. R., Frank, K. A., & Krause, A. (2007, April). *A social network approach to examining the effects of distributed leadership in schoolwide reform initiatives.* Paper presented at the American Educational Research Association Annual Meeting, Chicago, IL.

Penuel, W. R., Frank, K. A., & Riel, M. (2007, February). *Instructional change and improved achievement: The significance of the internal social structure of schools.* Paper presented at the Conference on Human and Social Capital in Learning Systems, Pittsburgh, PA.

Penuel, W. R., Kreikemeier, P., Venezky, D. Y., Blank, J. G., Davatzes, A. E. K., & Davatzes, N. C. (2006, December). *Assessing teachers' comprehension of what matters in Earth science.* Paper presented at the American Geophysical Union Fall Meeting 2006, San Francisco, CA.

Penuel, W. R., Sussex, W., & Korbak, C. (2005, October). *Mapping the distribution of expertise and resources in a school: A social capital approach to evaluating school capacity.* Paper presented at the Joint Conference of the Canadian Evaluation Society and the American Evaluation Association, Toronto, Ontario.

Penuel, W. R., & Sussex, W. (2005, August). *GLOBE Year 10 evaluation results.* Paper presented at the 10th Annual GLOBE Conference, Prague, Czech Republic.

Penuel, W. R., Riel, M., Korbak, C., & Means, B. (2004, April). *Investigation of a social capital approach to the adoption of reform practices.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Penuel, W. R., Shear, L., Korbak, C., & Sparrow, E. (2004, April). *The roles of regional partners in supporting an international science inquiry program.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Yarnall, L., & Penuel, W. R. (2004, April). *Designing handheld software to support classroom assessment.* Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

Penuel, W. R., & Means, B. (2004, February). *The effectiveness of technology-supported science education: Studying what works how, when, and for whom.* Paper presented at the Annual Meeting of the American Association for the Advancement of Science, Seattle, WA.

RECORD OF EXTERNAL FUNDING FOR RESEARCH

As Principal Investigator or Project Director

2012-2014	"Connected Learning Research Network Survey" $190,795 Funder: MacArthur Foundation
2011-2012	"Developing and Testing Theories of Implementation: A Workshop on Design Research with Educational Systems" $184,779 Funder: REESE Program, National Science Foundation
2010-2015	"Evaluation of the Ready to Learn Content Alliance" $4,874,999 Funder: Office of Innovation and Improvement, U.S. Department of Education
2008-2012	"Developing Contingent Pedagogies: Integrating Technology-Enhanced Feedback into a Middle School Science Curriculum to Improve Conceptual Teaching and Learning" $2,199,970 Funder: DRK-12 Program, National Science Foundation
2007-2009	"Evaluation of the MathForward Initiative" $728,000 Funder: Texas Instruments, Inc.
2006-2010	"Evaluation of the Ready to Learn Initiative" $2,070,000 Funder: Office of Innovation and Improvement, U.S. Department of Education
2006-2009	"Analyzing the Flow of Network-Embedded Expertise in Schools: A Longitudinal Study of Individual and Organizational Change" $551,484 Funder: Human and Social Dynamics Program, National Science Foundation
2005-2009	"Comparing the Efficacy of Three Approaches to Transforming Instruction in Earth Science Education" $1,864,415 Funder: Institute of Education Sciences, U.S. Department of Education

Record of External Funding for Research (Cont'd)

2004-2008	"21st Century Community Learning Centers Program Implementation Study" $1,642,462 Funder: Program and Policy Studies Service, U.S. Department of Education
2003-2007	"Evaluation of the Global Learning to Benefit the Environment (GLOBE) Program: A Systemic Approach." $910,659 Funder: Elementary, Secondary, and Informal Education, National Science Foundation
2003-2007	"Exploration of a Social Capital Framework for Evaluative Studies of Technology Integration" $1,346,733 Funder: ROLE, National Science Foundation
2003-2005	"Evaluation of the *Routes to Learning* Initiative" $75,000 Funder: Koret Foundation
2002-2005	"Handheld Assessment: Portable Scaffolds for Project-based Learning in Science?" $ 1,822,042 Funder: ROLE, National Science Foundation

As Co-Principal Investigator

2013-2017	"A Research+Practice Collaboratory" $1,441,305 Funder: National Science Foundation
2012-2015	"INDP: Inquiry Hub" $1,520,531 Funder: National Science Foundation
2012-2015	"From Users to Coproducers of Research Evidence: A Study of Place-Based Research Partnerships" $591,901 Funder: William T. Grant Foundation

Record of External Funding for Research (Cont'd)

2011-2013	"Synergies: Understanding and Connecting STEM Learning in the Community" $601,177 Funder: Noyce Foundation
2010-2014	"Efficacy Trial of Project Based Inquiry Science" $5,000,000 Funder: National Science Foundation
2006-2011	"Evaluation of the National Writing Project" $5,000,000 Funder: U.S. Department of Education
2003-2005	"The CATAALYST - Planning a Rigorous Study" $231,607 Funder: National Science Foundation

PROFESSIONAL SERVICE

2012-present	Member, National Research Council committee on Assessment and the Next Generation Science Standards
2012-present	Conference co-chair, 11th International Conference of the Learning Sciences
2011-present	Member, Geographical Sciences Education Research Committee
2011-present	Associate Editor, *American Educational Research Journal*
2011-present	Reviewer, *Harvard Educational Press*
2010-present	Editorial Board Member, *American Journal of Evaluation*
2009-present	Reviewer, *Elementary School Journal*
2008-present	Editorial Board Member, *Cognition & Instruction*
2007-present	Editorial Board Member, *Teachers College Record*
2007-present	Reviewer, *Educational Evaluation and Policy Analysis*
2007-present	Reviewer, *Sociology of Education*
2006-present	Editorial Board Member, *Educational Technology Research and*

	Development
2006-present	Reviewer, *American Journal of Evaluation*
2005-present	Reviewer, *Science Education*
2009	Reviewer, *American Educational Research Journal*
2008	Reviewer, Informal Science Education Program (NSF)
2006	Reviewer, Human and Social Dynamics Program (NSF)
2004	Reviewer, SBIR program (NSF)
2003	Reviewer, ROLE program (NSF)
1996-2000	Reviewer, *Journal of Research on the Teaching of English*
1995-1997	Vice President, Cultural-Historical SIG of the American Educational Research Association

MEMBERSHIPS

American Educational Research Association
National Association for Research in Science Teaching
American Sociological Association
International Society of the Learning Sciences

William Penuel Updated Current and Pending Support

Grant	Award Amount	Grant Period	Annual Percent Effort
CURRENT			
Efficacy Study of Project-Based Inquiry Science (NSF)	$4,999,999	8/15/2010 – 8/14/2015	5%
National Center for Quality Teaching and Learning for Head Start (DHHS)	$147,494	9/14/2011 – 9/13/2014	8%
Synergies: Understanding and Connecting STEM Learning in the Community (Noyce)	$1,847,494	11/01/11 – 5/31/2015	8%
Connected Learning Longitudinal Survey Study (MacArthur)	$538,500	1/1/12-12/31/14	0%
Research+Practice Collaboratory (NSF)	$1,441,305	11/01/2012 – 10/31/2017	8%
INDP Inquiry Hub (NSF)	$2,500,000	1/01/2012 – 5/31/2016	11%
From Users to Co-Producers of Research: Research Use in Research-Practice Partnerships (WT Grant)	$551,484	1/01/2012 – 12/31/2014	7%
Building and Sustaining Research-Practice Partnerships for Equity in STEM Education (NSF)	$212,981	12/1/2013-11/30/2015	0%
Early Career and Doctoral Consortium Workshop at ICLS 2014 (NSF)	$70,148	1/1/14 – 12/31/14	0%
FUSE Studios: An Alternative Infrastructure for STEM Learning and Interest Development (NSF)	$80,385	6/1/14-5/31/17	4%
PENDING			
Qualitative Understanding of the Role of Distributed Leadership for Equity in STEM	$1,500,000	8/1/14-7/31/17	4%
Center for Interactive Knowledge Utilization (IES)	$4,954,853.46	07/01/14 to 06/30/19	10%
Science Adaptable Learning Lab (ALL) Math-Science Partnership	$ 7,498,990	10/1/14-9/30/18	10%