DISCOVERY RESEARCH K-12
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A Digital Resource for Developing Mathematics Teachers' TPCK

Grant #	0918339
NSF Program	NSF
PI	Jeremy Roschelle
Co-PI(s)	Jose Blackorby, Charles Patton, Janet Bowers, Sue Courey
Institution	SRI International
NSF Program Manager	Jim Fey
Grade Level Band	Middle School
Target Audience	Preservice
STEM Content Area	Mathematics
Deliverables	A Digital Mathematics Text

We aim to advance the preparation of preservice teachers in middle school mathematics, specifically on the topic of proportionality. Proportional reasoning is a centrally important and difficult topic in middle school mathematics and essential to students' later success in algebra. To address the profound need for a workforce of high-quality teachers to teach this mathematics to diverse and struggling middle school students, we will develop a digital text that could be widely used by preservice teacher training institutions to communicate the unique transitional nature of middle school mathematics, as distinguished from elementary school and high school mathematics. Based on the interesearch-based concept of Technological Pedagogical Content Knowledge (TPCK), our goal is to enhance preservice education in three synergistic aspects:

- Content: Increasing the accuracy, coherence, and conceptual depth of preservice teachers' knowledge of proportionality and related pre-Algebra concepts.
- Pedagogy: Enhancing the abilities of preservice teachers to use mathematical language effectively and to formulate questions that drive students' mathematical thinking.
- Technology: Incorporating technology into teaching for two important research-based purposes: (1) to support diverse students' engagement with demanding mathematics and (2) to interact with dynamic representations to increase conceptual understanding.

Strong research foundations underlie our design concept, development plan, and evaluation efforts. For example, guided by findings from large-scale randomized experiments, we emphasize the use of technology to provide interactive representations that enhance conceptual understanding. We further incorporate Universal Design for Learning (UDL), which shows how to provide affective, strategic, and cognitive support for engaging with challenging subject matter. We use the Framework for Research-Based Curriculum to organize our research towards dual purposes: (1) to inform iterative development and (2) to contribute to the research literature on teacher learning of TPCK. Formative research includes usability testing, design research, and analysis of mathematical accuracy and pedagogical appropriateness.

A Learning Progression for Scientific Modeling

Grant #	0628199
NSF Program	IMD
PI	Brian Reiser
Co-PI(s)	Joseph Krajcik, Elizabeth Davis, Christina Schwarz, David Fortus
Institution	Northwestern University
NSF Program Manager	David Hanych
Grade Level Band	PreK, Middle School
Target Audience	Students, Preservice, Inservice
STEM Content Area	Science
Deliverables	Learning Progression, Educative Curriculum Materials

The project is a 42-month research and development effort to develop a learning progression for scientific modeling and investigate its implementation in two grade bands. The project focuses on the scientific practice of modeling because of its centrality in both the practice of science and as a vehicle for science learning. A learning progression characterizes variations of the practice that are appropriate for learners, and a sequence of successively more complex versions of that practice possible for learners. A learning progression for a scientific practice contains; (a) a model of the target practice appropriate for learners, (b) the starting points of learners'' intuitive understandings and practices, (c) a sequence of successively more sophisticated understandings and practices, and (d) instructional supports to help learners develop the practice.

The theoretical contribution of the proposed work is to develop an empirically-tested learning progression for scientific modeling. The project identifies two related learning goals for modeling that serve as the two major constructs it will track: modeling practices and metamodeling knowledge. Each construct is broken into several progress variables that are tracked across time. The project will provide an empirically-supported learning progression for a key scientific practice, scientific modeling. Although the field has produced snapshots demonstrating the promise of engaging learners in scientific practices, systematic empirical research demonstrating how the practice can develop across years is lacking.

The specific instructional materials created as part of the project can serve as a model other developers can use to design materials supporting scientific modeling and other practices. The model for educative curriculum materials as a form of teacher support can be adapted to support teacher learning about modeling or other scientific practices in other curriculum materials.

A Longitudinal Randomized Trial Study of Middle School Science for English Language Learners (Project MSSELL) (Collaborative Research - Irby)

Grant #	0822153
NSF Program	NSF
PI	Beverly Irby
Co-PI(s)	
Institution	Sam Houston State University
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Students - Special Population, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science
Deliverables	Research-based Curriculum/Practices

Built on the success of our research team's U.S. Department of Education (DOE), Institute of Education Sciences (IES) funded project, this collaborative research project, Middle School Science for English Language Learners (Project MSSELL), engages Texas A&M University and Sam Houston State University in Texas along with Aldine Independent School District, and proposes a randomized trial longitudinal experimental study that investigates an enhanced intervention in science education. The intervention involves 200 Spanish-speaking English language learners (ELLs) and 200 English-speaking students from eight classroom cohorts across fifth grade and terminating at the end of sixth grade. Specifically, Project MSSELL will test an enhanced standards-based science curriculum model integrated with English-as-a-second-language (ESL) strategies and technology along with student, teacher, and classroom characteristics. The enhanced curriculum will be aligned with the state and national standards, covering various science topics including life science, physical science, and earth science. Family involvement in science at home in the native language of Spanish and in English will be assessed as a component of the enhanced science curriculum model. Additionally, scientists will be involved in enhancing the curriculum through specifically designed activities from mentoring to engaging students on designated Saturdays at the university campus with scientists and honors students majoring in science. Three research questions will guide this study: (1) How effective is the enhanced science program in developing science achievement and academic English proficiency for ELLs whose first language is Spanish? (2) Are there student, teacher, home, or school characteristics that predict academic success in science achievement for ELLs whose first language is Spanish? (3) Do student characteristics interact with program type (enhanced or typical) and/or teacher or school characteristics to predict academic success in science for ELLs whose first language is Spanish?

To evaluate the intervention, learning gains will be compared on standardized tests of science achievement and reading comprehension by fifth- and sixth-grade students randomly assigned to receive one of the two types of science education: experimental or control. Through the use of multilevel modeling techniques of individual growth curves, we will be able to describe and predict learning rates for science literacy. Additionally, science instruction will be monitored and compared across classrooms through field observation. Qualitative data also will be collected because they provide fertile descriptions and explanations of processes that may be outside the purview of classical quantitative methods. An external evaluation of the fidelity of project implementation will take place at six time points throughout the project. Dissemination will include (a) publication of student materials and teacher intervention processes in print and on the Web; (b) presentations as national, regional, and state levels; (c) newsletters and family science literacy involvement to actively engage parents in their children's science learning; and (d) publication in peer-reviewed sources.

A Longitudinal Randomized Trial Study of Middle School Science for English Language Learners (Project MSSELL) (Collaborative Research - Lara-Alecio)

Grant #	0822343
NSF Program	NSF
PI	Rafael Lara-Alecio
Co-PI(s)	
Institution	Texas A&M University
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Students, Students - Special Population, Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science
Deliverables	Research-based Curriculum/Practices

Built on the success of our research team's U.S. Department of Education (DOE), Institute of Education Sciences (IES) funded project, this collaborative research project, Middle School Science for English Language Learners (Project MSSELL), engages Texas A&M University and Sam Houston State University in Texas along with Aldine Independent School District, and proposes a randomized trial longitudinal experimental study that investigates an enhanced intervention in science education. The intervention involves 200 Spanish-speaking English language learners (ELLs) and 200 English-speaking students from eight classroom cohorts across fifth grade and terminating at the end of sixth grade. Specifically, Project MSSELL will test an enhanced standards-based science curriculum model integrated with English-as-a-second-language (ESL) strategies and technology along with student, teacher, and classroom characteristics. The enhanced curriculum will be aligned with the state and national standards, covering various science topics including life science, physical science, and earth science. Family involvement in science at home in the native language of Spanish and in English will be assessed as a component of the enhanced science curriculum model. Additionally, scientists will be involved in enhancing the curriculum through specifically designed activities from mentoring to engaging students on designated Saturdays at the university campus with scientists and honors students majoring in science. Three research questions will guide this study: (1) How effective is the enhanced science program in developing science achievement and academic English proficiency for ELLs whose first language is Spanish? (2) Are there student, teacher, home, or school characteristics that predict academic success in science achievement for ELLs whose first language is Spanish? (3) Do student characteristics interact with program type (enhanced or typical) and/or teacher or school characteristics to predict academic success in science for ELLs whose first language is Spanish?

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A Study of Professional Learning Communities Amongst Secondary Science & Mathematics Teachers: Changes, Support Systems, Student Learning

Grant #	0554579
NSF Program	TPC
PI	Tamara Nelson
Co-PI(s)	Anne Kennedy, David Slavit
Institution	Washington State University Vancouver
NSF Program Manager	Julia Clark
Grade Level Band	Middle School, High School
Target Audience	Inservice
STEM Content Area	Science, Mathematics
Deliverables	Research Article, Conference Proceedings

This study seeks to answer the following research questions on a professional development (PD) project entitled Partnership for Reform in Secondary Science and Mathematics (PRiSSM): How do the interactions between teachers engaged in collaborative inquiry in a professional learning community (PLC) contribute to new understandings of teaching and learning mathematics and/or science? What are the ways in which facilitators and school/district administrators, systems, and structures interact to frame and enact the notion of support for teachers engaged in PLC work? How do school-based PLCs affect students' mathematical and/or scientific achievement?

PRiSSM was a three-year (2004-2007) project funded through a Title II-B Department of Education grant. Teachers received support for 80 hours of PD annually, including summer academies and ongoing support of facilitators throughout the school year. PRiSSM began with 45 mathematics and science lead teachers within six school districts and expanded in Year 2 to include 100 additional teachers. In Year 3, teachers continued their PLC work and additional teacher leaders attended the summer academy.

The PRiSSM model facilitated teacher learning through activities that fostered collaboration, dialogue, and inquiry over an extended time period. The critical characteristic of this model is supported teacher collaborative inquiry in PLCs. PRiSSM built from a theoretical and empirical knowledge base that recognizes teacher change as a complex process requiring time for reflection, discourse, practice, and feedback rather than a one-time or short-term encounter with others' ideas (Fullan, 1993, 1999; Loucks-Horsley, Hewson, Love, & Stiles, 1998). The research is grounded in a social-constructivist view of learning and a situated perspective on development (Brown & Campione, 1990; Lave, 1991; Lave & Wenger, 1991).

This research is making a significant contribution to the PD knowledge base in analyzing the various paths of development of participating teachers and the impact of their PLC inquiry on student learning, as well as in contextualizing the activities and sustainability of teachers' collaborative inquiry with respect to various school-, district-, and state-based supports and constraints. The research design makes use of mixed methods (Creswell, 2003). Case studies are being developed on five school-based PLCs, embedding 12 teacher case studies, and district and building data. Qualitative data sources include classroom and PLC meeting observations and video records, interviews, and artifacts such as meeting notes and lesson plans. Quantitative data from surveys serve to contextualize the PLC and individual teacher case studies in the broader context. Student achievement data includes state and classroom assessments.

Based on three years of data, we developed a theoretical framework for understanding the ways in which teachers interact with data in supported collaborative inquiry. This frames an analysis of teachers' data selection, collection, and analysis through three dimensions: teachers' dialogic interactions, their stance toward data, and the technical aspects of their interactions with data. Using this framework, we examine the three-year journey of one middle and high school mathematics and science PLC as they learned to use student data in the context of supported collaborative inquiry.

A Study of the Struggling Learner's Knowledge and Development for Number and Operation

Grant #	0918060
NSF Program	NSF
PI	John Lannin
Co-PI(s)	Delinda van Garderen
Institution	University of Missouri
NSF Program Manager	Ferdinand D. Rivera
Grade Level Band	PreK
Target Audience	Students, Students - Special Population
STEM Content Area	Mathematics
Deliverables	Learning Trajectories, PD Conference

This three-year study targets first- and second-grade children who struggle to develop a deeper understanding of the mathematical strand of number and operation. A research team from the University of Missouri-Columbia will (a) identify the various specific cognitive obstacles of first- and second-grade students who are struggling in number and operation, and (b) explore how instructional tasks designed to address specific cognitive obstacles affect the learning trajectory of struggling learners in number and operation.

During the first year of the study, two classes of first-grade children in two schools (approximately 40 children) in the Columbia public school system will be assessed on their number and operations knowledge and skills using a project-developed interview measure. Based on the initial assessment, a subset of 10 children struggling in mathematics will be identified to receive instruction. The intervention will involve a small-group teaching experiment designed to build on what the children know in number and operation. Videotapes of the sessions and student samples of work will be collected to monitor progress and development. This process will repeat for children at the second-grade level. The research team will also collect data from teacher interviews and classroom observations of the regular mathematics instruction to better understand the mathematical knowledge developed in the school setting.

The data will be analyzed by constructing individual cases of struggling children and through comparison of the learning trajectory of these children to typically developing children.

A Technology Exemplar: Post-Textbook UDL Materials

Grant #	0628242
NSF Program	IMD
PI	Carolyn Staudt
Co-PI(s)	
Institution	Concord Consortium
NSF Program Manager	Mike Haney
Grade Level Band	PreK
Target Audience	Students, Students - Special Population, Inservice
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	A Web site: http://udl.portal.concord.org

There are no classroom-ready elementary STEM curriculum materials that use Universal Design for Learning (UDL). There is a particular urgency to developing UDL materials now because the 2004 Individuals with Disabilities Education Act (IDEA) included provisions for a process that will result in a voluntary National Instructional Materials Accessibility Standard (NIMAS). Initially, states adopting NIMAS will require all publishers to provide electronic versions of textbooks. The UDL Elementary Science Materials use inquiry as the cornerstone for the development of elementary science, technology, engineering, and math (STEM) activities. These electronic versions of print texts will be a starting point that will support some UDL goals, but will hardly take full advantage of information technologies.

Exemplars are needed now to demonstrate what is possible when UDL materials are designed from the start for electronic delivery. Because of NIMAS, an effective exemplar could have far-reaching impact. The goal of this project is to create practical science materials designed with UDL principles for students and teachers in inclusive classrooms. The project will create sufficient materials to test the effectiveness of the approach and provide an exemplar that can inspire additional content and further development. The materials are aimed at upper elementary grades and are being tested in 19 classrooms in Fresno, CA; Anchorage, AK; Maryville, MO; and Acton, MA.

The units are developed around four driving questions:
- Why are there clouds?
- What if there was no friction?
- What do plants eat?
- What is electricity?

Each unit contains grade-appropriate (grades 3–4 and grades 5–6) hands-on, model-based and probe-based activities with a wide range of alternatives for the way tools are used in the classroom, materials are represented and communicated, and learning is assessed. While this project focuses on just part of the grade 3–6 science curricula, the research results and the technologies developed will be applicable to other levels and disciplines of science as well as to mathematics and engineering education.

ABI and CSTA Collaboration to Reach K-12 Teachers from Under-represented Communities at the 2009 Grace Hopper Celebration

Grant #	0936706
NSF Program	NSF
PI	Dr. Telle Whitney
Co-PI(s)	Dr. Chris Stephenson, Dr. Suzanne Westbrook, Deanna Kosaraju
Institution	Anita Borg Institute for Women and Technology
NSF Program Manager	Michael R. Haney
Grade Level Band	PreK, Middle School, High School
Target Audience	Inservice
STEM Content Area	Technology
Deliverables	K12 Computing Teachers Workshop & Paper

The Anita Borg Institute for Women and Technology requested funding from the National Science Foundation to collaborate with the Computer Science Teachers Association. The collaboration is designed to convene K–12 teachers who work with underrepresented populations of students at the 2009 Grace Hopper Celebration and will produce a workshop and white paper designed to (1) instigate a discussion of equity and computer science curricula; (2) create knowledge sharing opportunities on concrete solutions grounded in teachers' articulated, specific needs; (3) disseminate these solutions to a broad audience of teachers, STEM practitioners, and interested stakeholders via workshop, Town Hall meeting, and dissemination of a white paper; and (4) evaluate the effectiveness of these solutions in classrooms that serve underrepresented student populations.

The effort will advance understanding of the issues facing K–12 computer science education for underrepresented populations, and develop and disseminate effective pedagogic approaches to the teaching of computer science for underrepresented students. The Town Hall meeting will bring greater awareness of the scope of the underrepresentation problem and its impacts at the classroom level to a broad community of educators and concerned industry representatives. The workshop will facilitate the development of solutions and best practices grounded in cultural and classroom realities. Dissemination of a white paper stemming from this workshop and focusing on applicable solutions for computer science teachers will heighten both awareness and discourse relating to teaching computer science to underrepresented populations, and will provide practical solutions that are culturally appropriate and pedagogically sound for better engaging underrepresented students.

Accessing Science Ideas: Enhancing Curriculum to Support Scientific Reasoning of Students with Learning Disabilities

Grant #	0822039
NSF Program	NSF
PI	Karen Mutch-Jones
Co-PI(s)	Gilly Puttick
Institution	TERC
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Students - Special Population, Inservice
STEM Content Area	Science
Deliverables	Curricula and Research Findings

To support the development of scientific thinking in students with learning disabilities, the Accessing Science Ideas (ASI) project will (1) design integrated content enhancements and educative teacher guides that address challenges in FOSS Diversity of Life and Populations and Ecosystems units for middle school students and (2) research their effectiveness. Content enhancements are learning strategies and devices that do not change content but rather "enhance" it by making it accessible to all learners. For this project, we will focus on students with verbal learning disabilities associated with executive function disorders. Often, these students find it difficult to plan, organize, prioritize, remember information, shift flexibly between abstract concepts and literal details, and monitor their work. Thus, the content enhancements will be designed to support students' thinking about science, making the science work more explicit and making concepts, ideas, and their relationships more concrete.

During the development stage, ASI staff will pilot individual lessons to confirm that the reasoning challenges we have identified are the appropriate ones to address, to identify additional challenges, and to test individual enhancements and teacher materials. Once all the content enhancements have been integrated, we will pilot the entire units in 10 classrooms. ASI project staff will conduct observations in a sample of the classrooms, interview a sample of regular education students and students with learning disabilities, and examine their work on FOSS assignments. These and additional evaluation data focused on teachers and students use of the enhancements and guides will inform revisions.

After piloting, we will research the effectiveness of content enhancements. Using an experimental design, we will compare students' scientific reasoning, content knowledge, and confidence in 76 intervention classrooms with those in 76 comparison classrooms in which the same units are used without enhancements and guides. We will disaggregate and compare the achievement of students with learning disabilities (LD) and their peers without disabilities in the intervention and comparison classrooms to examine whether content enhancements narrow the achievement gap. In addition, we will measure teacher understanding of student reasoning challenges, perceptions of LD students' science abilities, and teachers' sense of efficacy in meeting the instructional needs of LD students. The summative evaluation will focus on project and research implementation so that we can identify factors that may have contributed to the project's success or may have presented unanticipated challenges.

The immediate products for dissemination will be the content enhancements and teacher guide, along with associated research findings. The content enhancements will be available on the web for public use, and we will disseminate information about them via the network of districts that use the FOSS units. We will work with the publisher to extend dissemination further. We will present our findings at national conferences as well as submit papers to peer-reviewed journals. The broader vision is to contribute to a conversation in the field about science accessibility and to provide an impetus and guidance in the development of universally designed science curricula that offer multiple instructional options for teachers and embedded scaffolds to enhance student learning.

Across the Sciences: Multidisciplinary Learning for Teachers through Multimedia

Grant #	0554217
NSF Program	TPC
PI	Pamela Van Scotter
Co-PI(s)	David Davis
Institution	Oregon Public Broadcasting
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Online Professional Development Course

Across the Sciences is an online professional development course of study for high school science teachers. Oregon Public Broadcasting, BSCS, RMC Research, and NTEN are partners on this project. The course of study is designed to support teachers who find themselves teaching out of field. There are 10 interactive units: 1 on inquiry and 3 each in physical science, earth science, and life science. The National Teachers Enhancement Network (NTEN) at Montana State University is currently hosting the units for our national field test. RMC is conducting the evaluation.

When the units are completed, they will be available through the BSCS website, and teachers can use any of the units free of charge. For a fee, teachers will also be able to take the entire course for college credit through Montana State University .

The content of the course aligns with BSCS Science: An Inquiry Approach, a multidisciplinary program for high school, which was funded through NSF.

Active Physics Teacher Community

Grant #	0733268
NSF Program	NSF
PI	Arthur Eisenkraft
Co-PI(s)	
Institution	UMass Boston
NSF Program Manager	Gerhard Salinger
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Online Courses

The number of students taking physics across the United States has recently risen because of state requirements and the success of the Physics First and Physics for All movements, initiatives that encourage schools to teach physics to all ninth graders. Schools that adopt these initiatives must move from a physics instruction model that was designed for the highest-performing juniors and seniors to an instructional model that works for all ninth graders. At the same time, these schools must also ensure that their new curriculum can be taught by the science teachers they already employ, not just experienced physics teachers with a high level of content knowledge. To accomplish these goals, schools and teachers will need new forms of professional development that can evolve to meet the myriad needs of the new physics teachers and their students.

In this project, UMass Boston plans to develop, implement, and study a dual model of professional development that augments traditional professional development with an online platform: the Active Physics Teacher Community. The Teacher Community will help teachers prepare for their lessons by providing them with formal instruction that is directly related to the lessons they are teaching in the classroom. It will also provide a moderated forum for teachers to share their classroom experiences, successes, and questions with other teachers who are using the same lesson plans and the same curriculum. In addition, the Teacher Community will help teachers compare their success in the classroom to other teachers' and modify their learning strategy appropriately. This professional development platform will be developed in partnership with large centers that teach physics to all of their ninth-grade students using the Active Physics curriculum. Teachers will make the first contribution to a living literature of practice called The Active Physics Teachers' Resource Center, a resource that will be incorporated into the online professional development platform and used by future teachers.

Addressing the Needs of the Nation's Physics Teachers through State-of-the-Art Video Applications and Contemporary Pedagogy (Collaborative Research - Zollman)

Grant #	0455772
NSF Program	TPC
PI	Dean Zollman
Co-PI(s)	Scott Stevens, Michael Christel
Institution	Kansas State University
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Web site & Digital Video Database

The Physics Teaching Web Advisory (Pathway) is continuing to demonstrate the ability to address pedagogical issues of many physics teachers via the Web and to evolve as a tool for teachers. Pathway's "Synthetic Interviews," which engage teachers in a natural language dialogue about effective teaching of physics, now can display additional information in the forms of graphics and videos. The interview database is a growing digital library and now contains about 6,000 different recorded answers and over 10,000 question/answer pairs. A new component is a collection of videos that are related to the interview questions and can be used directly in the classroom. This collection includes both professional and teacher-produced videos. Pathway is available at http://www.physicspathway.org

An Architecture of Intensification: Building a Comprehensive Program for Struggling Students in Double-Period Algebra Classes

Grant #	DRL-0918434
NSF Program	NSF
PI	Martin Gartzman
Co-PI(s)	Alison Castro-Superfine, Linda Chaput, Susan Goldman, Susan Hull, James Pellegrino, Cynthia Schneider, Uri Treisman
Institution	University of Illinois at Chicago Learning Sciences Research Institute
NSF Program Manager	James Fey
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Mathematics
Deliverables	Algebra 1 Program for Two-Period Classes

The University of Illinois at Chicago Learning Sciences Research Institute, in collaboration with the University of Texas Charles A. Dana Center and education technology company Agile Mind Inc., are carrying out a research and development initiative to increase the success rates of our most at-risk high school students—ninth-grade students enrolled in algebra classes but significantly underprepared for high school mathematics. It will also result in new understandings about effective approaches for teaching mathematics to struggling students and about effective ways for implementing these approaches at scale, particularly in urban school districts.

Using a design-based research approach, we will develop and study a new program, called Intensified Algebra, that is engineered for use with students who are enrolled in the double-period algebra classes that are commonly scheduled for underprepared students in school districts throughout the country. Central to our design plan is the assumption that students who struggle in mathematics need more than just a good algebra curriculum to be successful. Thus, in addition to a rigorous mathematics core, our approach addresses the social, affective, linguistic, and strategic cognitive and metacognitive dimensions of learning mathematics. The project's extensive research component will inform the program's development and revision, and will lay the foundation for future research studies.

The project's goals are as follows:
Goal 1: Iteratively design and test student and teacher materials for a full-year, ninth-grade, double-period algebra program that integrates effective approaches for teaching algebra with instructional features that, independently, have proven to be effective with struggling learners.

Goal 2: Develop and test materials and strategies that enable teachers to effectively implement the comprehensive Intensified Algebra program and that help promote collaboration within and across schools among teachers of the course. A particular target will be novice or inexperienced teachers, who disproportionately teach the double-period classes.

Goal 3: Develop and test structures and tools that promote the program's scalability in large, urban districts and elsewhere. The project will investigate the feasibility and effectiveness of leveraging technology to organize and deliver at scale consistent, high-quality supports for program implementation.

The project will develop a unique, coherent program that incorporates into algebra instruction areas that historically reside outside of the domain of typical algebra classes but are fundamentally important to students' success. The program aims to influence students' beliefs about themselves as effective mathematics learners and their attitudes about mathematics, as well as their teachers' beliefs about the mathematical capabilities of underprepared students. The tight linkage of the design-based research and the program development components offers a viable, productive model for collaboration between researchers and developers.

The project is an initiative of the Urban Mathematics Leadership Network (UMLN), a network of the mathematics directors in 22 of our nation's largest urban districts. It will have broad applicability nationally in

helping school districts address the needs of underprepared ninth-grade algebra students.

An Examination of the Impact of Teachers' Domain as a Professional Development Tool on Teacher Knowledge and Student Achievement in Biology

Grant #	0732186
NSF Program	NSF
PI	Lauren Goldenberg
Co-PI(s)	Shelley Pasnik
Institution	Education Development Center, Inc.
NSF Program Manager	Dave Campbell
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Conf. Presentations, Research Articles

The goal of this research project is to examine the impact of an online professional development experience on science teachers' content and pedagogical knowledge, and on their students' achievement. We explore this through the context of material developed by WGBH Teachers' Domain and distributed through PBS TeacherLine, a service providing online professional development. Using an experimental design, this study randomly assigned high school biology teachers to either the control group or one of two treatments: (1) a full course on teaching high school biology (high-dosage group) that incorporates genetics and evolution content, as well as pedagogy or (2) a short course that incorporates content only (low-dosage group). By examining the impact of the two professional development courses on teachers' content and pedagogy knowledge, the study examines the impact of varying the amount and type of professional development. As part of the professional development course, teachers learn to use rich-media resources in their classrooms for difficult-to-teach topics such as genetics and evolution, including videos, animations, and interactive Web-based activities for teachers and students. Thus, a second focus of the study is to investigate the impact of teachers' use of rich media. The project is designed to answer the following research questions:

Research Question 1: Does participating in the professional development program increase teachers' knowledge of content (genetics and evolution) and effective pedagogical practices? Is learning moderated by teacher-level covariates, such as years of experience, certification, or advanced degree? Does participating in the higher dosage group result in greater learning of effective pedagogical practices than participating in the shorter course? Is the impact of course length moderated by teacher-level covariates?

Research Question 2: Is student learning influenced by teachers' participation in the professional development program? Are there differences in student learning between those whose teachers were in the treatment groups and in the control group? For students of treatment teachers (those who participated in the professional development course), are there differences in student learning by whether the teacher was in the high- or low-dosage group? Is student learning mediated by teacher's rich use of rich media?

The sample consists of approximately 120 educators who teach biology in public high schools in New York State and their 9th- and 10th-grade students. Data collected include pre- and post-measures of teachers' content and pedagogical knowledge, pre- and post-measures of students' knowledge of genetics and evolution, and teacher and student surveys.

There is general consensus on the characteristics of good professional development and also on the potential benefits of rich media in the classroom. However, empirical studies that tie specific professional development initiatives with teacher outcomes and student achievement are scarce, as are studies that link online professional development with teacher learning and student achievement.

This study will contribute to our understanding of the link between online professional development, teacher learning, and student achievement, as well as the role of teacher background, knowledge, and rich media use as potentially mediating variables.

An Investigation of Elementary Teachers' Learning, Understanding and Use of Research-based Knowledge about Students' Mathematical Thinking

Grant #	0838137
NSF Program	TPC
PI	Michael Battista
Co-PI(s)	
Institution	Ohio State University
NSF Program Manager	David Campbell
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Research: Teacher Learning and Practice

Numerous studies indicate that when teachers obtain appropriate knowledge of students' mathematical thinking, their instructional practices change in ways that improve their students' mathematics learning. So, it is critical to understand the nature of "appropriate" teachers' knowledge of students' mathematical thinking, and how different forms of this knowledge affect teachers' practice.

The present project is called CBA2 for Cognition Based Assessment, Phase 2. It started in June of 2006, and its goal is to investigate how elementary teachers make sense of and use research-based knowledge about the development of students' reasoning about particular mathematical topics, as represented by teacher-friendly materials such as the Cognition Based Assessment (CBA) materials developed by PI Michael Battista during a previous NSF project (CBA1).

The research describes case studies of teachers' understanding of the strategies and underlying mental processes that elementary students use in reasoning about several particular topics in elementary school mathematics. This research elaborates on a neglected portion of teachers' Knowledge of Content and Students (KCS). It analyzes in detail the nature of the cognitive/psychological component of teachers' conceptualizations of students' thinking and how these conceptualizations affect teachers' conceptualizations of instruction. It was found that, often, even though teachers' could correctly judge the validity of students' reasoning mathematically, they did not understand that reasoning psychologically. Even so, because CBA materials give instructional suggestions that target very specific types of student reasoning, teachers were still often able to choose appropriate instructional activities. However, without appropriate conceptualizations of student reasoning, teachers' implementation of appropriate activities—from interpretation of student responses to follow-up questions—was sometimes limited.

Teachers who studied CBA materials thought that CBA could move them toward richer types of mathematics instruction and assessment. Teachers' comments indicated the following

- CBA helped teachers see a need to move from summative to formative assessment.
- CBA equipped teachers to handle classroom diagnosis and remediation for struggling students.
- CBA focused teachers' attention on understanding their students' mathematical thinking, needs, and difficulties.
- CBA helped teachers adjust their teaching to better meet students' needs—from choosing instructional tasks to asking questions in class.
- CBA helped teachers discover deficiencies in their teaching and their students' learning.
- CBA helped teachers communicate students' mathematical development to parents.
- CBA helped teachers see inadequacies in district and state tests, and in their current curricula.

Several CBA2 teachers made extraordinary progress in their teaching, finding ways to incorporate CBA ideas throughout their teaching so that they were constantly designing and adjusting high-quality, high-level instruction to better meet the learning needs of their students.

An Investigation of the Impact of Strengthening the "T" and "E" Components of STEM in High School Biology and Chemistry Courses

Grant #	0917540
NSF Program	NSF
PI	Debra Brockway
Co-PI(s)	Sandra Alberti, Cary Sneider
Institution	Stevens Institute of Technology
NSF Program Manager	Daniel Householder
Grade Level Band	High School
Target Audience	Students, Inservice, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering
Deliverables	Curriculum Materials

Stevens Institute of Technology and the New Jersey Department of Education are addressing the DR-K12 challenge of assuring that all students have appropriate opportunities to learn significant STEM content. The project is developing high school biology and chemistry instructional materials that incorporate engineering design and inquiry activities closely linked to the content, while simultaneously introducing students to cutting-edge research in STEM fields.

The goal of this project is to strengthen the technology and engineering components in high school STEM courses taken by a majority of students. The hypothesis is that increasing the presence of engineering and technological design at the high school level, specifically by integrating activities in bioengineering and chemical engineering into high school biology and chemistry classes, improves student understanding of science concepts and strengthens students' 21st century skills more than traditional instructional methods.

The study employs an experimental design with matched pairs of classrooms randomly assigned to treatment or control conditions. Instruction in the treatment group includes an engineering design activity in addition to the existing curriculum, while instruction in the control group consists of the existing curriculum and an additional activity presented via traditional methods. Changes in performance on achievement and skills tests for the matched pairs are then compared.

The study is intended to contribute to the body of research on the effectiveness of engineering design activities in improving student understanding of science concepts as compared to other teaching methods. An experienced, multi-disciplinary, multi-institutional research team and project advisors utilize rigorous methodologies to investigate the impact of engineering design activities on the learning of science content and 21st century skills.

This study contributes new knowledge to both state and national efforts to improve the effectiveness of STEM education at all levels for all students. By incorporating engineering design in high school science, students are exposed to engineering concepts and the interdisciplinary connections among science, technology, and engineering. Introducing engineering design concepts in courses with larger and more diverse enrollments helps to align public perceptions with reality, increases student enrollments in STEM courses, and enhances the diversity of students considering post-secondary engineering programs.

Analyzing and Building Science Inquiry Skills through Evidence-based Technology Integration

Grant #	0554556
NSF Program	TPC
PI	Yiping Lou
Co-PI(s)	Pamela Blanchard
Institution	Louisiana State University
NSF Program Manager	Michael Haney
Grade Level Band	Middle School
Target Audience	Students, Preservice, Inservice, Higher Education
STEM Content Area	Science
Deliverables	Web Application and Research Articles

The Pathways to Inquiry Project has developed two interrelated tools, an Inquiry Skill Analyzer (iSA) and an Inquiry Activity Portal (iAP). The iSA is designed for teachers to analyze and monitor the progress of their inquiry skills in different inquiry skill areas, as well as those of their students based on the National Science Education Standards. The iAP consists of activity matrices that are keyed to both earth science content and specific science process skills. Pilot and field studies were conducted in eight middle schools during 2007-2008 and ten middle schools in 2008-2009 academic years. Analyses of the inquiry assessments showed good content and discrimination validity along with test reliability. Teachers found both tools easy to use and valuable in helping students understand science inquiry skills and engage in inquiry-based learning of earth science content.

Application of Evidence-Centered Design to State Large-Scale Science Assessment

Grant #	0733172
NSF Program	NSF
PI	Geneva Haertel
Co-PI(s)	Robert J. Mislevy
Institution	SRI International
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Policy Makers, Other
STEM Content Area	Science
Deliverables	Paper, Articles, Assesment Design Documents, Website

This project brings evidence-centered design methodology (ECD) (Mislevy, Steinberg, & Almond, 2003; Mislevy & Haertel, 2006) to bear on developing technology-based tasks in the context of a state large-scale assessment system. SRI International, the University of Maryland (UMD), Pearson Educational Measurement (PEM), and the Minnesota Department of Education will collaborate to apply evidence-centered design processes to the design, development, and implementation of technology-based science assessment tasks. The proposed research will comprise a more stringent test of the feasibility of ECD design processes than has been conducted to date. It will extend beyond the applications of the design system that were implemented as part of the Principled Assessment Designs in Inquiry (PADI) project, which were conducted in two research settings (Songer, 2007) and on a much smaller scale than the currently proposed project.

Stated broadly, the goals of the proposed project are to determine ways in which ECD can enhance the quality of large-scale technology-based assessments and the efficiency of their design, to implement the resulting procedures in operational state test development cycles and to disseminate the findings to the assessment community, the science educational researchers, and policy makers.

Methodology
1. Through the lens and data structures of ECD, we will identify points for streamlining assessment design, development, and delivery processes, including generative schemas for conceptual elements and re-use of operational elements and data structures.
2. Extend design components and tools developed in the prior PADI project to exploit these efficiencies, through a design layer that interacts with the PEM development infrastructure.
3. Implement the ECD methodology in the context of an operational large-scale, state-level, high-stakes accountability testing program, the science tests in the Minnesota Comprehensive Assessments—Series II (MCA-IIs). The implementers will be test-development professionals who develop the operational assessments.
4. Evaluate the effectiveness of the ECD strategies and tools as part of operational assessment cycles.
5. Connect the methods and products of the work to formative and games-based assessment. These extensions will not be fully implemented but sketched out in a technical report.
6. Produce a technical report series.

Anticipated Products
- Training materials for intended users, namely, state education experts and operational test developers.
- ECD-based processes for designing technology-supported, science-task development systems that shift from a task-based development perspective to a system-based perspective.
- Data structures and authoring interfaces building on the PADI object model and design wizards.
- Exemplar design patterns and PADI task templates that led to the assessment tasks and descriptions of the processes that produced them.
- Exemplar tasks in science.
- Cognitive lab evaluations of design patterns used by storyboard and item writers.
- Data analyses of large-scale administration of tasks at the state level (approx. 70,000 students).
- Publications in scientific journals and presentations to annual professional conferences.

Applying Research on Science Materials Implementation: Bringing Measurement of Fidelity of Implementation (FOI) to Scale

Grant #	0628052
NSF Program	IMD
PI	Jeanne Rose Century
Co-PI(s)	Andy Isaacs
Institution	University of Chicago
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	
Target Audience	
STEM Content Area	
Deliverables	Measures, Instruments, User's Guide, Web

The Applying Research on Science Materials Implementation: Bringing Measurement of Fidelity of Implementation (FOI) to Scale project resides at the Center for Elementary Mathematics and Science Education (CEMSE) at the University of Chicago. Working with the Chicago Public Schools, CEMSE is nearing completion of this three-year applied research project to develop instruments for measuring the use of science and mathematics instructional materials. This work builds on existing theoretical work on FOI in the fields of education and health and on recent studies of FOI of science and mathematics instructional materials.

The project is completing development of a suite of instruments including teacher and school leader questionnaires, a teacher instructional log, a classroom observation protocol, teacher and school leader interview protocols, and a school-wide observation protocol. The instruments were tested over two years, ending with a 40-school field test completed in June 2009. Each instrument in the suite has an accompanying set of User's Notes and, when the project is complete, will be accompanied by a User's Guide that includes guidelines for suggested use.

The instruments were developed using an FOI conceptual framework as a foundation. The framework was developed building from existing FOI work in health and education, and organizes "critical components" into framework categories that facilitate description and analysis of program enactment. The project developed instruments to measure use of NSF-supported science instructional materials Full Option Science System (FOSS), Science and Technology for Children (STC), Science Education for Public Understanding Program (SEPUP), and Investigating Earth Systems (IES) as well as the non-NSF-funded program Science Companion, and the NSF-funded mathematics program Everyday Mathematics.

In addition to instruments for measuring the programs named above, CEMSE has developed a process for customizing the instruments to other programs. CEMSE also provides training for others wishing to use the instruments.

Assessing Instructional Quality in Mathematics: A Comparative Study of High and Low Value-added Teachers' Videotaped Lessons

Grant #	0732204
NSF Program	NSF
PI	Nicole Kersting
Co-PI(s)	James Stigler
Institution	University of Arizona
NSF Program Manager	Paula Sztajn
Grade Level Band	PreK
Target Audience	Inservice, Policy Makers, Other
STEM Content Area	Mathematics
Deliverables	No deliverables yet

The Assessing Instructional Quality in Mathematics project aims to identify effective teaching strategies in mathematics and explore the validity of value-added teacher effect estimates. In this project we will compare the teaching practices of 60 fifth-grade mathematics teachers, who vary in their effectiveness, to identify teaching strategies and instructional elements that promote student learning. To identify teachers' degrees of effectiveness we estimated teachers' value-added scores based on four years of student achievement data. Values-added scores were obtained for all fifth grade math teachers in one of the largest school districts in the US. Exploring the stability of the value-added scores within teachers across time showed some variation. While value-added scores of about half the teachers stayed within the same or the adjacent inter-quartile range across years, value-added scores for the other half of teachers varied by up to three inter-quartile ranges. The degree of variation found for some teachers raises questions about how such patterns might be explained.
From this large sample of fifth-grade teachers we recruited 60 teachers with different value-added scores and videotaped each of them five times during his/her teaching of a unit on fractions. Specifically, we sought to capture from each teacher two lessons on the meaning of fractions (e.g., part-whole relationships, equivalency), and three lessons on addition of fractions. Project staff also administered a short student test on fractions in each classroom prior to and after completing the unit on fractions. Finally, teachers completed three online surveys: (1) a scale on fraction knowledge for teaching from the MKT item bank developed by Heather Hill, Deborah Ball and colleagues at the University of Michigan, (2) a Classroom Video Analysis Assessment (CVA) developed by our group, and (3) a background questionnaire on their professional preparation and experience and their beliefs about teaching mathematics.
The videotaped lessons were digitized and transcribed. An objective coding rubric will be developed that measures instructional quality in mathematics and, blind to teacher effectiveness, it will be applied to all lesson videos.
For analyses, the teacher value-added estimates will be linked to their scores on the MKT fraction scale, their scores on the CVA, and their student gains on the fraction test to explore the relationship amongst them. Using regression models we will investigate whether and which teaching strategies and instructional elements are predictive of student learning (i.e., both in terms of value-added effect estimates and student gains on the project based fraction test). Teacher background variables will be added to the statistical models to investigate mediating and moderating effects on teaching practice. Finally, the reliability of teaching practice measures across multiple lessons will be investigated empirically.

Assessing Teachers' Pedagogical Design Capacity and Mathematics Curriculum Use (Collaborative Research - Kim)

Grant #	DRL-0918126
NSF Program	NSF
PI	Ok-Kyeong Kim
Co-PI(s)	
Institution	Western Michigan University
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	PreK
Target Audience	Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	An Assessment Tool and Construct of PDC

This research and development project is assessing the capacities (knowledge, abilities, ways of understanding, and acting) needed by elementary teachers for productive use of mathematics curriculum materials. The project is guided by the assumption that well-designed curriculum programs have the potential to contribute to improvement in mathematics learning opportunities in K-12 classrooms. Yet, minimal research has examined the kind of knowledge and capacities necessary for teachers to use these resources productively. The project team will undertake research to examine and identify these capacities (referred to as pedagogical design capacity or PDC) and develop tools to assess them. A key resource to be developed is a tool to assess elementary teachers' knowledge of mathematics embedded in the representations and tasks in curriculum materials (Curriculum Embedded Mathematics Assessment [CEMA]).

The project includes interrelated development and research activities. The development activities include developing the CEMA and developing and refining tools for gathering data on teachers' use of curriculum materials. The research activities involve employing these tools to gather and analyze data on teachers' curriculum use and the capacities critical to it for the purposes of both refining the tools and developing a conceptual model of PDC. These activities are organized into three stages of work. The Instrument Design stage involves designing the CEMA and developing and adapting other tools to collect data on teachers' curriculum use. The Instrument Pilot stage consists of a pilot study of teachers' use of five different curriculum programs using all project instruments in order to refine them and develop an initial model of PDC. The Instrument Implementation stage consists of the study of teachers' curriculum use using the refined instruments in order to develop a conceptual model of PDC to guide future research and professional development. To consider the role that particular curriculum features and resources play in influencing teachers' use of the materials, each of the five programs will be analyzed during the first stage.

Assessing Teachers' Pedagogical Design Capacity and Mathematics Curriculum Use (Collaborative Research - Remillard)

Grant #	0918141
NSF Program	NSF
PI	Janine Remillard
Co-PI(s)	Ok-Kyeong Kim
Institution	University of Pennsylvania
NSF Program Manager	VanderPutten
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Curriculum Embedded Mathematics Assessme

This research and development project is assessing the capacities (knowledge, abilities, ways of understanding, and acting) needed by elementary teachers for productive use of mathematics curriculum materials. The project is guided by the assumption that well-designed curriculum programs have the potential to contribute to improvement in mathematics learning opportunities in K-12 classrooms. Yet, minimal research has examined the kind of knowledge and capacities necessary for teachers to use these resources productively. The project team will undertake research to examine and identify these capacities (referred to as pedagogical design capacity or PDC) and develop tools to assess them. A key resource to be developed is a tool to assess elementary teachers' knowledge of mathematics embedded in the representations and tasks in curriculum materials (Curriculum Embedded Mathematics Assessment [CEMA]).

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Assessing the Educational, Career, and Social Impacts of the XO Laptop Program in Birmingham, AL City Schools (SGER)

Grant #	0819063
NSF Program	NSF
PI	Shelia Cotten
Co-PI(s)	Casey Borch, Scott Snyder, Betty Nelson, Michael Howell-Moroney
Institution	University of Alabama - Birmingham
NSF Program Manager	Kusum Singh
Grade Level Band	PreK
Target Audience	Students, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Five Presentations

The goal of this 24-month longitudinal multi-method, multi-disciplinary study is to assess the educational, career and social impacts of disseminating the XO laptop to minority elementary school students in Birmingham, Alabama, city schools. This project is the first of its kind to examine the XO laptop in a large sample of U.S. students.

The following objectives are being examined through a combination of individual interviews and surveys involving approximately 1,700 fourth- and fifth-grade students attending Birmingham City Alabama Public Schools:
1. Determine technology usage levels and types, and education and career intentions prior to the laptop dissemination.
2. Determine the impacts of the laptop dissemination on technology usage levels and types after the laptop dissemination. We can then examine trends in the levels and types of usage over time. Moreover, we will be able to better ascertain the causal relationship between laptop usage and variety of outcomes related to technology.
3. Determine if change in technology usage levels and types are related to education and career intentions.
4. Determine how technology usage affects social connections, belonging, personal expression, freedom, and accomplishment among students.

This study is led by a diverse research team representing sociology, education, and government. The outcomes from this project include a better understanding of (1) technology usage in impoverished communities prior to the laptop dissemination; (2) impacts of the XO dissemination on technology usage, education, and career intentions; and (3) whether such an intervention enhances perceptions of social connection, belonging, personal expression, freedom, and accomplishment among minority school students.

Findings will benefit educators and researchers in understanding whether and how XO laptops, which are highly cost effective, can be disseminated and utilized in school districts. This will be important for policy makers and educators as further efforts to decrease the multiple layers of the digital divide are undertaken to prepare students for a technologically sophisticated work world. This should also increase diversity and inclusive practices in computing professions, which may impact national competitiveness in STEM fields. Minority students will be able to learn about research activities. Findings will be disseminated broadly via presentations and publications, across sociology, education and STEM disciplines, to educators in the field, to governmental officials, and to residents of Birmingham, Alabama. Five presentations have occurred in the past year.

ASSISTments Meets Inquiry

Grant #	0733286
NSF Program	NSF
PI	Janice Gobert
Co-PI(s)	Neil Heffernan, Carolina Ruiz, Ryan Baker
Institution	Worcester Polytechnic Institute
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Science
Deliverables	Assessment Modules for Physical Science

Inquiry is highly regarded in our national standards and is critical to science reform, but when it comes to classroom practice, inquiry is typically substituted with rote learning of vocabulary, facts, and formulas, because inquiry is difficult to assess and because rote knowledge is what is prioritized on high-stakes tests. Inquiry skills, developed in rich scientific contexts, need to be assessed within the contexts in which they are embedded (Mislevy et al., 2002). The difficulty remains, however, as to how we will reliably measure inquiry skills, an important set of process skills used in science learning, and what measures we can provide teachers as indices about their students' inquiry skills. The Assistments Meets Inquiry (AMI) project intends to address this problem by developing a technology-based assessment system for Middle School Physical Science to be aligned with the Massachusetts Curricular Frameworks. We will do this by (1) leveraging from the existing authoring functionality in the ASSISTments project for Math (developed by Neil Heffernan & colleagues) in order to develop Science Assistments; (2) extending the logging functionality for this system in order to capture students' fine-grained actions with models as was done in the Modeling Across the Curriculum project (Gobert et al, 2006; Horwitz et al, 2007); (3) evaluating students' interactions with models using a framework for aggregating students' actions into domain-general inquiry skills (DoGIS); and (4) extending the existing reporting infrastructure to report students' inquiry skills to teachers for formative assessment so they can determine on which skills their students are performing poorly.

The current ASSISTment tutoring system for Math is particularly novel because while the system collects assessment data, the student receives intelligent tutoring support, and teachers are freed up because they are not required to use valuable instructional time to gather these assessment data. From the point of view of assessment, inquiry skills can be measured using fine-grained logging technologies. The presupposition to our development efforts is that by engaging students in deep inquiry with micro-worlds, and by reacting to their inquiry strategies in real time, we can tutor them on their inquiry strategies, thereby, positively affecting both their inquiry skills and, in turn, their content learning.

In terms of anticipated products, we will produce a sophisticated intelligent tutoring system capable of tutoring and assessing inquiry skills that will generate specialized teacher reports by class, by student, by inquiry skill, etc., as well as a full set of micro-worlds that will serve as assessment items for middle school physical science in six content areas.

The intellectual merit of the AMI project is that it combines state-of-the-art technology in intelligent tutoring systems with newly formulated ideas about how to measure skills and bootstrap these in the service of content learning. The broader impact is that this could significantly impact teachers' practices for inquiry and, in turn, students' science learning by teaching them "how to learn science"; these skills are important to the STEM disciplines and could impact scientific literacy and lifelong learning skills.

Astrobiology in the Secondary Classroom Project: An Interdisciplinary Curriculum Developed by a Collaboration of Scientists and Educators from Three Different Minority Communities.

Grant #	0733188
NSF Program	NSF
PI	Todd Gary
Co-PI(s)	Susan W Brown, Ruben M Ceballos, Gregory W Henry, Susan M Pfiffner
Institution	Tennessee State University
NSF Program Manager	Julia Clark
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science, Technology, Engineering
Deliverables	ASC Curriculum, ASC Learning Community

The goal of the Astrobiology in Secondary Classroom (ASC) curriculum development project is to establish a successful model for increasing the use of authentic scientific data to connect underrepresented high school students to the real world of science and scientists. The Web-based ASC modules are being developed by Tennessee State University in partnership with the Minority Institution Astrobiology Collaborative and the NASA Astrobiology Institute. The five initial curriculum implementation sites are in public schools or after-school programs in which 90% or more of the participants are African American, Hispanic, or Native American.

The six ASC modules are organized around fundamental questions in the field of astrobiology: How does life begin and evolve? Does life exist elsewhere in the universe? What is the future of life on earth and beyond? What are the ethics of visiting other planets and returning samples to Earth? The Web site (http://www.astroclassroom.org/) contains resources for students, classroom teachers, and informal educators. Students can view engaging multi-media resources with links to current scientific discoveries and authentic scientific datasets. Downloadable lesson guides and short video demonstrations will feature hands on activities with materials, equipment, learning technologies, and explanations of scientific concepts for teachers. Formal and informal educators can select appropriate instructional sequences for their settings and state performance standards.

During the first two years of the project, pilot classroom trials were established in three school systems: Miami-Dade County Public School System in Florida; Las Cruces Public Schools in New Mexico; and Chinle Unified School District No. 24 in the Navajo Nation in Arizona. An after-school enrichment program at Tennessee State University in Nashville, Tenn., was also used to pilot the ASC curriculum. The third year will provide support to the sites above, adding two additional sites in communities in Montana and South Carolina. Three of the locations in this project are NASA-funded Science, Engineering, Mathematics, and Aerospace Academy (SEMAA) programs. A long-term goal is to scale up the ASC project for implementation by SEMAA sites across the country as well as to incorporate ASC materials into other NASA enrichment outreach programs for secondary students.

The focus of ASC is to address the unique learning issues present in diverse classrooms in both formal and informal educational settings. ASC modules incorporate research-based teaching strategies that diminish achievement gaps and increase participation of underrepresented groups in science, technology, engineering, and mathematics. Evaluation of the ASC curriculum includes Web-based collaboration among teachers, scientists, and curriculum developers to enhance the modules. Progress has been made during years one and two in all of the goals for the ASC curriculum project, and evidence to support this progress will be described in the poster presented at the 2009 PI meeting.

AutoMentor: Virtual Mentoring and Assessment in Computer Games for STEM Learning

Grant #	0918409
NSF Program	NSF
PI	David Shaffer
Co-PI(s)	Arthur Graesser
Institution	University of Wisconsin
NSF Program Manager	Michael Haney
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	

This project will develop a system for producing automated professional mentoring while students play computer games based on STEM professions. The automated AutoMentor is regarded as a critical piece of technological infrastructure for a new, more motivating and more inclusive approach to STEM education a decade or more in the future. The project explores a specific hypothesis about STEM mentoring: A sociocultural model as the basis of an automated tutoring system can provide a computational model of participation in a community of practice, which will produce effective professional feedback from nonplayer-characters in a STEM learning game.

The project adds two important NSF-funded components to prior work on NSF-funded STEM computer games. First, the AutoMentor mentoring technology builds on previous research on automated tutoring systems. Specifically, AutoTutor is a computer tutor that helps students learn about science and technology topics by holding a conversation in natural language with the learner. Second, Evidence Centered Assessment Design incorporates an Epistemic Network Analysis, a methodology developed to assess students' ability to think and act like STEM professionals through game play.

The project will use a Wizard of Oz methodology in which data will be collected about player/mentor interactions over multiple instances of game play. The resulting database is used to develop and validate a system for automatically coding interactions. The coded database will then be used to generate automated responses to player actions in the game, and the resulting system will be tested to see whether players' STEM learning with automated mentoring are comparable to outcomes with live mentors.

The project team includes leading researchers in intelligent tutoring systems (Graesser), assessment (Mislevy), and game-based learning (Shaffer). The team also includes a computer scientist (Gleicher), a STEM content expert (Asligul Gocmen), a measurement expert (Andre A. Rupp) and a collaborating institution with expertise in STEM educational programming (Massachusetts Audubon Society). The combination of these areas of expertise has the potential to transform work in each of the core areas of the proposal: intelligent tutoring, assessment, and game-based learning. The development of a computational model of participation in a community of practice will provide an important link between traditional cognitive science and situated views of learning. It will also potentially contribute to research in artificial intelligence and intelligent agents.

The project enhances the infrastructure for joint research by forming a collaborative partnership among three research institutions (the University of Wisconsin-Madison, the University of Maryland, and the University of Memphis) and an educational delivery organization (The Massachusetts Audubon Society). Results will be disseminated through scientific papers and conferences, but also through the work of the Massachusetts Audubon Society. The game incorporating AutoMentor will be available for use by schools and nonprofit organizations.

Beyond Penguins and Polar Bears: Integrating Literacy and IPY in the K-5 Classroom

Grant #	0733024
NSF Program	NSF
PI	Kimberly Lightle
Co-PI(s)	Carol Landis, Carl Lagoze, Susan VanGundy
Institution	Ohio State University Research Foundation
NSF Program Manager	David Campbell
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Website: http://beyondpenguins.nsdl.org/

Blockbuster movies and even soft drink commercials have made our planet's polar regions and their inhabitants popular-culture superstars. At the same time, many people have either been confronted with what they believe to be climate change weather events or find themselves wondering about how melting polar ice sheets and rising ocean temperatures might affect their lives in the future. Despite this onslaught of data, scientific discovery, drama, and speculation, misconceptions about the polar regions and their importance abound.

Beyond Penguins and Polar Bears, an online professional development magazine for elementary teachers, focuses on preparing teachers to teach polar science concepts in an already congested curriculum by integrating inquiry-based science with literacy teaching. Such an integrated approach can increase students' science knowledge, academic language, reading comprehension, and written and oral discourse abilities.

Launched in March 2008, the magazine is published monthly. Each thematic issue relates elementary science topics and concepts to the real-world context of the polar regions and includes standards-based science and content-rich literacy learning across five departments (In the Field: Scientists at Work, Professional Learning, Science and Literacy, Across the Curriculum, and Polar News and Notes). The magazine has covered many common earth and space science topics (geography, seasons, rocks, minerals and fossils, the water cycle, energy, erosion) and is now turning to plants, animals, and other life science topics. The indigenous peoples of the Arctic, climate change, and polar research and explorers will round out the 20 planned issues.

In addition to highlighting and contextualizing existing digital resources such as science and literacy lesson plans, the magazine also includes multimedia such as images, video clips, and podcasts. A monthly column, Feature Story, provides a nonfiction article written for students and available at three grade levels as text, printable books, and electronic books with narration. The Virtual Bookshelf, written by a children's librarian, recommends quality children's literature to complement and extend the science activities. A regular column details commonly held misconceptions and provides assessment tools for classroom use. Additional functionalities include a change language feature and browsable photo gallery.

A companion blog is used to report on polar news and research and professional development opportunities. Additionally, blog posts feature multimedia content and direct viewers to new articles and features of the magazine. Viewers can use the RSS feed or Feedburner subscriptions to automatically receive new blog posts, including a monthly announcement of the magazine's latest issue. In a time of observable and measurable climate change, it is vitally important to understand the science of the polar regions. Beyond Penguins and Polar Bears helps teachers go beyond a superficial understanding to foster deep, meaningful scientific understanding at a critical time: both in their students' development and the planet's wellbeing. Project partners include Ohio State University College of Education and Human Ecology, School of Teaching and Learning; Byrd Polar Research Center; The Columbus Center for Science and Industry (COSI); the Upper Arlington Public Library; and the National Science Digital Library (NSDL).

Biocomplexity and the Habitable Planet -- An Innovative Capstone Course for High School (Collaborative Research - Berkowitz)

Grant #	0628189
NSF Program	IMD
PI	Alan Berkowitz
Co-PI(s)	Steward T. A. Pickett
Institution	Cary Institute of Ecosystem Studies
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Curriculum and Supporting Materials

TERC and the Cary Institute of Ecosystem Studies are designing an elective capstone course that incorporates cutting-edge research on biocomplexity and coupled nonhuman-human systems. The inquiry-based curriculum engages students of all abilities in a case-based approach to land-use decisions. The first module presents a land-use decision at an urban high school, coupled with a conservation decision related to the affects of climate change in the Arctic. The second module presents a land-use decision regarding the suburban/agricultural interface in the United States coupled with a conservation decision in Amazonia related to agricultural use. Students progress from describing and representing relationships among components in systems qualitatively to quantifying these, and finally to using models predictively. They use models to predict the outcomes of their land-use and conservation decisions, which in turn help them refine their arguments in support of their chosen case solutions.

The first module was piloted in spring 2008 in two urban and one rural high school classrooms that included a range of sophomores, juniors, and seniors. Using examples of student work, we present qualitative data showing how students (1) engage with, understand, and model complexity, and (2) construct arguments for their case solutions. Both modules are currently being piloted in a mix of 24 urban, suburban, and rural classrooms.

Biocomplexity and the Habitable Planet -- An Innovative Capstone Course for High School (Collaborative Research - Puttick)

Grant #	0628171
NSF Program	IMD
PI	Gillian Puttick
Co-PI(s)	Brian Drayton (TERC) & Alan Berkowitz (IES)
Institution	TERC and Institute of Ecosystem Studies
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Instructional Materials, Web Site

Biocomplexity and the Habitable Planet is an innovative 11th-12th grade capstone course in Ecosystem/Environmental Science under development at TERC, in partnership with the Institute of Ecosystem Studies in Millbrook NY.

The curriculum consists of two semester-long modules that can be taught together as a unified curriculum in a full-year course or individually as a semester-long course. The first module focuses on urban ecology, climate change and biodiversity. The second module focuses on suburban sprawl, regional-landscape ecology, and agriculture. Both modules engage students in the science of “coupled natural and human” systems

Students conduct local field- and lab-based investigations, and, working with datasets and GIS images from urban, arctic, suburban and Amazonian ecosystems, construct models that facilitate understanding of complexity and support projections about dynamics in CNH systems. Each module encourages students to build evidence-based arguments that support decisions about land or other resource use.

Student materials and teacher guides will be text-based, supported by CD and Web materials.

In addition, the project engages in research on students’ understanding of models and their use in science inquiry. Findings will contribute to the choice of which curricular design and instructional methods best support students to develop representational competence and model-based reasoning about complex systems.

Bioinformatics: Learning by Doing

Grant #	0733255
NSF Program	NSF
PI	Andrew Vershon
Co-PI(s)	William Sofer
Institution	Rutgers University New Brunswick/ Waksman Institute
NSF Program Manager	Julia Clark
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	DNA Sequence Analysis Program

Bioinformatics: Learning by Doing is an NSF-funded, full-scale project that is developing state-of-the-art Web-based tools and resources for use in high school settings. As a result of using these instruments, students are able to make real contributions to the scientific knowledge base by conducting authentic research in bioinformatics and publishing their findings in GenBank, a national repository that carries all of the DNA sequence data in the world.

The major software product of this project is DSAP: the DNA Sequence Analysis Program, an online, multifaceted, interactive, learning and teaching tool that incorporates embedded assessments. DSAP guides instruction and will provide users with feedback about their understanding of molecular biology and bioinformatics. Users of DSAP become knowledgeable about the emerging field of bioinformatics, which draws upon mathematics, biology, computer science, and molecular biology—the foundation of the biological sciences. DSAP tools and resources are Web-based and, therefore, almost all public schools or libraries will be able to provide access to the program. Thus, regardless of socioeconomic background and/or geographic location, all students will be able to participate in original research and contribute to scientific investigations by using DSAP.

The DSAP tool is made up of the following five components: (1) a student DNA sequence analysis scaffolding program; (2) an administrative program so that teachers can view student work and communicate with their students; (3) a staff administrative program that allows observation of student and teacher work; (4) an embedded assessment tool; and (5) a series of tutorials and “help modules” to guide students through their DNA sequence analysis.

During the second year of the grant, scientists from the Waksman Institute, Rutgers University, continued working with educational evaluators at WestEd (a nonprofit educational research, development, and service agency) and computer programmers to develop and refine the DSAP core. DSAP was launched in January 2009 and over 450 students from 27 schools have logged on and used the program to analyze 918 DNA sequences. Comments from students, teachers, and the program evaluators were used to direct modifications and enhancements in the program. These include incorporating into DSAP four different DNA sequences (known as Practice Clones or PCs) that all students must complete before working on the unique DNA sequences that they isolate in the laboratory. PCs are pre-screened by the project faculty to exemplify the types of challenges that may be encountered when DNA sequence data is analyzed. Prior to and immediately following their work on the PCs, students complete an online, pre- and post-survey assessment that is linked to DSAP.

A second major iteration of DSAP will be released for field testing in mid-fall 2009. In addition to examining the pre- and post-survey data and students' responses to the DSAP, revisions, expansion, and further development of ancillary resources for the program are planned for next year.

BSCS Science: An Inquiry Approach -- A Phase II Proposal

Grant #	0242596
NSF Program	IMD
PI	Pamela Van Scotter
Co-PI(s)	Janet Carlson Powell
Institution	Biological Sciences Curriculum Study (BSCS)
NSF Program Manager	Gerhard Salinger
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Instructional Materials

BSCS is developing a three-year science program for grades 9, 10, and 11. This program presents the core concepts in physical science, life science, earth-space science, and inquiry as articulated in the National Science Education Standards (NRC, 1996). In addition, the program engages students in integration across the disciplines in relevant, social contexts to address other standards. This program provides high school students and teachers nationwide with a coherent alternative to the traditional sequence of biology, chemistry, and physics.

This BSCS program is a response to needs expressed by teachers, and school districts:
- Teachers seek a coherent alternative to the discipline-based sequence.
- Teachers see a multidisciplinary science program as a way to help students meet state standards and help students prepare for tests related to those standards.
- Science that integrates across the disciplines engages a greater diversity of learners.
- Science that integrates across the disciplines reflects the unity of the natural world.

The key features of BSCS Science: An Inquiry Approach include the following:
- Rigorous, standards-based content
- Activity-centered lessons
- Opportunities for structured and open inquiry in relevant contexts
- A constructivist, student-centered approach
- The BSCS 5E instructional model
- A collaborative learning environment
- Assessment that aligns with instruction
- The use of student science notebooks

The program consists of six modules at each grade level:
1. A two-week science-as-inquiry unit
2. An eight-week physical science core
3. An eight-week life science core
4. An eight-week earth-space science core
5. An eight-week integrated unit
6. A full-inquiry that begins mid-year

Each core unit includes three chapters that expose students to fundamental concepts in each discipline. The fourth chapter in each unit allows students to apply what they have learned in an integrated context. This approach builds a foundation of knowledge across time and provides a compelling context for learning—an approach supported by recent research in learning (Bransford, J. Brown, A. & Cocking, R., 2000; Pellegrino, J. Chudowsky, N. & Glaser, R., 2001).

Building BLOCKS for Science--What Young Children Should Know and Be Able to Do When They Enter Kindergarten

Grant #	0821988
NSF Program	NSF
PI	James Barufaldi
Co-PI(s)	Mary Hobbs
Institution	University of Texas at Austin
NSF Program Manager	Julia Clark
Grade Level Band	PreK
Target Audience	Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science
Deliverables	Assessments for Pre-K Science

Building BLOCKS for Science integrates research and applied education to take intimate looks inside pre-kindergarten classrooms in order to assess young learners' knowledge and skills and test strategies for teaching core science concepts to young learners. The project, conducted in a variety of pre-kindergarten settings, involves teachers from multiple backgrounds, with an emphasis on including classrooms where students are culturally and economically diverse. The mixed-methods research includes data collection via case studies and technology-based assessment techniques. To conduct this research, the Center for Science and Mathematics Education at the University of Texas in Austin will, over four years, develop and test protocols, rubrics, and formative assessment strategies intended to address what STEM content and concepts are most appropriate and what science knowledge and skills are reasonable to expect of children entering kindergarten.

Utilizing a robust research community of science and early childhood educators, science content specialists, researchers, and classroom teachers, the project will conduct four years of intense classroom observation and data collection in 50 pre-kindergarten classrooms with the intent of probing for answers to the following questions:

- What should children know and be able to do when they enter kindergarten?
- What core STEM ideas should be stressed in pre-kindergarten/kindergarten science learning activities?
- What professional development practices best support the teaching of complex STEM concepts and processes to young learners?

Building BLOCKS for Science takes a proactive view of STEM teaching and learning by evaluating the knowledge base on what constitutes appropriate science instruction for young children, an area where little research has been attempted. The project offers a unique opportunity to investigate the boundary between pre-K and K-2 science understanding and build a foundation for subsequent knowledge and skills acquisition.

Information, models, and other outcomes of Building BLOCKS for Science are expected to generate additional research and provide a basis for future curriculum planning, assessment, and revisions of standards (guidelines) for pre-kindergarten science.

Calipers II: Using Simulations to Assess Complex Science Learning

Grant #	0733345
NSF Program	NSF
PI	Edys Quellmalz
Co-PI(s)	Mike Timms
Institution	WestEd
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Simulation-based Science Assessments

Calipers II: Using Simulations to Assess Complex Science Learning is a five-year assessment project funded by the DR-K12 program at the National Science Foundation. The goals of the Calipers II project are to (1) develop formative and benchmark simulation-based assessments of science knowledge for key content in physical, life, and earth science and for science inquiry strategies; (2) enhance formative assessment simulation modules with immediate, individualized feedback, reflection activities, and supplementary instruction; (3) develop and document technology-based assessment designs and exemplars that take advantage of simulation environments to provide assessments of science standards for formative and summative purposes; (4) document the technical infrastructure and reusable designs and processes employed; (5) provide evidence of the technical quality, feasibility, and usability of the new assessments; and (6) study the influence of formative assessments on complex science and inquiry learning.

Capacity Building Conference Series: Supporting an Emerging Community of Science Education Researchers

Grant #	0711264
NSF Program	NSF
PI	John Settlage
Co-PI(s)	Adam Johnston
Institution	University of Connecticut
NSF Program Manager	Sharon Lynch
Grade Level Band	Post Secondary
Target Audience	Inservice, Higher Education, Policy Makers
STEM Content Area	Science
Deliverables	Website: http://www.sciedxroads.org

The purpose of this project was to provide a forum to support and extend the work of science education stakeholders. We call our initiative Science Education at the Crossroads as an indication of the urgency of science education reform. Central to our project has been supporting young scholars to develop as professionals. This has necessitated the presence of senior scholars, classroom teachers, and policy to provide the necessary range of expertise. Unlike other professional organization's meetings, the expressed purpose of this project was to return the "confer" to conference. In particular, the goal of this project was to develop a professional development approach that was generative and supportive of individual efforts to enhance science education research.

Two structural features of Crossroads shape the discussions. First, each attendee must prepare a two-page Vexation and Venture in which they identify a challenge within science education that is impinging upon their work and then describe an undertaking they are preparing to make that will address the problem. These essays are submitted as proposals, and those that are accepted receive critical feedback to be incorporated in a revision. All Vexations and Ventures are bound as a Proceedings that is mailed to attendees in advance of the conference. The second structural feature that distinguishes Crossroads is the presentation format. Incubators are scheduled with two presenters within 75-minute sessions. A facilitator is on hand to keep the group on a schedule that proceeds as follows:

- 10 minutes for presenter to verbally describe the V&V
- 5 minutes of clarifying questions from the audience
- 15 minutes of discussion with presenter maintaining silence
- 5 minutes of reply and reaction by the presenter

The response by participants to the project has been uniformly positive. While clearly not a substitute for more formal venues for disseminating research (e.g., NARST or AERA), especially for the targeted population of emerging scholars in science education, Crossroads provides a form of professional support that is timely and valuable. By virtue of the participants' interests and commitments, issues of educational equity have emerged as the most common theme. More specific information about the project is available at http://sciedxroads.org

Cases of Reasoning and Proving in Secondary Mathematics (CORP)

Grant #	0732798
NSF Program	NSF
PI	Margaret Smith
Co-PI(s)	Fran Arbaugh
Institution	University of Pittsburgh
NSF Program Manager	Jim Fey
Grade Level Band	High School
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Professional Development Materials

The purpose of this project is to develop a practice-based curriculum for the professional education of preservice and practicing secondary mathematics teachers that (1) focuses on reasoning and proving; (2) has narrative cases as a central component; and (3) supports the development of knowledge of mathematics needed for teaching. The CORP (Cases of Reasoning and Proving in Secondary Mathematics) curriculum will comprise eight constellations of activities that focus on key aspects of reasoning and proving, such as identifying patterns (i.e., looking for a relationship that fits a given set of data); making conjectures (i.e., stating a hypothesis that is subject to testing); providing proofs (i.e., making an argument from accepted truths for or against a mathematical statement); and providing non-proof arguments (i.e., making an empirical or rationale argument) (Stylianides, 2005; Stylianides & Silver, 2004). A constellation is defined as a set of practice-based activities anchored by a mathematical task or set of related tasks. Each constellation will provide opportunities for teachers to develop aspects of knowledge needed for teaching the processes of reasoning and proving through the exploration of mathematical tasks, the analysis of student work samples, and the analysis of a narrative case. In addition, each constellation will include a set of facilitation materials that will provide general suggestions for using the tasks, student work samples, and narrative cases in a range of teacher education settings.

The intellectual merit of the proposed CORP project lies in the creation of new materials for use in a range of professional education settings that have the potential to help teachers develop critical aspects of knowledge needed for teaching. Specifically, through the creation of the professional development materials, the CORP project will identify a body of core mathematical content that mathematics teachers need in order to possess a deep and integrated knowledge base for teaching reasoning and proof. The CORP project will also create a model of teacher education based on well-respected research and theories of effective mathematics teaching and learning and of effective professional development for mathematics teachers. In addition, the evaluation will produce empirical evidence regarding the viability of the approach, including impact on teachers' instructional practices.

The CORP project has the potential to have a broad impact on mathematics education by (1) creating a set of curricular materials for the professional education of secondary mathematics teachers that will be commercially available to all stakeholders and be useful in a range of settings; (2) creating facilitation materials that will support the use of curriculum by facilitators with varying levels of experience; and (3) providing empirical evidence regarding what teachers learn from their experiences with the CORP curriculum and how these experiences influence their practices. Hence, the CORP materials will serve as a model for a practice-based curriculum for the professional education of secondary mathematics that focuses of developing mathematics knowledge needed for teaching.

CENSNet: An Architecture for Authentic Web-based Science Inquiry in Middle and High School

Grant #	0352572
NSF Program	IMD
PI	William Sandoval
Co-PI(s)	Christine Borgman
Institution	Graduate School of Education & Information Studies, UCLA
NSF Program Manager	Michael Haney
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Website: http://censei.gseis.ucla.edu

CENSEI is a Web-based architecture that provides middle school students and teachers access to live scientific data from the Center for Embedded Networked Sensing (CENS, an NSF STC funded in 2002) and curriculum modules built around sensor networks that target core life science content and inquiry standards. The intellectual merit of the project lies in students' ability to pursue meaningful questions by tasking the same networked sensing systems and exploring the same data that scientists use, and in the development and evaluation of a model for fading technological and pedagogical scaffolds for inquiry as students gain competence. The broad impact of the work comes from the deliberate choice to develop and field test materials with teachers from ethnically diverse urban schools, which are typically underserved by technological innovation, and by making empirically tested inquiry materials available nationally.

CENSEI will develop a Web-based portal architecture comprising a sequence of inquiry modules in ecology built around a CENS ecosystem monitoring network. The sequence progresses systematically from more- to less-structured modules that guide students to take increasing responsibility for their own inquiry. The primary objective of the project is to document students' increasing competence in conducting inquiry; evidence for this goal will include improvement in scientific argumentation, data collection strategies, and question posing. A second core objective is that the guided and open modules produce demonstrable learning gains in national content standards for middle school life science in comparison to more typical instructional methods. Secondary objectives include improving students' attitudes toward science, their engagement in science courses, and their beliefs about the nature of science. Teacher support materials and resources will be developed through close collaborative study of field-test teachers, and will be provided online as materials are disseminated. Measurable teacher outcomes include module evaluations, perceptions of ease of use, quality of support, impact on student learning and engagement, and teachers' own science knowledge.

Materials will be developed by a team that includes learning scientists, information scientists, teachers, biologists, and software developers. Anticipated products include Web-based curriculum materials, assessments, and teacher resources and services to task CENS networks, archive student work, and track student learning and teacher change. Research outcomes include a model for fading inquiry supports, assessments of inquiry competence grounded in the domain of ecology, documentation of processes of teacher adaptation of innovation, and improved standards of metadata description of online educational learning objects. Results will be disseminated as broadly as possible to research audiences in education and information sciences, and to educational practitioners, policy makers, and stakeholders.

Change Associated with Readiness, Education and Efficacy in Reform Science (CAREERS)

Grant #	0455685
NSF Program	TPC
PI	Betty Young
Co-PI(s)	Paul Bueno deMesquita, Barbara Nowicki, Minsuk Shim, Barbara Sullivan Watts
Institution	University of Rhode Island
NSF Program Manager	Joan Prival
Grade Level Band	PreK
Target Audience	Higher Education
STEM Content Area	Science
Deliverables	Research & Practitioner Articles, Survey

The CAREERS research project is advancing the knowledge base on preparation and induction of elementary science teachers by examining teacher learning and the effects of professional development at the preservice level over time. A team that includes science educators, district-based scholar-practitioners and teachers, psychologists, and research scientists collaborate to conduct and disseminate important findings for academic and school-based audiences.

The goals of CAREERS are to provide a longitudinal study of teacher skills and dispositions over three critical transition periods along the teacher professional continuum from preservice methods through student teaching and into induction years; import constructs (e.g., efficacy and models of behavior change) from the field of psychology and adult education (e.g., transfer of training) to study the changes in teacher attitudes, dispositions, and practice following experiences with inquiry pedagogy; determine the optimal combination of experiences and support (both materials and mentoring) that lead to highly qualified elementary science teachers; and develop a partnership between researchers and practitioners to conduct useful research that will have an impact on school practice in science as well as making a significant contribution to the research literature.

Research Questions

Elementary preservice teachers: science methods through student teaching and induction years:
- How do beliefs about science teaching and self-efficacy for teaching science change over time from the elementary science methods course to student teaching?
- How are multiple factors (i.e., content knowledge, beliefs, readiness to change, self-efficacy, and cooperating teacher/university faculty modeling) related to the quality of practice in teaching inquiry-based science lessons in elementary classrooms at various points along the teacher professional continuum?

Cooperating teachers who supervise student teachers:
- How are multiple factors of cooperating teachers (i.e., content knowledge, beliefs, readiness to change, and science teaching efficacy beliefs) related to the quality of practice in teaching inquiry-based science lessons in elementary classrooms?
- How are the characteristics of cooperating teachers' practice in science teaching associated with student teacher performance?

Sample & Data Collection:

Data will be collected from several groups:
- 500 practicing K-6 teachers (survey of beliefs, readiness to use inquiry practices in science, efficacy in teaching science)
- 60 elementary preservice teachers, 30 per cohort (science content knowledge, survey of beliefs, readiness to change-TISS, efficacy in teaching science, science lesson observation/video, interviews)
- 60 elementary cooperating teachers, 30 per cohort matched to preservice sample (same data as above)
- 30 elementary teacher education graduates, 15 per cohort, during induction years (same data as above)

Implications & Dissemination:

CAREERS will provide key information concerning the preservice instruction and district support that is needed to develop highly qualified elementary teachers of science. The results are presented to academic and practitioner audiences. The interdisciplinary nature of the research team invites the dissemination of findings in several fields: teacher education (preservice and in-service), science education, adult education, and psychology.

Change Thinking for Global Science: Fostering and Evaluating Inquiry Thinking About the Ecological Impacts of Climate Change

Grant #	0918590
NSF Program	NSF
PI	Nancy Songer
Co-PI(s)	Phil Myers, Jim Beach
Institution	University of Michigan
NSF Program Manager	Dave Campbell
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Learning Progression, Simulations, Curriculum

This work will develop learning progression-driven visualization technologies, curriculum units, and assessments towards realizing empirical evidence about middle and high school students' complex thinking about ecological impacts of global climate change. During the lifetimes of our current middle and high school students, it is likely that our planet will undergo more anthropogenic change than it has during all of human history to date. With a national interest in complex thinking for globally competitiveness, a sense of urgency exists to build a solid, research-based foundation about a new, interdisciplinary focus area within pre-college science education—students' complex reasoning about the impact of global changes on ecosystem dynamics. Recognizing the need for systematic development of resources, Change Thinking for Global Science will build from existing resources and utilize a learning progression approach for the systematic design of coordinated curriculum, tool, and assessment products. Quasi-experimental research studies on matched and consecutive cohorts will be conducted to document learning outcomes and trajectories. Cross-sectional investigations will be used to determine information on the effectiveness of curriculum programs on student achievement. Growth-curve analysis will be used to descriptively examine students' complex reasoning growth trajectories throughout curriculum programs.

This work will provide dynamic, age-appropriate visualization and modeling tools, associated curriculum units and assessment instruments to serve as foundational, empirically based information on teaching and learning about the impacts of global climate change. This work will also provide an empirical and theoretical basis for content and inquiry reasoning progressions that articulate critical concept development in science and that explain how learning development is consistent with theories of learning. Data from middle and high school students coordinated with longitudinal data from students in grades 4–6 will provide information on student growth trajectories and achievement outcomes that will contribute to an understanding of possible learning progressions-driven outcomes over multiple units and years. Research results will also provide insights into the character and dynamics of learning trajectories and the challenges that occur as content and reasoning knowledge develops.

As a coherent research program contributing empirical data to explain knowledge development in a new and emerging discipline of science, Change Thinking for Global Science provides broad insights on how to make essential science concepts accessible to middle and high school students, and how to guide a new generation of scientists and citizens to be fluent in understanding change in complex, biological systems. Populations include high-poverty urban, rural, and small city schools to gather evidence to address pockets of underperformance and to provide empirical information to be used as a model and a case of how to address issues of deep learning with various subpopulations of American science students. Mentoring of postdoctoral scholars, graduate students, and teachers will be an integral part of our work. Outcomes include substantial empirical data, curriculum and assessment products, models of effectiveness, and characterization of challenges and obstacles that are of value to teachers, students, scientists, science educators, and policy makers.

Chemistry Education Research Doctoral Scholars Program

Grant #	0733642
NSF Program	NSF
PI	Stacey Lowery Bretz
Co-PI(s)	
Institution	Miami University
NSF Program Manager	Sharon Lynch/Michael Haney
Grade Level Band	High School, Post Secondary
Target Audience	Students, Higher Education
STEM Content Area	Science
Deliverables	Website: http://www.users.muohio.edu/bretzsl

The chemistry education research (CER) Doctoral Fellows Program at Miami University provides a targeted response to the critical need for scholars with deep content knowledge in chemistry and the specialized training to conduct CER. The CER Doctoral Fellows Program prepares Ph.D. scholars whose research studies examine the underlying processes of teaching and learning in both chemistry classrooms and laboratories. Research by the Fellows cohort marries expertise in the design of concept inventories with the extensive literature on chemistry misconceptions, resulting in the development of reliable and valid measures of student learning for use by both chemistry teachers and chemistry education researchers.

Five CER Fellows have successfully completed their first year, taking graduate courses in chemistry, chemistry misconceptions, and statistics. Fellows initiated both their cognate research projects and their dissertation research; they successfully defended their research proposals at their first year conferences. The Fellows also attended the spring American Chemical Society (ACS) national meeting and the Gordon Research Conference on Chemistry Education Research and Practice, and hosted Science Week at Miami for 1,100 elementary school children.

In June 2009, we hosted the first of two planned CER Graduate Student Conferences for 40 students, each of whom presented a poster on their research. The conference featured plenary sessions and workshops to provide intense professional mentoring into the NSF as a funding agency, the Journal of Chemical Education as a peer-reviewed journal, and the ACS Examinations Institute as a national assessment initiative.

The project evaluators (Dr. Jennifer Lewis and Dr. Maralee Mayberry, both of University of South Florida) conducted a site visit in September 2008 and again during the CER graduate student conference in June 2009. At the conference, the evaluators interviewed CER Fellows and their non-cohort peers from across the country, in addition to administering a survey to all participants regarding the construct of Researcher Identity. The external evaluation indicates the project has met or exceeded the planned project goals to date.

Chemistry Facets: Formative Assessment to Improve Student Understanding in Chemistry

Grant #	0733169
NSF Program	NSF
PI	Angela DeBarger
Co-PI(s)	Carlos Ayala, Jim Minstrell
Institution	SRI International
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Facet Clusters, Diagnostic Assessments

The ChemFacets project brings together experts in assessment, science education, chemistry teaching, and chemistry content to develop a Web-based system to support teachers' use of formative assessment to promote conceptual change in chemistry. The goals of the project are to (1) identify and develop clusters of facets (student ideas and understandings) related to key high school chemistry concepts; (2) develop assessment items that diagnose facets within each cluster; (3) enhance the existing Web-based Diagnoser assessment system for administering items, reporting results, and providing teacher resources for interpreting and using the assessment data; (4) develop teacher professional development and resource materials to support their use of facet-based approaches in chemistry; and (5) examine whether student learning and motivation to learn in chemistry improves for students in chemistry classes that incorporate a facet-based assessment system.

The facet-based approach to chemistry instruction links standards, curricula, and research in a meaningful way for teachers and students and, as a result, will support teachers in understanding their students' conceptual strengths and weaknesses. The assessments will be available for free to teachers and students via a Web-based assessment tool, Diagnoser, thus facilitating the dissemination of these important chemistry assessments and learning resources. Diagnoser will auto-score items and link student performance on items to preconceptions and goal understandings. Diagnoser also will incorporate the teacher resources with lessons to address preconceptions. As a result, teachers should be better equipped to tailor their teaching to support students' learning in chemistry, and students can monitor their own understanding.

Anticipated sets of products include (1) 16-20 facet clusters and up to 20 validated items per cluster; (2) teacher resources including elicitation questions and classroom activities related to each cluster, and a framework for professional development; and (3) a Web-based Diagnoser for chemistry, including student assessments and teacher resource materials.

The evaluation plan consists of three components: (1) a small-scale experimental study to examine the efficacy of the use of Diagnoser with Washington and California high school chemistry students and teachers; (2) an Advisory Board to monitor and assess the work; and (3) an external evaluator who will assess the facet and item development, as well as factors affecting implementation. Multiple forms of evidence will be used to demonstrate achievement of the project goals. Facet clusters will be validated with internal and external expert reviews and teacher and student interviews. Assessment items will be validated in multiple ways: science assessment expert alignments of items with standards, facet clusters, and established measures of chemistry knowledge; confirmatory factor analyses; and think-alouds with students.

Coherent Implementation of Mathematics Instructional Materials: A Study of the Variations and Effects of District Supports for Implementation

Grant #	0918109
NSF Program	NSF
PI	June Mark
Co-PI(s)	Deborah Spencer
Institution	Education Development Center, Inc.
NSF Program Manager	Sharon J. Lynch
Grade Level Band	PreK
Target Audience	Administrators, Policy Makers, Other
STEM Content Area	Mathematics
Deliverables	Conference Presentations, Research Papers

The Coherent Implementation of Mathematics Instructional Materials project is a four-year, longitudinal, mixed-methods study of 10-12 school districts' implementation of elementary mathematics instructional materials. We will study the relationships among the district level of coherence of implementation, the school level of support for implementation, the school level of use of materials, and the effects on student outcomes. This project builds directly on our earlier work in the NSF-funded K-12 Mathematics Curriculum Center, which found greater centralized decision making regarding instructional materials at the district level, and variation in the supports districts provided for the implementation of mathematics instructional materials.

These central questions will focus the research:
- What are the dimensions of district-level coherence of implementation of instructional materials?
- What are the dimensions of school-level support for implementation of instructional materials?
- How does district-level coherence relate to changes in school-level student mathematics scores, at a single point in time and over time?
- Does school-level support for implementation and/or school-level use mediate the relationship between district-level coherence and student outcomes?

Data will be gathered through interviews and surveys of district and school staff, and elementary teachers in 10 -12 districts. Participation will be limited to those districts that have adopted Everyday Mathematics or Investigations in Number, Data and Space.

The results of this study will assist district and school administrators and policy makers in planning effective implementation of mathematics instructional materials. This project will also contribute to the work of STEM education researchers by clarifying the dimensions of coherent implementation and offering ways to operationalize and measure these dimensions. Disseminations will include collaborations with colleagues involved in related research, submission of articles to peer-reviewed journals, and conference presentations.

Collaborative Learning with Classroom Networks: Integrating Technological and Pedagogical Innovations

Grant #	0747536
NSF Program	NSF
PI	Tobin White
Co-PI(s)	
Institution	UC Davis
NSF Program Manager	James Fey
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Mathematics
Deliverables	Lessons & Activities, Research Papers

Computer technologies have long been the subjects of dual and competing narratives in educational discourse. Proponents praise their revolutionary potential for transforming student learning, for infusing curricula with authentic connections to real-world content, and for expanding the classroom through the new social and informational linkages provided by network tools and infrastructure. At the same time, too many reports point to the failure of promising new technologies to significantly affect student learning or instructional practice, or even to achieve widespread use, because their arrival in classrooms fails to be accompanied by well-articulated or fully elaborated models of their integration into and transformation of classroom practice. This project seeks to build on that potential while avoiding those shortcomings by integrating the design and investigation of novel learning tools with efforts to deeply situate the promise of those tools in the daily practices of teachers. To accomplish this dual focus on learning and teaching, this research will blend two approaches. The first involves a series of design experiments in which new technology designs provide a context for exploring student learning through collaborative problem-solving activities and investigations. The second involves alternating between two different settings for conducting four successive year-long cycles of those design experiments: a set of high school algebra classrooms taught by teachers who serve as collaborative partners in the design and implementation of new activity designs, and another high school algebra classroom in which the principal investigator will spend two years as a researcher-teacher.

By carefully and systematically integrating the design of novel classroom tools and the investigation of student learning with the elaboration of teaching practices, this research aims to produce both a rich account of new possibilities for technology-supported collaborative mathematics learning and a well-articulated model for integrating those tools and practices into classroom instruction. These efforts center on a relatively new category of classroom tools: handheld computers and graphing calculators connected through a local wireless network. Several innovative projects in recent years have begun to map out a range of novel activity structures and promising instructional possibilities presented by these classroom networks.

This work extends those prior investigations in at least three ways. Firstly, the design efforts are particularly focused on supporting collaborative learning opportunities for dyads and small groups—a pedagogical mode that is both well-suited to, and not yet well-understood in, classroom networks. Secondly, this project aims to move from relatively short-term curriculum units and occasional activities toward models for incorporating networked devices into a full year of daily mathematics instruction. Thirdly, the combination of long-term collaborative partnerships with classroom teachers and my own sustained engagement in teaching with these tools will bring aspects of classroom practice and instructional integration to the fore. The resulting study aims to intertwine these elements to produce deeply grounded accounts of the new forms of both student learning and teaching practice that emerge in the context of collaborative classroom network designs over the timescale of a year-long instructional cycle.

Collaborative Online Projects for ELL Students (COPELLS)

Grant #	DRL-0918832
NSF Program	NSF
PI	Carolyn Harper Knox
Co-PI(s)	Kenneth M. Doxsee
Institution	University of Oregon
NSF Program Manager	Julio E. López-Ferrao
Grade Level Band	Middle School
Target Audience	Students - Special Population
STEM Content Area	Science
Deliverables	Collaborative Online Projects

Project COPELLS is a 42-month research and development project proposed by University of Oregon's National Center for Supported Electronic Text (NCSeT) and the Center for Advanced Technology in Education (CATE). The U of O will partner with the Instituto Latinamericano de la Communicacion Educativa (ILCE) to select, translate, enhance, and evaluate culturally relevant and linguistically appropriate Collaborative Online Projects (COPs) in science for middle school Spanish-speaking English language learners.

Headquartered in Mexico, ILCE's primary objective is to contribute to education in Mexico through the use of rich, collaborative, online multimedia resources. They create and provide sets of online collaborative projects for Mexican schools through their Red Escolar website. Red Escolar projects are written in Spanish, and students in Mexican and South American schools learn collaboratively through the use of these projects

Project COPELLS will translate a small set of middle school science mini-courses from Red Escolar, so they will be available in both Spanish and English, and align them to National Science Education Standards and the Oregon State Department of Education Science Curriculum Standards. In addition, they will be enhanced with supportive resources (etext supports) designed to promote bilingual use of the materials and increase science literacy in both English and Spanish. The project staff has research-based experience enriching online reading materials with content-specific multimedia supports designed to scaffold text comprehension and content learning for struggling students. Specific etext supports identified as potentially useful for this population include alternative text and/or definitions in simpler English and/or Spanish, text-to-speech, and multimedia resources that become available only when clicked to open by the reader.

The project's two major goals are to (1) facilitate and improve science content-area learning for Spanish-speaking ELL students and (2) facilitate their acquisition of Academic English while learning science content. Feasibility and usability of the COPs will be classroom tested: gathering information on the impact of the bilingual online science materials for improving science content-area learning, student attitude toward scientific learning, student and teacher satisfaction, and science academic language proficiency of ELL students.

Using quasi-experimental and qualitative research designs the project will investigate the following research questions:
(1) Do the COPs facilitate science content learning, scientific attitudes, and second language development
(2) What factors influence students' effective use of COPs?
(3) Are teachers and students motivated to use the COPs in the future?

Community Oriented Science Education

Grant #	0918836
NSF Program	NSF
PI	Herbert D. Thier
Co-PI(s)	Kevin Cuff
Institution	University of California, Berkeley
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Students, Students - Special Population, Inservice, Higher Education, Administrators, Other
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Student and Teacher Materials

Community Oriented Science Education (COSE) is a three-year project that will contribute to the emerging knowledge base for reform-minded middle school STEM instructional materials development. This will occur through the development, field-testing, and evaluation of a prototype instructional materials module specifically designed to stimulate and sustain urban-based students' interest in STEM. The module will include guided inquiry-oriented activities thematically linked by the standards-aligned concept of energy transfer, which highlight the fundamental processes and integrative nature of 21st century scientific investigation. Coupled with these activities will be design-oriented, project-based experiences that enable students to apply conceptual understandings in culturally responsive and relevant contexts.

The module will require approximately one month to complete, during which it will support a learning progression comprising the following components: (1) experience with and understanding and use of selected concepts related to energy; (2) understanding of fundamental processes of scientific investigation; (3) Acquisition of skills necessary to carry out investigations; (4) application of newly acquired skills and understandings through participation in teacher-guided research projects; and (5) execution of student-designed and -directed research projects related to energy resources and use. Prototype materials will be field tested in Northern California inner city schools with student populations representative of the ethnic and socio-economic diversity that typifies many urban American schools. Throughout the field-testing process, we will investigate the use of Smart Phone technology in addition to written reports to provide direct student feedback on module activities in a variety of digital formats.

Learning associated with prototype COSE materials will be assessed through the combined use of embedded assessment tasks and performance assessments describing their investigations. Our hypothesis is that inquiry/design-oriented, culturally responsive and relevant instructional materials can increase urban-based middle school students' STEM-oriented interest, self-efficacy, confidence, and attitudes, and promote the development of robust STEM identities. Information from field tests will inform the design of learning progressions for activities that form the core of a future, multi-year middle school program that focuses on the concept of energy transfer and transformation. Project implementation will occur through a collaboration that includes instructional materials developers based at the University of California at Berkeley, experienced science teachers, and researchers from other universities.

The project will generate information that is useful in developing student-centered instructional materials that effectively present important fundamental concepts (e.g., energy transfer and transformation) in culturally relevant, nurturing educational contexts that offer a high degree of active involvement and ample opportunities to succeed. The proposed project will generate information that contributes to an empirical framework upon which future, reform-minded development of middle school materials and intervention strategies may be built. Furthermore, the project will identify elements associated with inquiry and design oriented, project-based materials that affect positive changes in students' STEM-related learning, attitudes and capacities. As such, the project has the potential of broadly affecting how science is taught and learned in middle schools.

Conference Series for Recent Graduates and Advanced Doctoral Students in Mathematics Education

Grant #	0922410
NSF Program	NSF
PI	Barbara J Reys
Co-PI(s)	Robert E Reys
Institution	Univesity of Missouri
NSF Program Manager	Spud Bradley
Grade Level Band	Post Secondary
Target Audience	Higher Education
STEM Content Area	Mathematics
Deliverables	Summer Conference Series and Networking

The Induction Program for New Doctoral Graduates in Mathematics Education will support networking of early career professionals in mathematics education in higher education. Summer conferences and academic year networking will allow time for trust and collegiality to develop, and thereby provide opportunities for important issues/challenges to be identified and addressed. This sustained effort will promote networking, construct an environment that will allow working research groups to be established, and will provide time for significant professional growth and leadership capacity to flourish.

The program will be organized to bring together a cadre of future leaders of mathematics education in order to:

• establish a support structure for advancing the scholarship of recent graduates and advanced doctoral students of CLT programs;
• expand the networking of recent graduates/advanced graduate students initiated by CLTs to graduates/advanced graduate students from other institutions;
• showcase research priorities for the field and discuss appropriate methodologies for addressing important issues questions; and
• facilitate the establishment and development of research groups involving young mathematics education scholars from different institutions.

Connected Chemistry as Formative Assessment

Grant #	DRL-0918295
NSF Program	NSF
PI	Xiufeng Liu
Co-PI(s)	Noemi Waight, Roberto Gregorius
Institution	State University of New York at Buffalo
NSF Program Manager	Julio E. Lopez-Ferrao
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Assessment Modules

This exploratory project will develop, validate and evaluate computer modeling based formative assessments to improve high school students' learning in chemistry. This project targets high school chemistry; the objectives are:
1. To develop a series of NetLogo computer models and Flash animations related to key topics taught in a high school chemistry course;
2. To develop a series of short constructed-response questions based on the NetLogo computer models and Flash animations to probe student understanding of matter and energy;
3. To develop rubrics for scoring student responses to the probing questions;
4. To identify resources appropriate for different levels of student conceptual understanding of matter and energy; and
5. To develop a teacher professional development resource on how to integrate formative assessments into a high school chemistry course.

This project is grounded in current research on how students learn chemistry. Specifically, it integrates two promising strategies suggested in the literature, i.e. computer modeling and formative assessment. Computer modeling is based on Connected Chemistry, a Flash simulation enhanced NetLogo-based computer modeling environment in which students experience simultaneously three levels of representation of chemical phenomena: macroscopic, submicroscopic, and symbolic. The formative assessment is based on a modern measurement model (i.e. Rasch) implemented in ConstructMap. Both NetLogo and ConstructMap are NSF-funded resources; they are available free of charge. The development of formative assessments follows the constructive approach and is guided by research on learning progression of big ideas in science (i.e. matter and energy). The project research design includes both quantitative and qualitative data collection and analysis to establish evidence of validity, reliability, and absence of bias of formative assessment materials. The evaluation design focuses on assessing the impact of formative assessments on improving student learning in chemistry. The project team, consisting of university chemistry content and chemical education researchers and high school chemistry teachers, possesses comprehensive expertise to carry out the project successfully.

This project will achieve two main outcomes: (a) a formative assessment system with established validity, reliability and absence of bias; and (b) improvement of students' learning by integrating the formative assessment into a high school chemistry course. The formative assessment materials will be disseminated broadly through a monograph, a CD-ROM, and a website. We will conduct workshops for teachers and present at science teacher conferences. Research findings will also be reported in science and chemical education research journals. This project will facilitate integration of research, teaching and training. All the materials and findings of this project will be incorporated into our teacher education and graduate courses related to technology, measurement and evaluation of science teaching. This project can contribute to new knowledge and understanding on the validity and reliability of computer modeling as formative assessment in high school chemistry. In addition, it will enhance the infrastructure for research and education on computer modeling as formative assessments in chemistry by contributing formative assessment resources and educating future researchers.

Connecting Science and Literacy Program: Professional Development Resources for Elementary Teachers

Grant #	0353368
NSF Program	TPC
PI	Karen Worth
Co-PI(s)	
Institution	Education Development Center, Inc.
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK
Target Audience	Inservice, Higher Education, Other
STEM Content Area	
Deliverables	Professional Development Guide and Book

The Connecting Science and Literacy Program (CSLP) is a collaboration between EDC's Center for Science Education (CSE) at Education Development Center, Inc. (EDC), and Tufts University. The goal of this project was to develop professional development materials that will enhance elementary teachers' understanding of similarities among cognitive structures students use and develop as they engage in scientific inquiry and literacy learning, and increase teachers' use of instructional strategies that promote students' structured and intentional use of appropriate literacy strategies in their development of scientific reasoning and understanding.

The CSLP materials, now published by Heinemann, consist of two publications. One is "Science and Literacy, A Natural Fit: A Guide for Professional Development Leaders," a comprehensive manual for professional development leaders that provides an overview of the program, guidance for implementing eight workshops on inquiry science, classroom culture, discourse, and writing in science.Included are handouts,and other materials, and a DVD with Powerpoint slides, hand-outs, and video clips from five different classrooms. The second publication, "The Essentials of Science and Literacy: A Guide for Teachers," is a short book to provide a foundation for understanding the science literacy connection.

There is increasing evidence to suggest that the integration of science and language arts is "synergistic," with each domain benefiting the other. Theoretical frameworks for instruction in science and literacy reflect the compatibility of science and literacy education. Yet, progress towards a rigorous and explicit use of language in science has been slow. There are many reasons: One is the lack of emphasis on literacy use in science programs; a second is a lack of professional development opportunities for teachers to move beyond hands-on activities towards rigorous data collection, research, and communication, all of which require the use of important literacy strategies.

A review of this research on the link between literacy and science learning makes clear that language is essential for effective science learning. In addition to engaging in direct investigation of scientific phenomena, students make meaning by writing science, talking science, and reading science. At the root of deep understanding of science concepts and scientific processes is the ability to use language to form ideas, theorize, do research, share and debate with others, and, ultimately, communicate clearly to different audiences. The potentially powerful linkages between science and literacy are supported by research on cognition. Research also suggests the benefits to literacy development of linguistic and culturally diverse learners.

During the first two years of the project, staff worked closely with three classroom teachers to identify critical components of the connections between science and literacy and to formulate a framework for the professional development materials. Components were piloted in several different settings. In the spring of Year 3, eight geographically diverse sites implemented the CSLP in at least one workshop setting with over 100 teachers. The overall summative evaluation question was whether field-test teachers change their instructional practices as a result of their experiences with the CSLP. A secondary question was focused on how effective the materials were in guiding the professional developers. Evaluation tools included teacher and facilitator questionnaires, interviews, and classroom observation. These results informed the final revision of the materials last year.

Considering the Future of K-12 STEM Curricula and Instructional Materials: Stimulating and Supporting New Developments

Grant #	DRL-0958058
NSF Program	NSF
PI	Barbara J Reys
Co-PI(s)	Robert E Reys
Institution	University of Missouri
NSF Program Manager	Spud Bradley
Grade Level Band	PreK, Middle School, High School, Other
Target Audience	Students, Policy Makers, Other
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Report to NSF on Questions Posed

The objective of this project is to provide visionary leadership to the education community by (a) identifying and analyzing the needs and opportunities for future STEM curriculum development and (b) recommending policy positions and actions by funding agencies and STEM educators regarding the development and implementation of STEM school curricula. Specific questions to be addressed include:

• What will a high-impact, technology-intensive STEM classroom look like in the near and long-term future?
• What materials development and research are required to make this future vision possible?
• What design, development, and diffusion processes are most likely to produce new approaches to STEM education that are implemented in schools?

The vehicle for accumulating, discussing, and articulating future technology-intensive STEM curriculum needs and opportunities is a series of workshops. Initially, a small visionary group will produce a framework for the future. Subsequently, larger and broader groups of education and curriculum developers will consider the vision and opportunities for implementation. An Advisory Board will oversee all aspects of the project. The result of this work will be a collection of information, ideas, and recommendations organized for practitioners (teachers and administrators), curriculum developers, and researchers.

Content Mentoring and Its Impact on Middle Grades Mathematics and Science Teacher Effectiveness

Grant #	0554441
NSF Program	TPC
PI	David Boger
Co-PI(s)	Jane Davis; Robin Liles
Institution	North Carolina A&T State University
NSF Program Manager	Julia Clark
Grade Level Band	Middle School
Target Audience	Inservice, Higher Education
STEM Content Area	Science, Mathematics
Deliverables	Presentation Proposal to 2009 DR-K12

The purpose of this study is to investigate the extent to which content mentoring in mathematics and science for middle-grade teachers enhances quality of instruction, student performance, and teacher retention in the profession. The proposed research will strengthen the theoretical underpinning of “best practices” in middle-grades mathematics and science teaching and enhance the knowledge base for teacher recruitment, preparation, induction, and retention. Findings from this research will add to the knowledge base and empirical data that support the development of infrastructure needs. Findings from this study will (1) enhance teacher recruitment strategies; (2) improve preservice teacher preparation, induction, and retention programs; and (3) increase student performance.

The goal of the proposed research study is aligned with the following TPC goals:
• Advancing the knowledge base on the preparation, induction, enhancement, and retention of STEM teachers and on the strategies that strengthen and diversify the STEM workforce
• Promoting scientifically based research that examines teacher learning of STEM content and pedagogy and assesses the subsequent impact of this learning on practices
• Encouraging research on effective professional development models and experiences that enhance STEM teachers’ pedagogical content knowledge and its alignment with classroom practice
• Understanding, through research, those instructional practices that enhance student learning in STEM disciplines
• Developing innovative resources, materials, tools, and ideas for preparing and supporting STEM teachers and those who educate them
• Fostering effective collaborations between the communities of STEM K-12 teachers, STEM researchers, practitioners, and others contributing to STEM education
• Disseminating research findings, effective models, and field-tested resources to national audiences of practitioners, administrators, researchers, policy makers, education faculty, and/or STEM disciplinary faculty

Cumulative Learning using Embedded Assessment Results (CLEAR)

Grant #	0822388
NSF Program	NSF
PI	Marcia Linn
Co-PI(s)	
Institution	UC Berkeley
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Research, Assessments, Curriculum, PD

Cumulative Learning using Embedded Assessment Results (CLEAR) focuses on the challenge of using assessment of relevant STEM content to improve K-12 teaching and learning. CLEAR takes advantage of new technologies and research findings to investigate ways that science assessments can both capture and contribute to cumulative, integrated learning of standards-based concepts in middle school courses. The project will research new forms of assessment that document students' accumulation of knowledge and also serve as learning events. CLEAR will use cohort and randomized classroom comparisons to determine what combinations of instruction and assessment enable middle school students to gain cumulative understanding of energy concepts in science. CLEAR will study whether the project's approach when used in one course affects progress in the next. The project will put design principles from across the field to the test by determining which instruction and assessment strategies encourage cumulative understanding and help learners develop integrated ideas about science.

There is an urgent need to develop accurate student assessments that measure cumulative knowledge while eliminating the disruptions caused by tests. By measuring students' developing understanding and ongoing efforts to make sense of new materials, the project will be able to foster coherent understanding. The project will do this by making assessment an integral part of computer-based curricula.

By aligning assessment and instruction around the goal of promoting understanding, the project will demonstrate how to improve learning outcomes for any STEM course. The project will also make courses more effective and efficient by converting assessment from a time-wasting, curriculum-limiting chore into an integral part of learning that fosters the accumulation of concepts across topics and grades. The results of the proposed research will have an important bearing on the design of effective all-electronic media, which are playing a more and more central role in learning as technology continues to drop in price.

The project is designed to have a major impact by undertaking the kind of careful, statistically valid research design that leads to reproducible results that can support policy. The project will be able to tailor instruction to specific learners, increasing the impact on students at risk for failure. The partners will continue their practice of widely disseminating findings, materials, and open source software through reviewed papers, popular articles, talks, workshops, its website, and newsletters.

Cyber-Enabled Design Research to Enhance Teachers' Critical Thinking Using a Major Video Collection on Children's Mathematical Reasoning (Collaborative Research - Maher)

Grant #	0822204
NSF Program	NSF
PI	Carolyn Maher
Co-PI(s)	Cindy Hmelo-Silver, Grace Agnew, Sharon Derry, Marjory Palius
Institution	Rutgers University
NSF Program Manager	Karen Marongelle
Grade Level Band	Post Secondary
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Video Repository, Teacher Professional Development

The Video Mosaic Collaborative (VMC) is a collaboration portal that integrates the Robert B. Davis Institute for Learning Video Collection, a video collection capturing mathematics learning experiences across a range of grades, types of schools, and a time span of 20+ years, with a collaboration platform and tools designed to transform mathematics research, teaching and learning. The VMC combines innovative research into the teaching and learning process with videos and tools that enable teachers, teacher educators, and researchers to analyze and utilize the videos to make new discoveries in math education and the learning sciences.

In the first year of funding, we have had major accomplishments in two areas: development of the VMC repository and pilot studies of teacher professional development (TPD). The VMC website, built on the RUcore architecture, has been constructed to preserve videos, catalog resources using the METS (metadata encoding and transmission standard), and develop a prototype analytic tool to enable individual and community use of videos. Developing an analytic tool for a large, complex video collection that would support both individual and collaborative analysis is a key challenge that we are addressing. Video analytics can range from simple coding to complex interpretive texts that must be associated with the appropriate video it analyzes, and are thus metadata. But these analytics are also creative works and need to be afforded the same treatment as the video that it analyzes.

We conducted pilot studies using VMC video in interventions that used video cases showing multiple forms of reasoning in a range of school settings, math content domains, and grade levels. As an integral part of these pilot studies, we developed and refined instruments to measure beliefs about teaching and learning mathematics, content knowledge, and a video assessment of ability to recognize forms of mathematical reasoning. These studies were conducted at three preservice sites and one in-service site with elementary and middle school teachers. In a typical intervention, teacher-learners collaboratively engaged in cognitively challenging mathematical tasks with manipulatives available for building models from which they could reason and develop solutions. They shared solutions, representations, and justifications. Following their own problem solving, these teacher-learners studied children working on the same task. Our preliminary analysis of the beliefs instrument shows that there are two factors—one related to beliefs about student learning and another about the effects of teaching—and that these beliefs are positively affected by participating in the VMC interventions.

The project is demonstrating the use of cyber-enabled technologies to build and share adaptable interventions for TPD that effectively make use of major video collections and have high promise of success at multiple sites. The cyber infrastructure provided by the VMC and significantly extended through this project is supporting development and documentation of additional interventions for TPD using this video collection, as well as other videos that might be added in the future by teacher educators or researchers, including those working in other STEM domains.

Cyber-Enabled Earth Exploration: Development of Materials for Middle School Earth Science Instruction

Grant #	0918683
NSF Program	NSF
PI	Heather Almquist
Co-PI(s)	Lisa Blank
Institution	The University of Montana
NSF Program Manager	David Campbell
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Science, Technology
Deliverables	Cyber-enabled Earth Science Curriculum

Cyber-Enabled Earth Exploration (CE3) is a research and development project aimed at motivating and challenging students in science. The project will develop new instructional materials for middle school science teachers that help create a compelling classroom culture of scientific discovery, engage students in the creative opportunities that abound in science, and inspire them to pursue the high school science coursework needed for future careers in science.

The materials will incorporate emerging and widely available technologies such as Google Earth to engage middle school students in exploring an essential science question, “Does the Earth’s structure affect you?” A complete learning unit and teacher’s guide will be developed in Year 1 by a team of experts in K-12 curriculum design, geology, and geography, using a Learning-for-Use curriculum design framework. The materials will be tested for ease of use and effectiveness in approximately 10 classrooms across Montana, which include a range of class sizes, urban and rural communities, and white and Native American students.

In Year 1, field-test teachers will administer science, self-efficacy, and career interest surveys, as well as content knowledge assessments to their students. These students will be used as a comparison group for students who go through the unit during the Year 2 field test. Using a quasi-experimental approach, the self-efficacy and science and career interest surveys will be administered at the beginning of the year to both comparison and field-test students (comparison in Year 1; field test in Year 2) and used as covariates to adjust content assessment scores administered to students at the end of Years 1 and 2. This design will increase confidence that the unit either does or does not meet its outcome targets by holding the teacher constant while varying the instructional approach across two groups of students. The content assessment will be developed by the project team and aligned with curricular standards that the unit is designed to address.

During Year 3 the evaluation will focus on data analysis to determine the extent to which student interest, self-efficacy, knowledge, and content changed as well as final refinements to the curriculum. In addition, revised units will be disseminated through a website, and downloading activity and feedback forms filled out by teachers will be monitored. Following of the completion of the project an external evaluator will write a final summative report that details the chronology and process of development; summary of lessons learned through all input strategies; impacts on students, teachers, and schools that are found; and overall assessment of the extent to which the project met its goals.

Data Games--Tools and Materials for Learning Data Modeling (Collaborative Research - Finzer)

Grant #	0918735
NSF Program	NSF
PI	William Finzer
Co-PI(s)	Cliff Konold
Institution	KCP Technologies
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Mathematics
Deliverables	software, activities, papers, articles

Students playing computer games generate large quantities of rich, interesting, highly variable data that mostly evaporates into the ether when the game ends. What if in a classroom setting, data from games students played remained accessible to them for analysis? In software and curriculum materials being developed by the Data Games project at UMass Amherst and KCP Technologies, data generated by students playing computer games form the raw material for mathematics classroom activities. Students play a short video game, analyze the game data, conjecture improved strategies, and test their strategies in another round of the game.

The video games are embedded in TinkerPlots and Fathom, two data analysis learning environments widely used in grades 5–8 and 8–14 respectively. The game data appear in graphs in real time, allowing multiple cycles of strategy improvement in a short time. The games are designed so that these cycles improve understanding of specific data modeling and/or mathematics concepts. Lessons will be embedded in LessonLink from Key Curriculum Press to facilitate their integration into standard curricula.

The three-year project expands research in students' understanding of data modeling and their ability to learn mathematical content embedded in data-rich contexts. Among the questions being investigated are: To what extent do students view data produced by games as the result of a production process? How do students view data that do not fit conveniently into rows and columns (for example, hierarchically structured data)? How do students' understandings, interpretations, and interactions with data change as a function of the size of the data set? To what extent do the mechanisms the project builds for Web-enabled collaboration and data sharing enhance classroom activities?

During the first two years of the project, researchers will work in one middle school and one secondary school, forming "data clubs" for informal work with students and observing field-test classrooms whose teachers are an integral part of the project. In the third year, three additional field-test schools at each level will participate in the project to test generalizability of the developed materials.

Formative evaluation is built into the iterative research and design process. External evaluation comes from an advisory panel, an evaluator, and a panel of curriculum materials reviewers.

Dissemination of software and curriculum materials will take place approximately one year after the end of the project through online publication by Key Curriculum Press. Dissemination of research results will be through conference presentations, articles in research journals, at least one article in The Mathematics Teacher, and an article in an educational games publication.

Data Games--Tools and Materials for Learning Data Modeling (Collaborative Research - Konold)

Grant #	0918653
NSF Program	NSF
PI	Clifford Konold
Co-PI(s)	William Finzer
Institution	University of Massachusetts Amherst
NSF Program Manager	John Bradley
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Mathematics
Deliverables	Software, Curriculum materials, Published research

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Design and Use of Illustrations in Test Items as a Form of Accommodation for English Language Learners in Science and Mathematics Assessment

Grant #	0822362
NSF Program	NSF
PI	Guillermo Solano-Flores
Co-PI(s)	
Institution	University of Colorado, Boulder
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Science
Deliverables	Research Publications, Manuals

This exploratory project addresses validity in the assessment of science and mathematics for English language learners (ELLs) and the urgent need for effective testing accommodations for ELLs. We will investigate the factors that are relevant to designing and using a new form of accommodation in the assessment of science and mathematics for ELLs—vignette illustrations. A vignette-illustrated item can be defined as an illustrated item with three properties: (1) the illustration provides a simple, concrete representation of one of the components; (2) the text of the item does not refer the test taker to the illustration; and (3) the text of the item provides all the information needed to understand it and respond.

The purposes of this project are to (1) identify the role of illustrations in the cognitive activities elicited by vignette-illustrated items; (2) determine whether any differences between performance on vignette-illustrated items and other kinds of items are due to this form of accommodation's capacity to address language as a construct-irrelevant factor; (3) identify the set of practical and methodological issues that are critical to properly developing and using vignette-illustrated items; and (4) propose a set of documents and procedures for the systematic and cost-effective design and development of vignette-illustrated items.

Throughout a period of three years, we will test ELL, native Spanish speaking students and non-ELL, native English speaking students with items of three types (vignette-illustrated items whose illustrations are designed systematically, vignette-illustrated items whose illustrations are created arbitrarily, and items without illustrations) at two levels of distance to the enacted curriculum (close and distal). Diverse forms of analysis will allow us to determine whether and how ELL and non-ELL students differ on the ways in which they use vignettes to make sense of items, whether the use of vignettes reduces test score differences due to language factors between ELL and non-ELL students, and whether the level of distance of the items moderates the effectiveness of vignette-illustrated items.

This project will provide information that will help to advance our understanding in two assessment arenas: effective accommodations for ELLs and item development practices. While illustrations are frequently used in test items, there is not guidance in the assessment development literature on how to approach illustrations. Furthermore, the value of illustrations as a resource for ensuring that ELL students understand what a given item is about and what the item asks them to do has not been systematically investigated. Semiotics, cognitive psychology, and linguistics and socio-cultural theory are brought together to develop systematic procedures for developing illustrations as visual supports in tests. Understanding the role that images play in test taking is relevant to devising more effective ways of testing students. While this project aims to improve testing-accommodations practices for ELLs, knowledge gained from it will inform test development practices relevant to all student populations.

Designing Learning Organizations for Instructional Improvement in Mathematics

Grant #	0554535
NSF Program	TPC
PI	Paul Cobb
Co-PI(s)	Thomas Smith
Institution	Vanderbilt University; Peabody College
NSF Program Manager	Paola Sztajn
Grade Level Band	Middle School
Target Audience	Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Website, Instruments, Publications

A substantial body of research reveals that improving mathematics instruction on a large scale has to be framed as a problem for schools and districts that encompasses instructional leadership and management as well as teaching. The primary goal of this project is to test and refine a set of conjectures about school and district support structures that enhance the impact of professional development on mathematics teachers' instructional practices and student achievement. The support structures on which we are focusing include (1) teacher learning communities and informal networks, (2) shared vision for mathematics instruction, (3) distribution of instructional leadership across formal and informal leaders, (4) reciprocal accountability between teachers and instructional leaders, and (5) depth of instructional leaders' understanding of the instructional program and the challenges of using it effectively. We are investigating our conjectures about the role of these support structures in enhancing the effectiveness of professional development by employing a mixed methods design that involves both a formal hypothesis-testing component and design research component.

We are working in four urban school districts, three of which have partnered with the University of Pittsburgh's Institute for Learning (IFL) to formulate and implement comprehensive middle-school mathematics reform initiatives that focus on the institutional setting of mathematics teaching as well as curriculum and teacher professional development. We are collecting data in each of the four collaborating districts once each year for four years. In the hypothesis-testing component of the project, we will analyze these longitudinal data sets to test our theory-based conjectures about support structures associated with improvements in teachers' instructional practices and student achievement.

In the design research component of the project, we will refine our conjectures by (1) identifying additional support structures, (2) specifying the conditions in which particular support structures are important, and (3) clarifying the interdependencies between support structures. To accomplish this, we will (1) share the results of our ongoing analyses with district personnel after each round of data collection, and (2) collaborate with them to identify any adjustments that might make the district's improvement plan for middle-school mathematics more effective. We will then document the consequences of these adjustments in subsequent rounds of data collection. The overall product of the two components of the project will be a framework for guiding, monitoring, and assessing school and district-wide institutional improvement in mathematics. This Institutional Improvement Framework will identify the support structures that our findings document are important, explain why they are important and under what conditions, clarify how they are interdependent, and illustrate how their development can be accomplished.

We will disseminate our findings to researchers through scholarly journal articles in mathematics education and leadership and policy, and to teacher developers and school and district leaders through more practitioner-oriented journals. We will conduct workshops for IFL and other potential users of the Institutional Improvement Framework and will develop and maintain a website from which working papers, published articles and summaries, interview protocols, surveys, and a description of the framework designed for a broad audience can be downloaded.

Designing Professional Development Resources that Lead to Effective Science and Expository Writing Instruction

Grant #	0554651
NSF Program	TPC
PI	Elaine Woo
Co-PI(s)	Betsy Rupp Fulwiler, Kathryn Show
Institution	Seattle Public Schools
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Science
Deliverables	Two Books and a DVD (Video)

This project will develop professional resources to strengthen elementary teachers' ability to guide students in developing their scientific thinking and process skills, conceptual understanding, and expository writing skills through focused instruction and the use of science notebooks. Co-PI Betsy Rupp Fulwiler is the author for the resources, which include a book, published in April 2007; a second book; and a DVD for teachers. Co-PI Kathryn Show from Seattle Public Schools and Susan Mundry from WestEd will provide support and consultation in this work. Ms. Fulwiler will develop these products for teachers, teacher leaders, and professional development providers so they understand how to effectively implement the science writing approach in the classroom and integrate professional development on expository writing and science instruction in their particular districts, as well as develop high-quality professional development and unit-specific science writing curricula. The work has been informed by extensive feedback from teachers, district program staff, and independent evaluators.

The project is based on a highly successful program developed in the Seattle Public Schools. During the program's 11-year history, it has undergone extensive evaluation by Inverness Research Associates, demonstrating the program's efficacy and positive impact on student performance. Ms. Fulwiler received foundation grants to develop and refine components of these resources. The project is grounded in the theory that both elementary teachers and students need structured support in learning how to write analytically about science, and that a strategic process of learning proficient scientific writing can result in increased achievement in science. Prior to dissemination, the proposed resources will undergo field tests involving almost 100 teachers in Central and Western Washington, rural Maine, and South Carolina, where high numbers of diverse students, including English language learners, will be involved. A pilot has been completed in the Seattle Public Schools.

Inverness Research Associates will conduct the independent evaluation, addressing these questions:
1. To what extent is the project able to develop and disseminate curriculum and professional development resources that have sufficient quality, value, and utility that they can support improved teaching and learning in science and writing in a range of districts in comparable ways to how they perform in Seattle classrooms?
2. What are the lessons learned for the field about the design, creation, and use of professional development resources for the teaching of elementary science and writing across a range of district and school contexts?

In the field-test districts, Inverness will observe the professional development, interview teachers, and assess student work in science notebooks to look for evidence of enhanced conceptual understanding, scientific processes and thinking, and expository writing.

Heinemann published the project's first book, Writing in Science: How to Scaffold Instruction to Support Learning. The remaining resources, the second book, and the DVD are scheduled to be published by Heinemann in spring 2011.

Developing a Professional Learning Community Model for Secondary Precalculus Teachers: A Model for Teacher Professional Growth

Grant #	0353470
NSF Program	TPC
PI	Patrick Thompson
Co-PI(s)	Marilyn Carlson
Institution	Arizona State University
NSF Program Manager	Dan Maki
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Tools and Process for Professional Learning

The goals of this project are (1) to understand the synergy between (a) precalculus teachers' involvement in Reflecting on Practice Sessions (RPSs) that focus on their reconceptualization of their instructional practices and (b) courses that aim to have teachers develop profound understandings of the mathematics they teach; (2) to understand the influence of teachers' activities in courses and RPSs on their formation of Professional Learning Communities (PLCs); and (3) to leverage these understandings to develop a conceptual framework for secondary mathematics teacher professional development.

Data include video of course sessions, RPSs, clinical and task-based interviews, teachers' classroom instruction, and a variety of artifacts generated in these settings. Qualitative research techniques were used to uncover important trends or developments to refine the RPS model and course content, and to create new frameworks for studying and understanding mathematics teacher knowledge and teacher change.

Through use of a design-experiment methodology, we cycled through three iterations of courses and PLC-style support structures, ending with (1) a set of mathematics modules for use in mathematics education graduate courses for in-service teachers that can also be used in a series of PD workshops; (2) a set of video-based case studies for use in PD settings; and (3) a model for preparing teachers to participate effectively in PD settings aimed at reconceptualizing their teaching and curriculum both in relation to reconceptualizing students' learning.

Five Ph.D. dissertations (near completion) are examining (1) a teachers' transformation of practice over a year of intensive engagement with project staff as she redesigns her Algebra I course; (2) the mathematical knowledge for teaching of one teacher deemed by us and by his school as being exceptionally effective in producing high levels of student understanding and skill; (3) students' understandings of exponential functions in the context of a teachers' efforts to design coherent instruction on exponential growth and decay; (4) the character of teachers' capacities to reflect on their practice and the implications that has for their reform of practice; (5) the negotiation of meaning between a teacher and a researcher as the teacher attempts to transform her teaching from being teacher-centered to being student-centered with the support of the researcher.

Developing Algebra-ready Students for Middle School: Exploring the Impact of Early Algebra

Grant #	0918239
NSF Program	NSF
PI	Maria Blanton
Co-PI(s)	Eric Knuth
Institution	University of Massachusetts Dartmouth
NSF Program Manager	James T. Fey
Grade Level Band	PreK, Middle School
Target Audience	Inservice, Higher Education
STEM Content Area	Mathematics
Deliverables	Assesments, Algebra Learning Progression

Teaching and learning algebra has undergone a critical transformation over the past two decades, with scholars now arguing that students need long-term, sustained algebra experiences in school mathematics beginning in the elementary grades. It is therefore critical that we understand the impact of early algebra education on students' success in algebra in later grades. A prerequisite to that work is identifying a curricular learning progression across upper elementary and middle grades and designing validated means to assess student learning in that domain. To that end, this project aims to build the essential preliminary components necessary to investigate the impacts of early algebra education on students' algebra readiness in middle grades. In particular, the project goals are:

1. To coordinate (empirical) research, curricular perspective, and mathematical perspectives to design a curricular learning progression (CLP) that identifies core algebraic concepts and their progression in children's thinking across upper elementary and middle grades (grades 3-7).
2. Using the CLP to design grade-based assessments of students' algebra understanding for upper elementary and middle grades (grades 3-7) and to validate these assessments through psychometric testing.
3. To conduct a preliminary study concerning the impact of an early algebra intervention based on the CLP and measured by the assessments developed in Project Goal 2.
4. To use the CLP and associated tasks to identify appropriate tasks for content-based teacher professional development (TPD) and to refine this through implementation of the TPD.

We anticipate a number of products to result from this project, including the following:
• Curricular Learning Progression: The CLP will provide a comprehensive, research-based progression of core algebra ideas, based on the two domains of generalized arithmetic and functional thinking for upper elementary and middle grades. We expect the CLP to be flexible in terms of its adaptability to different schools and curricula, and in that sense, should be broadly accessible to researchers and practitioners.
• Validated Assessments of Students' Algebra Understanding: We will produce a collection of validated, grade-based assessments that can be used in upper elementary and middle-grades school settings to measure students' algebra understanding.
• Teacher Professional Development Sequence of Tasks: We will develop a field tested sequence of TPD tasks that supports the integration of algebra in viable and sustainable ways in classroom practice.

We will work to make these products accessible to a general audience of researchers and practitioners through publications and, where appropriate, free downloads via a project website. As part of this information, we will also make available support materials that detail relevant issues of design of materials and guidelines for use.

Developing an Empirically-Tested Learning Progression for the Transformation of Matter to Inform Curriculum, Instruction and Assessment Design

Grant #	0822038
NSF Program	NSF
PI	Namsoo Shin
Co-PI(s)	Joseph Krajcik
Institution	University of Michigan
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice, Policy Makers
STEM Content Area	Science
Deliverables	Learning Progression and Assessment Item

This project brings together individuals with expertise in science, science education, learning science, and psychometrics who propose to improve science education by aligning curriculum, instruction, and assessment. To support the development of science literacy, school curricula and assessments must begin to emphasize not only the learning of individual topics but also the connections between currently taught and previously learned concepts, and how these ideas develop over time.

This project aims to provide a principled framework for the development and application of learning progressions in science education. Intensive classroom-based studies that examine the growth of middle school students' understanding of the transformation of matter (ToM) will be conducted during a three-year longitudinal study. As an exemplar, a hypothetical research-based learning progression will be developed that characterizes a trajectory that grade 6-12 learners may follow when building conceptual understanding of ToM. Based upon the hypothetical learning progression, assessments will be developed that require the use of higher cognitive skills (e.g., constructing explanations and model building) to measure student understanding. A portion of the learning progression will be empirically tested using the developed assessments and the Investigating and Questioning our World through Science and Technology (IQWST) curriculum, which was developed to specifically help students build integrated knowledge about ToM. Each of these tasks will iteratively inform each other. The resulting set of assessments will afford an instrument to measure any student against the scale provided by the empirically-tested learning progression for ToM. An investigation will be undertaken to explore the relationship between student factors (e.g., attitude toward science, gender, reading ability) and teacher factors (e.g., experience, knowledge and beliefs about teaching and students) with the different levels of students' developmental learning.

This project has the potential to substantially impact middle and high school student achievement in science. The framework developed for creating these tools can be applied to support student learning of other core ideas in science, particularly emergent sciences (e.g., biotechnology, nanotechnology), whose inherent interdisciplinary nature requires a focus on helping students build connections between ideas from very different science constructs. The project will contribute to the curricular, instructional, and assessment tools needed to support students in integrating and applying their understandings across topic areas in science, thereby broadening student participation in STEM and supporting the development of an electorate and a workforce with a richer understanding of what it means to be scientifically literate.

Developing an Integrated Assessment and Support System for Elementary Teacher Education

Grant #	0554416
NSF Program	TPC
PI	Pamela Moss
Co-PI(s)	Deborah Loewenberg Ball, Timothy A. Boerst, Annemarie Sullivan Palincsar, and Mark R. Wilson
Institution	University of Michigan
NSF Program Manager	Lee Zia
Grade Level Band	PreK
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Assessment and Instructional Materials

Developing an Empirically-Tested Learning Progression for the Transformation…

Our goal is to develop, implement, and evaluate a prototype for an integrated assessment system in elementary mathematics teaching that (a) supports the development of student teachers (STs) in using the special content and pedagogical knowledge needed for teaching mathematics, (b) supports the development of the school- and university-based faculty who work with them in analyzing teaching practice and giving feedback, (c) facilitates cooperation (and common understanding) across these different communities of practice, and (d) warrants the quality of the teacher education program and the decisions made about readiness-to-teach for accountability purposes. The “learners” in this environment are both the STs and the faculty who support them. For the purposes of this project, we focus on three contexts of learning to teach elementary mathematics: (1) the subject matter methods course and related field instruction; (2) the student teaching semester and related seminar; and (3) the initial induction year, for assessment purposes only. In addition to following the development of the STs in the practice of teaching mathematics, we will also follow the development of school-based cooperating teachers and university-based field instructors as they learn to analyze the practice of the STs and provide feedback.

The assessments we develop for STs in these learning contexts will address multiple purposes: (1) to facilitate learning and teaching; (2) to document progress and demonstrate accomplishment; (3) to warrant consequential decisions about readiness to teach; and (4) to evaluate (and allow fine tuning of) the teacher preparation program. Different assessment practices will contribute to these purposes in different ways and provide corroborating validity evidence. By creating shared records of teaching practice, a common language of analysis, and routine forms of dialogue, these assessments will bring together cooperating teachers (CTs) and university-based teachers (including methods course teachers and field instructors) in learning communities to facilitate common understanding and program coherence across these sites. We will document the impact of the assessment program on CTs and field instructors (FIs), as well as draw upon expertise from these groups as we develop, evaluate, and use facets of the assessment system. The research agenda will also allow us to study and represent a coherent developmental trajectory for student teachers in these subject areas and for the CTs and FIs who are learning to analyze their practice and give feedback.

The unique contributions of this project to knowledge about assessment in teacher education lie in (a) its emphasis on assessing beginning teachers’ ability to make disciplinary knowledge learnable by pupils, (b) its conception and study of assessment as an integral part of a complex social system and a means to facilitate cooperation and collaborative learning across school- and university-based contexts; (c) its explicit attention to the ongoing validity evidence needed for warranting consequential decisions about preparation to teach in ways that outsiders will find credible; and (d) its contribution to knowledge about the developmental trajectory in teaching mathematics across the first years of learning to teach/teaching.

Developing Contingent Pedagogies: Integrating Technology-Enhanced Feedback into a Middle School Science Curriculum to Improve Conceptual Teaching and Learning

Grant #	0822314
NSF Program	NSF
PI	William Penuel
Co-PI(s)	Angela Haydel DeBarger
Institution	SRI International
NSF Program Manager	David Hanych
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Interactive Assessment Activities

SRI is developing a formative assessment intervention that integrates existing classroom network technologies (GroupScribbles and Classroom Performance Systems), interactive formative assessments, and contingent curriculum activities to help teachers adjust instruction to improve middle school student learning of selected Earth science concepts (e.g., the rock cycle, forces that shape Earth's surface, and plate tectonics). To test the hypothesis that integrating response system technology, assessment, and curricula can improve K-12 science teaching and learning, the project is developing and testing (1) pedagogical routines for teachers to follow when using classroom network technologies, (2) diagnostic questions for teachers to elicit student preconceptions, (3) decision rules for teachers for using alternative learning activities that supplement an existing geoscience curriculum, (4) training materials that prepare teachers to enact the intervention, and (5) research- and classroom-based instruments that measure changes in teacher instructional practice, student thinking, and student achievement. The intervention is being tested in two urban school districts located in two western states (Colorado and California) that have ethnically and economically diverse student populations. Facet Innovations, a partner on the project, will develop facets and facet clusters that correspond to possible student conceptions regarding target constructs. American Geological Institute staff who developed the Investigating Earth Systems curriculum that will be the foundation for the intervention will develop supplementary curriculum materials.

Developing Science Problem-Solving Skills and Engagement Through Intelligent Game-Based Learning Environments

Grant #	0822200
NSF Program	NSF
PI	James Lester
Co-PI(s)	Hiller Spires, John Nietfeld, James Minogue
Institution	North Carolina State University
NSF Program Manager	Michael Haney
Grade Level Band	PreK
Target Audience	Students
STEM Content Area	Science
Deliverables	Publications, Software

Recent years have seen a growing recognition of the transformative potential of game-based learning technologies for STEM education. This project addresses the research question: How can intelligent game-based environments promote problem solving and engagement in STEM learning for upper elementary students? It targets the following three objectives:

1. Design a suite of intelligent game-based learning environment technologies for elementary science education. To promote effective science learning, we will create intelligent game-based learning-environment technologies that leverage the rich, interactive 3D game environments provided by commercial game engines and the inferential capabilities of intelligent tutoring systems. Building on our experience in these two areas, we are creating an engaging intelligent game-based learning environment for elementary science education that creates goal-based problem scenarios dynamically tailored to students' abilities, models students' problem-solving progress, and provides customized explanations and feedback. The environment will feature an immersive 3D storyworld with an expansive cast of characters in which students will play the role of a science detective.

2. Implement an empirically-based research program to provide a comprehensive account of elementary students' problem-solving processes and engagement with STEM content as they interact with intelligent game-based learning environments. To understand the cognitive mechanisms by which learning occurs, we will take a mixed method approach to investigating science learning with an intelligent game-based learning environment for fifth-grade science. These studies will investigate the central issues of problem solving (strategy use, divergent thinking, and collaboration), and engagement (motivation, situational interest, presence) with respect to achievement as measured by both science content knowledge and transfer. With diverse student populations drawn from both urban and rural settings, the studies will determine precisely which technologies and conditions contribute most effectively to learning processes and outcomes.

3. Evaluate the design and implementation phases of the research in order to assure high-quality processes and results. To ensure the success of the project, an external evaluator will provide formative and summative feedback to the project team.

It is expected that the proposed work will have a significant impact on the theory and practice of science education. By taking advantage of the high degree of interactivity offered by intelligent game-based learning environments, the project holds significant potential for creating compelling learning experiences for STEM content. Because the research will be conducted with a highly diverse student population in both urban and rural settings, and because of the synergistic interaction of the technology and learning science research, the project offers significant potential for creating compelling learning experiences that lead to higher achievement for all students.

Developing the Next Generation of Middle School Science Materials -- Investigating and Questioning our World through Science and Technology (Collaborative Research - Krajcik)

Grant #	0439352
NSF Program	IMD
PI	Joseph Krajcik
Co-PI(s)	Brian Reiser, LeeAnn Sutherland, David Fortus
Institution	University of Michigan
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Student and Teacher Curriculum Materials

The Investigating and Questioning our World through Science and Technology (IQWST) project is developing the next generation of middle school science curricula designed to enable teachers with diverse knowledge and experiences to teach science effectively to students with a variety of backgrounds and strengths. IQWST is designed to foster coherent and deep understanding of both science content and scientific practices. IQWST brings together standards-aligned learning goals with project-based approaches to science pedagogy, incorporating research-based practices to support students' science learning and literacy. To support rigorous learning of content standards and engagement in scientific practices, we have developed a learning-goals driven design process that guides our development and iterative refinement of the curriculum materials. IQWST supports learning across time of core enduring ideas in science, in contrast with other curricula that may address more topics but address them in less depth. For this reason, we refer to the materials as "coherent." Core ideas from each scientific discipline are explored and built upon each year of middle school, supporting students as they construct an integrated understanding of scientific ideas and practices. The materials create contexts that involve students in challenging science content and practices while engaging them in complex tasks that build scientific literacy. The IQWST project is organized as collaborative grants awarded to University of Michigan and Northwestern University.

We are in our final year of a three-year national field trial. The evaluation design derives from one of the central principles of IQWST—building understanding of core science content and scientific practices over time. We follow cohorts of students as they use the IQWST materials across the three years of middle school. The evaluation comprises three types of assessments. The pre- and post-unit tests (near measures) are created by the developers. These tests provide classroom-level data that we use for research purposes and that teachers can use for assigning grades. The IQWST-aligned assessments are created by Horizon, Inc. These tests provide a proximal measure of the curriculum's effectiveness. They assess only content addressed in the curriculum and may include representations and contexts used in the units. Finally, a benchmarks-aligned assessment is an externally created, distal measure. This assessment samples content found in the National Science Education Standards and the Benchmarks for Science Literacy, whether or not the content is found in the IQWST curriculum. A comparison group of students also take the distal measure. As such, the design provides a picture of the benefits of IQWST's design. The evaluation design allows us to track and compare the growth of student learning of both IQWST and a comparison group of non-IQWST students across the sixth, seventh, and eighth grades. Findings from the analysis of near measures provide evidence that the curriculum does support students in developing increased understanding of core ideas across time, advancing the theory that curricular coherence, brought about through the purposeful introduction of related and increasingly sophisticated science ideas, supports students in achieving greater learning outcomes.

Developing, Researching, and Scaling Up SmartGraphs

Grant #	0918522
NSF Program	NSF
PI	Carolyn Staudt
Co-PI(s)	Andrew Zucker
Institution	Concord Consortium
NSF Program Manager	Mike Haney
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	TBA

Our goal in this four-year project is to develop SmartGraphs, document their effectiveness through rigorous research, and scale them up so they become widely available. SmartGraphs are digital learning objects that "know" about themselves. They are able to provide students with explanations about the meaning of axes in a graph, what the different parts of a graph mean (e.g., "here is where the ball reached its maximum height"), and generally help students learn to look at a graph the way an expert does. All activities are based on the hypothesis that SmartGraphs, when used by knowledgeable teachers as part of well-designed learning activities, help students learn about graphs and the concepts represented in graphs more effectively than instruction without these tools. We believe that all students will learn by interacting with SmartGraphs, especially those who have difficulties with numbers or language, or who need extra support and scaffolding to use and understand graphs and the concepts represented in graphs. Students using SmartGraphs will learn to recognize key features of graphs and build associations between these features and contextualized events and processes. Over time, they will learn the "language" of graphs and need to use the SmartGraphs less often. Outcomes of the project will be open source SmartGraphs, high-quality research, and efforts to ensure that SmartGraphs are widely used by teachers and students. We are collaborating with Pennsylvania's Classrooms for the Future program, which is the nation's largest deployment of computers: 140,000 laptops in classrooms serving more than 500,000 high school students.

Development of K-8 Teachers' Knowledge and the Transition from University Student to Professional

Grant #	0455781
NSF Program	TPC
PI	John Madsen
Co-PI(s)	Danielle Ford, Steve Field, Harry Shipman, Richard Donham
Institution	University of Delaware
NSF Program Manager	Joan Prival
Grade Level Band	PreK, Middle School
Target Audience	Preservice
STEM Content Area	Science
Deliverables	Research Articles, Model K-8 Science Teacher Curriculum

In this five-year project, we use the framework of pedagogical context knowledge (PCxK) as a theoretical lens to address questions linked to the development of K-8 teachers' understandings of science and pedagogy across repeated experiences with inquiry learning in a reform-based professional development continuum. Use of this PCxK framework extends existing work on pedagogical content knowledge (PCK) and builds on its empirical and theoretical limitations to document how intellectual and personal barriers affect the change process when teachers encounter unfamiliar, inquiry-based approaches. Our design includes an interpretative research paradigm and a mix of quantitative and qualitative methods to explore the different dimensions of teacher knowledge encompassed by the PCxK framework.

We will study prospective elementary/middle school teachers as they progress along a continuum from the first year of college to the early years of teaching, as well as a population of middle school teachers engaged in lesson study. The design includes aggregated, population-level, and group/individual case studies. Our research team integrates the perspectives of scientist-educator, science teacher educators-scholars, and veteran K-8 teachers. The intellectual merit of this study is the use of a PCxK framework to examine the influence of reform approaches across a critical period in teacher development, extending the framework of PCK to incorporate processes by which students begin to understand themselves as science teachers rather than only as students. The broader impact of this study will be on practical understandings of the ways that innovative teaching helps to develop teachers' knowledge of science and pedagogy, and the developmental barriers that must be addressed along the way.

Diagnosing Teachers' Multiplicative Reasoning

Grant #	0903411
NSF Program	NSF
PI	Andrew Izsak
Co-PI(s)	Joanne Lobato, Chandra Orrill, Allan Cohen, Jonathan Templin
Institution	San Diego State University
NSF Program Manager	VanderPutten
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Test Form, Simulation Studies, Articles

Diagnosing Teachers' Multiplicative Reasoning (DTMR) is an exploratory project that addresses the assessment component of the DR-K12 Contextual Challenges strand. Investigating knowledge that teachers need to enable students' learning and developing assessments of that knowledge are central challenges for mathematics education. One approach, driven by accountability, emphasizes correlations between amounts of teachers' knowledge and levels of students' achievement. Another, grounded in research on mathematical thinking, often uses case studies to investigate teachers' capacities for identifying and building upon opportunities in students' problem-solving strategies. Tensions exist between these approaches because instruments convenient for assessing large numbers of teachers are insensitive to capacities for reasoning, while case study methods used to investigate teachers' reasoning are not practical with large samples. The DTMR project seeks to build a demonstration instrument both suitable for use with large samples of teachers and informative of their capacities to reason about content in ways that support students' thinking.

We seek to answer the following research question:
How can instruments be designed to diagnose teachers' multiplicative reasoning?

In particular, the DTMR project seeks to develop and evaluate a test form that diagnoses teachers' capacities in two closely connected sub-areas within the multiplicative conceptual field. The first has to do with reasoning about quantitative units necessary for using problem situations to build general numeric methods for arithmetic with fractions. The second has to do with using problem situations to build covariation and proportional reasoning. The project focuses on aspects of such reasoning that are interconnected and fundamental to addition and subtraction of quantities, multiplication of quantities, quotative and partitive division of quantities, and ratios of quantities. A main goal of the project is to address content and construct validity of the demonstration form in sufficient depth so that larger scale work and predictive validity studies may follow.

We are developing our instrument using a new class of psychometric models called Diagnostic Classification Models (DCMs). Using DCMs involves specifying components of reasoning in a particular domain and then constructing test questions (typically multiple-choice) systematically so that each choice corresponds to reasoning with a different combination of those components. We are drawing from the research on students' and teachers' multiplicative reasoning to identify useful components for building and validating one-test forms of 30 to 40 items. DCM simulation studies of estimation and equating methods are also an important component of the project. A strong research base exists regarding DCMs, but researchers have yet to develop instruments for these models from the ground up within the DCM framework. As a result, the project promises to interest both psychometricians and mathematics educators. The process by which we construct assessments using DCMs—where mathematics educators, mathematicians, and psychometricians work collaboratively to specify fundamental components of reasoning and develop validated instruments in a given domain—could serve as a model for developing further instruments that diagnose reasoning in other areas of multiplicative reasoning and reasoning in other STEM content areas.

Diagnostic E-Learning Trajectories Approach (DELTA) Applied to Rational Number Reasoning for Grades 3-8

Grant #	0733272
NSF Program	NSF
PI	Jere Confrey
Co-PI(s)	Mark Wilson
Institution	North Carolina State University
NSF Program Manager	Larry Suter
Grade Level Band	PreK, Middle School
Target Audience	Students, Other
STEM Content Area	Mathematics
Deliverables	Diagnostic Measures of Rational Number

The DELTA project is designing diagnostic assessments for rational number reasoning (RNR) for learning trajectories based on syntheses of the rational number reasoning literature. The key question we address is how to create valid, reliable, student-centered assessments that track students' development (and grades) over time in key mathematical ideas of rational number reasoning, and simultaneously provide teachers with instructional guidance on the basis of their students' cognitive development in rational number reasoning. Several strands of work have been pursued over the first year of the project, during which the lead group at North Carolina State University, the Berkeley Evaluation and Assessment Research Center, and the evaluation team have forged an effective and novel collaboration.

The project questions whether the dominant curricular sequence for fractions is the best way to think of RNR. This project's work fits with, challenges, and goes beyond the recommendation of the National Mathematics Advisory Panel report. Our work incorporates a much larger research literature base, much of which was omitted from the NMAP review, and explores how our project links this literature into a much fuller notion of rational number (multiplicative) reasoning.

Building on the research syntheses, the project has identified the equipartitioning learning trajectory that we believe may form a cognitive underpinning for RNR. The corresponding progress variable and items have been developed and are being field tested this autumn. The equipartitioning progress variable begins with the fair sharing of collections of items using dealing, proceeds to fair sharing of a single whole and then to fair sharing of multiple wholes. Within each type of fair sharing, there is an ordered sequence of numbers of partitions used as tasks that draw upon number theoretic qualities and geometry. Each time students engage in a task, they are expected to solve a problem, use multiple methods, justify their answers, name the results, reverse the process, and, at the highest level of proficiency, demonstrate understanding of the fundamental mathematical properties of compensation, equivalence, and composition.

Young children engage in rich mathematical behaviors that underlie a number of rational number learning trajectories, but they are not proficient in reading and writing, so new techniques of assessment presentation are needed to elucidate their mathematical reasoning. We are experimenting with innovative forms of assessment delivery, including video scenarios and interview data collection on handheld devices. We place a high priority on developing assessment settings that leverage dynamic representations, with the aim of aligning the assessment of mathematical reasoning to the skills, environment, and cognitive tools of the types that are standard in modern work settings and increasingly available in schools.

Digital Libraries go to School (Proof-of-Concept)

Grant #	0554440
NSF Program	TPC
PI	Mimi Recker
Co-PI(s)	Andrew Walker
Institution	Utah State University
NSF Program Manager	Michael Haney
Grade Level Band	PreK, Middle School, High School
Target Audience	Preservice, Inservice
STEM Content Area	Technology
Deliverables	PD Workshop Materials, Review Rubric

This project addresses two main needs: one is to determine how teachers view their roles in terms of adapting, designing, and reusing online resource (or learning objects) from digital libraries such as the National Science Digital Library (NSDL.org) in diverse classroom situations. For those who are new to this type of utilization, the project will examine how teachers' knowledge and skills are changed as a result of their interactions with these technologies and resources. Such findings will help inform the design of the emerging CyberInfrastructure for Education.

The second need is the creation of a professional/content development model will help preservice and in-service teachers expand their design capacity and take advantage of the availability of high-quality, online resources for learning, and extend the research on the impact of technology on learning.

The primary audience consists of professional development personnel with a secondary audience of teacher preparation faculty and, through them, pre-service teachers, and inservice teachers. Deliverables in the form of workshop materials will be made available for interested persons to conduct their own workshops or to incorporate into courses. An online version of the workshop will also be available for direct teacher use along with collaboration mechanisms for all workshop participants.

Following best practices, the workshop content will focus not only the mechanics of the technology but also on integration into classroom practice. In addition, the workshop process will consist of distributed training and follow-up and will involve master teachers.

Samples consist of 60 in-service teachers from New York (both urban and rural areas) split into three cohorts. Forty in-service teachers from a rural Utah school district will be matched with teachers from another rural school district as a control. Finally, 20 preservice teachers from Utah will form the final cohort. Data collection will consist of pre- and post- surveys drawing items from established instruments to assess moderating variables. Interviews and classroom observations will examine impacts on STEM content and pedagogical knowledge Finally, webmetrics will provide a lens into how teachers design and use learning activities with online resources, as well as their quality. Data from the Year 1 cohorts will be used to inform substantive revisions to the workshop model and materials.

Potential impacts include a scalable workshop model either delivered via the Web or by local facilitators, and an examination of impacts that reach beyond attitudinal measures to include impacts on teacher practice as well as students. We look forward to future work that examines the role of technology integration in professional development as well as potential policy implications for initiatives such as Title II D: Enhancing Education Through Technology (EETT) of the No Child Left Behind Act (NCLB).

Disciplinary Experts in Science Education Research: A University of Maryland Program for Producing STEM Education Researchers

Grant #	0733613
NSF Program	NSF
PI	David Hammer
Co-PI(s)	Andrew Elby (PD), Spencer Benson, Janet Coffey, Dan Falvey, Joe Redish, Mike Stieff
Institution	University of Maryland College Park
NSF Program Manager	Sharon Lynch
Grade Level Band	Post Secondary
Target Audience	Higher Education
STEM Content Area	Science
Deliverables	Highly Trained Scholars

Research in science education tends to take place among different communities of scholars focused on different age levels. By and large, a greater representation of scholars with backgrounds in developmental or educational psychology conduct studies at earlier grades, while a greater representation of scholars with backgrounds in science disciplines study high school and college students. Recent research that looks across age levels, however, suggests the value of close contact between these efforts. In particular, studies of children's scientific knowledge and reasoning have challenged earlier claims of roadblock-like developmental constraints, providing compelling evidence of children's knowledge of everyday phenomena, their logical and mathematical reasoning abilities, their sense of causal mechanism, and their abilities for abstraction, argumentation, and analogical reasoning. Development, in this view, is understood not as a strictly linear passage through universal stages but as a looser, developmentally guided progression involving variation and contextual sensitivity, with abilities activating in some situations but not others. Studies have similarly begun to depict older students as having rich stores of productive conceptual ideas upon which to build and as having inquiry-related abilities for science. This work supports a view of learning as consisting in part of tapping and refining those cognitive resources. Few scholars, however, are prepared to study science learning from the seeds of scientific inquiry in young children to emerging disciplinary expertise in college and graduate students. This project—a graduate program to produce such scholars— is able to attend to the full spectrum of learning and development from early beginnings of scientific reasoning in childhood through disciplinary expertise as adults.

Building from an established Physics Education Research Group, which spans the departments of Physics and Curriculum and Instruction, the Disciplinary Experts in Science Education Program (DESEP) is a collaboration among faculty in those departments plus the Departments of Chemistry and Biochemistry and Cell Biology and Molecular Genetics. DESEP Scholars achieve masters-level understanding of their science disciplines, take courses centered in the learning sciences, and participate in research and teaching experiences that prepare them to collaborate with educational and developmental psychologists and with discipline-based science education researchers on issues that cut across ages, and develop and teach courses that break down the traditional barriers between science-teaching-methods courses and science-content courses for teachers.

Strong background in a science discipline and in the learning sciences prepares DESEP Scholars to address rich, instructionally relevant issues such as, What productive seeds of scientific thinking do young children exhibit that could contribute to disciplinary expertise as adults? How can teachers and learning environments help those seeds develop? How can that development be assessed?

Dynamic Geometry in Classrooms

Grant #	0918744
NSF Program	NSF
PI	Zhonghong Jiang
Co-PI(s)	Gilbert Cuevas
Institution	Texas State Univeristy San Marcos
NSF Program Manager	James T. Fey
Grade Level Band	High School
Target Audience	Students, Students - Special Population, Inservice
STEM Content Area	Technology, Mathematics
Deliverables	Website, Research Findings/Articles

This project is conducting repeated randomized control trials of an approach to high school geometry that utilizes DG software and supporting instructional materials to supplement ordinary instructional practices. It compares effects of that intervention with standard instruction that does not make use of computer drawing tools. The basic hypothesis of the study is that use of DG software to engage students in constructing mathematical ideas through experimentation, observation, data recording, conjecturing, conjecture testing, and proof results in better geometry learning for most students. The study tests that hypothesis by assessing student learning in 76 classrooms randomly assigned to treatment and control groups. Student learning is assessed by a geometry standardized test, a conjecturing-proving test, and a measure of student beliefs about the nature of geometry and mathematics in general. Teachers in both treatment and control groups receive relevant professional development, and they are provided with supplementary resource materials for teaching geometry. Fidelity of implementation for the experimental treatment is monitored carefully. Data for answering the several research questions of the study are analyzed by appropriate HLM methods. Results will provide strong evidence about the effectiveness of the DG approach in high school teaching—evidence that can inform school decisions about innovation in that core high school mathematics course.

The general plan for the four-year project is as follows:
Year 1: Preparation (research instruments, professional development training, resource materials, recruitment, and training of participants, etc.)
Year 2: The first implementation of the dynamic geometry (DG) treatment, and related data collection and initial data analysis
Year 3: The second implementation of the DG treatment, and related data collection and initial data analysis
Year 4: Careful and detailed data analysis and reporting

The advisory board will provide advice and help each year during the project implementation.

The work to be completed in project year 1 includes:
(1) The random selection of 76 teachers to participate in the efficacy trial, and the random assignment of these teachers to two groups—the Experimental Group and the Control Group;
(2) The development of the research instruments and curriculum/resource materials (i.e., geometry curriculum materials, professional development materials, conjecture-proving test, student belief questionnaire, DG implementation questionnaire, classroom observation instrument, and student interview protocol)
(3) The participating teachers' professional development training

The advisory board will provide advice and help on the above three tasks during project year 1, mainly in reviewing the research instruments and curriculum/resource materials that the project team developed.

Ecology Disrupted: Using Museum-based Science and Educational Technology to Link Real World Environmental Issues to Basic Ecological Principles (Gano-previous)

Grant #	0733269
NSF Program	NSF
PI	Steve Gano
Co-PI(s)	Yael Wyner, Rob DeSalle
Institution	American Museum Natural History
NSF Program Manager	Julia Clark
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Two Ecology Case Study Modules

Our project asks whether media-rich curriculum materials that immerse middle and high school students in real, current scientific research can improve students' understanding of science content, and their understanding and appreciation of science as a way to learn about the natural world. We are using Science Bulletins, digital media stories about current science produced by the American Museum of Natural History (AMNH) in New York City to develop middle and high school case-study units on contemporary issues in ecology for students underserved in their connection to nature.

We are developing two problem-based modules that use current scientific data to link ecological principles to real-world environmental issues. Each unit is constructed around a question linking the ecological topic with human daily life. One unit asks the question, How do snowy and icy roads put the Baltimore area's water supply at risk? The other asks the question, How does being able to drive between Los Angeles and Las Vegas in under five hours put the bighorn sheep at risk? The students must use source material to develop hypotheses to address these questions. They then analyze real data to test their hypotheses. Finally, they watch and analyze Museum media to connect the questions that they investigated to broader ecological principles and issues. Additionally, students are asked at the beginning and the end of these units to self-assess their understanding of the science content, the nature of scientific inquiry, and their place in the natural world.

Ecology Disrupted: Using Real Scientific Data about Daily Life to Link Environmental Issues to Ecological Processes in Secondary School Science Classrooms (Collaborative Research - Gano)

Grant #	0918583
NSF Program	NSF
PI	Steve Gano
Co-PI(s)	Rob DeSalle
Institution	CUNY City College
NSF Program Manager	Julia Clark
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	3 lesson modules, dissemination website

We are refining and testing two case study units on contemporary issues in ecology for urban middle and high school students underserved in their connection to nature. The case studies are based on two Science Bulletins, digital media stories about current science produced by the American Museum of Natural History (AMNH), which use current scientific data to link ecological principles to real-world environmental issues, and to link issues to human daily life. One unit asks the question, How are snowy and icy roads connected to a city's water supply? The other asks the question, How might being able to drive between Los Angeles and Las Vegas in just four hours put local bighorn sheep at risk? The units provide source material and real data for students to investigate these questions, video profiles of scientists that engage students in the science and the research, and the Museum Science Bulletins media for students to analyze and connect the questions to broader ecological principles and issues. We are using these modules to research the question, Can curricular units that link environmental issues to ecological principles through analysis of real data from published research on the environmental impacts of familiar everyday activities improve student learning of ecological principles, personal and human environmental impacts, and the nature of scientific activity?

Randomized control trials of 60 ninth-grade NYC public school classrooms will evaluate the efficacy of the modules. Assessment items from New York State Regents exams will be reviewed and new assessment items will be developed, field tested, and analyzed for validity and reliability. Students in the experimental and control classrooms will be pre- and post-tested using the assessments. In addition, teachers and students will complete pre-post surveys, and stratified samples of teachers will be observed and interviewed. To evaluate the effects of the intervention on student achievement and on instructional practices, descriptive and inferential statistics, including analysis of variance (ANOVA) models, will be employed in addressing the core research question about student achievement. ANOVA models will also be used to measure main effects and interactions between the intervention and other variables as they relate to student achievement.

Finally, we will apply our evaluation findings from testing the modules to develop a summative module on oyster fishing in Chesapeake Bay. Also, to disseminate the materials online to a national audience, we will develop an online "kit of parts" of module components to enable teachers to create customized modules that target their students' specific instructional needs.

Ecology Disrupted: Using Real Scientific Data about Daily Life to Link Environmental Issues to Ecological Processes in Secondary School Science Classrooms (Collaborative Research - Wyner)

Grant #	0918629
NSF Program	NSF
PI	Yael Wyner and Steve Gano
Co-PI(s)	Jonathan Becker and Rob DeSalle
Institution	City College of New York/American Museum of Natural History
NSF Program Manager	Dr. Julia Clark
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Curriculum

We are refining and testing two case study units on contemporary issues in ecology for urban middle and high school students underserved in their connection to nature. The case studies are based on two Science Bulletins, digital media stories about current science produced by the American Museum of Natural History (AMNH), which use current scientific data to link ecological principles to real-world environmental issues, and to link issues to human daily life. One unit asks the question, How are snowy and icy roads connected to a city's water supply? The other asks the question, How might being able to drive between Los Angeles and Las Vegas in just four hours put local bighorn sheep at risk? The units provide source material and real data for students to investigate these questions, video profiles of scientists that engage students in the science and the research, and the Museum Science Bulletins media for students to analyze and connect the questions to broader ecological principles and issues. We are using these modules to research the question, Can curricular units that link environmental issues to ecological principles through analysis of real data from published research on the environmental impacts of familiar everyday activities improve student learning of ecological principles, personal and human environmental impacts, and the nature of scientific activity?

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Ecosystems and Evidence Project (Collaborative Research - Berkowitz)

Grant #	DRL 0918610
NSF Program	NSF
PI	Alan R. Berkowitz
Co-PI(s)	Rebecca Jordan, Jacqueline DeLisi
Institution	Cary Institute of Ecosystem Studies
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Frameworks, Research, PD

Ecosystems and Evidence is an exploratory research and development project addressing DR-K12 Challenges 1, 2 and 3: developing and testing assessments for improving instruction, exploring how students can learn challenging content (ecological nature of science), and enhancing the ability of teachers to provide this content. The guiding question is, Can students develop an understanding of the ecological nature of science (ENOS) in high school biology and environmental science classes that is useful and productive in environmental citizenship? To address this question, the project will identify the essential elements of ENOS, investigate how these can be taught and learned, and explore how ENOS skills and understandings are used to enhance environmental citizenship. Four core hypotheses form the research focus and rationale for the project: (1) ENOS is distinctive in important ways from generic NOS; (2) ENOS mastery enhances students' abilities to critique claims, address issues, and support scientific approaches to problems; (3) personal facility with ENOS and related teaching, recognition of ENOS as a worthy target of instruction, and self confidence enable teachers to integrate ENOS into their instruction; and (4) students can develop ENOS mastery when they have direct experience creating arguments from ecological evidence of diverse types in diverse contexts, reflect on ENOS, and have scaffolded experiences transferring ENOS within ecology and to other arenas.

To explore these hypotheses, the project will define ENOS, develop assessment tools for describing students' and teachers' skills and understandings of ENOS, and test ways for teachers and students to become more adept at acquiring and applying ENOS skills and knowledge. ENOS Learning Communities (high school biology and environmental science teachers, ecologists and educators) at the Cary Institute (mid-Hudson Valley, NY) and Rutgers University (New Brunswick, NJ) will work with a Concept Development Team (8 ecologists, educators, and teachers) to develop an ENOS framework, plan and carry out student and teacher research, develop ENOS teaching experiments, test approaches to teacher professional development, and craft a plan for broader application of the ENOS framework and teaching models.

Ecosystems and Evidence Project (Collaborative Research - DeLisi)

Grant #	DRL-0918648
NSF Program	NSF
PI	Alan Berkowitz
Co-PI(s)	Rebecca Jordan, Jacqueline DeLisi
Institution	Cary Institute of Ecosystem Studies
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Frameworks, Research, PD

Ecosystems and Evidence is an exploratory research and development project addressing DR-K12 Challenges 1, 2 and 3: developing and testing assessments for improving instruction, exploring how students can learn challenging content (ecological nature of science), and enhancing the ability of teachers to provide this content. The guiding question is, Can students develop an understanding of the ecological nature of science (ENOS) in high school biology and environmental science classes that is useful and productive in environmental citizenship? To address this question, the project will identify the essential elements of ENOS, investigate how these can be taught and learned, and explore how ENOS skills and understandings are used to enhance environmental citizenship. Four core hypotheses form the research focus and rationale for the project: (1) ENOS is distinctive in important ways from generic NOS; (2) ENOS mastery enhances students' abilities to critique claims, address issues, and support scientific approaches to problems; (3) personal facility with ENOS and related teaching, recognition of ENOS as a worthy target of instruction, and self confidence enable teachers to integrate ENOS into their instruction; and (4) students can develop ENOS mastery when they have direct experience creating arguments from ecological evidence of diverse types in diverse contexts, reflect on ENOS, and have scaffolded experiences transferring ENOS within ecology and to other arenas.

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Educating about Statistical Issues in Large Scientific Data Sets

Grant #	0822178
NSF Program	NSF
PI	James Hammerman
Co-PI(s)	
Institution	TERC
NSF Program Manager	Robert Gibbs
Grade Level Band	High School
Target Audience	Students, Inservice, Other
STEM Content Area	Science, Technology, Mathematics
Deliverables	Lit Review and Reports/ Design Documents

The Exploratory project Educating about Statistical Issues in Large Scientific Data Sets identifies and describes the concepts and techniques in data analysis and statistics that are needed for secondary students to more effectively learn from and about large scientific and social scientific data sets, and develops a set of software and curricular design recommendations to address these needs. In a world in which increased technical and computing power makes it possible, even easy, to gather and analyze vast quantities of data, scientists and citizens alike must have a deeper understanding of the statistical and data analytic concepts and methods needed to make sense of these data, so that they can better understand the science and social science itself.

Many large data sets are used to investigate fascinating and critical social and scientific issues—climate change, environmental degradation, the human genome, the search for extra-solar planets, the value of medical innovations, economic justice issues, and the quality of schools, among others. Yet, students need tools and curricular supports to be able to understand the statistical ideas necessary for exploration and analysis of these data sets. This project assesses just what students need to know to analyze data in a number of disciplinary areas and makes recommendations for curricular innovations. It will clarify and integrate educational goals and needs across both statistics education and a variety of scientific and social scientific fields. The design recommendations stemming from interdisciplinary conversations have the potential to improve students' understanding of both statistical and scientific concepts.

The project reviews the literature on statistical learning especially as it relates to large data sets, and identifies a range of science and social science education projects using such data. We work intensively with a stellar set of scientist-educators from across several disciplines—biology, Earth science, environmental science, economics, astronomy, statistics, and software development—to explore a number of large data sets and to identify the data analytic concepts and techniques needed for secondary students to work with and understand them. A report on this research will summarize commonalities and differences in the data analytic needs of different sorts of data-intensive scientific investigations. It will also form the basis for a priorities-setting meeting that will result in recommendations for design of software and curricular tools to support data analytic learning centered on large data sets. Both reports will be presented at academic conferences and published online and in peer-reviewed journals.

This project taps the potential for student engagement with large scientific and social scientific data sets to deepen students' understanding of data and statistics and, thus, of the science or social science content. It brings together researchers across a variety of domains to have conversations about priorities for educational innovation, develops and disseminates curriculum and software design recommendations, and ultimately supports deeper student learning and thinking about important scientific and social scientific claims.

Effective Science Teaching for English Language Learners (ESTELL): A Pre-Service Teacher Professional Development Research Project Across Three Universities in California

Grant #	0822402
NSF Program	NSF
PI	Patricia Stoddart
Co-PI(s)	Alberto Rodriguez, Marco Bravo, Jerome Shaw, Andrea Whittaker
Institution	University of California, Santa Cruz
NSF Program Manager	Joseph Reed
Grade Level Band	PreK
Target Audience	Preservice
STEM Content Area	Science
Deliverables	Curriculum and Research Findings

The Effective Science Teaching for English Language Learners (ESTELL): A Pre-Service Teacher Professional Development Research Project is funded by the National Science Foundation DR-K12 Discovery Research Program. The ESTELL project focuses on improving the science teaching and learning of K-6 linguistic minority students who are currently underserved in K-6 education through improving the preservice education of elementary school teachers. The goal of this project is to design, implement, and evaluate a comprehensive, integrated model of preservice elementary science teacher education by adapting a model of linguistically and culturally responsive ESTELL pedagogy that prior research has demonstrated significantly improves the achievement of English language learners. ESTELL involves a collaboration between researchers and science teacher educators at the University of California-Santa Cruz, San Diego State University, San Francisco State University, and San Jose State University.

The empirical evidence for ESTELL is based on two bodies of prior work produced by researchers in the USDOE-funded Center for Research on Education Diversity and Excellence (CREDE) project and the NSF-funded Language Acquisition through Science Education in Rural Schools (LASERS) project. Both approaches have identified a common set of specific and observable teacher actions that a substantial body of empirical research has demonstrated raise the achievement of culturally and linguistically diverse students and improve their motivation to learn. This research has identified five areas of teaching practice that promote the achievement of ELL:
(1) Language & Literacy (LL): Teacher use of authentic science literacy tasks to support science learning. Teacher use of science discourse patterns and science vocabulary.
(2) Contextualization (C): Teacher elicitation of student expertise from home/community (culture) or local (environmental/natural surrounding) understandings of science-related phenomena in classroom science lessons.
(3) Collaborative Inquiry (CI): Student-led participation in science activities with a shared goal resulting in a material or symbolic product used for or an outcome of scientific processes.
(4) Instructional Conversation (IC): Teacher initiation of conversation that requires student scientific reasoning and dialogue.
(5) Complex Thinking (CT): Teacher elicitation and modeling of complex reasoning of science concepts.

The ESTELL teacher education program integrates ESTELL pedagogy into all components of preservice teacher education:
(1) ESTELL science teaching methods course
(2) Teaching practicum with coaching and support in the ESTELL pedagogy by teacher supervisors and cooperating teachers who model ESTELL pedagogy
(3) Coaching and support for ESTELL pedagogy in the first year of teaching.

The primary research focus is to compare the knowledge, beliefs, and practice of elementary-student and beginning teachers who participate in the ESTELL preservice teacher education program with that of student and beginning teachers who are not trained in the ESTELL model. Researchers will study three successive

cohorts of student teachers from their entry into the preservice teacher education program through their second year of teaching across three stages of implementation. Novice teachers will complete the ESTELL Teacher Beliefs Survey (ETBS) and be observed using the DAISI (Dialogic Activity in Science Instruction Rubric).

Effective Use of Mathematical Instructional Materials

Grant #	0454022
NSF Program	IMD
PI	June Mark
Co-PI(s)	Deborah Spencer
Institution	Education Development Center, Inc.
NSF Program Manager	John (Spud) Bradley
Grade Level Band	PreK, Middle School, High School
Target Audience	Administrators, Policy Makers, Other
STEM Content Area	Mathematics
Deliverables	Conf. Presentations, Research Papers

In recent years, national attention has focused on the use and role of instructional materials in mathematics education to improve student achievement. New national standards, international comparisons, and demands for increasing accountability suggest the need for broader research and stronger evidence about the effective use of mathematics curricula. This four-year project will address these needs. The project aims to:
• better understand curriculum leaders' needs for research to inform their decision-making;
• increase mathematics education researchers' understanding of those needs;
• identify, synthesize, and organize research that is most useful to curriculum leaders on the effective use of instructional materials in mathematics; and
• develop and test mechanisms for curriculum leaders to help them understand and make good use of such research.

The project combines applied research investigating curriculum decision making with resource development to improve curriculum leaders' access to and use of research on mathematics curricula. Specifically, the project will conduct a landscape study of curriculum decision making to learn more about how curriculum decision makers in K–12 mathematics education interact with research. We will use survey, interview, and case-study research methods to gather data. The study aims to understand the complexities and realities of how districts select curriculum materials. The centerpiece of the research study is a set of interviews conducted with more than 150 K–12 mathematics curriculum decision makers from districts in eight states. The states—Colorado, Louisiana, Maine, New York, Ohio, Texas, Washington, and West Virginia—represent a mix of state-adoption and open-territory states across the country. An analysis of our interview data is supplemented by other sources, including a survey of the members of the Association of State Supervisors of Mathematics; a series of surveys of curriculum leaders nationally conducted by our collaborators at Inverness Research Associates; an investigation of state-level documents and websites; and a review of the relevant literature. The project will also create a digital collection of resources, including research bibliographies, on the project website for use by district, state, and regional curriculum leaders as well as mathematics teacher educators.

The following questions guide the research:
• What processes do school districts use in selecting mathematics textbooks?
• What factors shape those decisions?
• How does textbook selection differ in state-adoption and open-territory states?
• What research do curriculum leaders find most useful in textbook selection?
• What questions about mathematics textbooks do decision makers need answered?

The project builds on the past work of EDC's K–12 Mathematics Curriculum Center and is conducted in partnership with Inverness Research Associates. The project is funded by the National Science Foundation's Instructional Materials Development program, under the category of Applied Research/Research-to-Practice.

Electronic Teacher Guide: Its Development and Use in Supporting Educative Curricula

Grant #	0918702
NSF Program	NSF
PI	Jacqueline S. Miller
Co-PI(s)	Bill Tally
Institution	Education Development Center, Inc.
NSF Program Manager	David Haynch
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Digital Teacher Guide

The Center for Science Education (CSE) and the Center for Children and Technology (CCT) at Education Development Center, Inc., are undertaking a research and development project aimed at enhancing the ability of teachers to provide science education. The project will develop a prototype of an electronic teacher guide (eTG) and, in a series of classroom-based studies, determine how its use impacts teacher learning and practice, particularly in relation to the fidelity with which teachers modify and adapt instructional materials at the secondary level.

The eTG will be based on a print teacher guide developed for a 12-week genetics unit from an NSF-funded high school science curriculum developed by CSE, Foundation Science: Biology, and will provide features of new media that support the needs of a range of teachers, customizing the content and providing different interfaces and layers for teacher resources and pedagogical supports. At its core, the eTG design will be based on a series of teacher profiles developed in early user research, enabling the tool to anticipate and meet teachers' varying needs and preferences in regard to curriculum planning and support. It will support teachers in planning, implementing, and reflecting on innovative instructional materials, providing "just-in-time" and "point-of-use" access to rich media resources relating to science content and best teaching strategies.

Once developed, pilot studies will examine the fidelity with which high school educators who are using the eTG teach the Foundations genetics curriculum, using measures of fidelity centered on the concept of "opportunities to learn." The studies will address the following question: Do teachers who make substantial use of the eTG teach Foundation Science lessons with at least a moderate level of fidelity (LOF) to the intended curriculum? More specifically, (a) for teachers who identify themselves as having relatively low subject matter knowledge (SMK), is use of the eTG associated with a moderate level of fidelity (or higher) in the teaching of the intended science content knowledge? and (b) for teachers who identify themselves as having relatively low pedagogical content knowledge (PCK), is use of the eTG associated with a moderate level of fidelity (or higher) to the intended pedagogy in Foundation Science lessons?

Project outcomes will include (1) a prototype electronic teacher guide for an NSF-funded high school genetics curriculum; (2) design guidelines for creating planning and teaching supports for rigorous science curricula that address varied teacher work styles and needs; and (3) research findings that illuminate the potential of digital media to enhance the educative properties of curriculum materials, as part of the broader effort to improve the quality of science teaching.

Elicitory Test Design: A New Model for Understanding the Relationship Between Test Item Features and Student Performance on Large-Scale Assessments

Grant #	0733329
NSF Program	NSF
PI	Sharon Nelson-Barber
Co-PI(s)	
Institution	WestEd
NSF Program Manager	Larry Suter
Grade Level Band	Middle School
Target Audience	Students - Special Population
STEM Content Area	
Deliverables	Journal Articles, Model, Book

Research establishes an urgent need to improve the cultural validity of large-scale tests across diverse contexts. Understanding how aspects of cultural knowledge can become visible within the formats of large-scale testing is essential to making assessment more equitable for all students. This exploratory study seeks to develop a model for "elicitory test design" based on identification of test features that extract student knowledge, allowing students to reveal what they know, regardless of how well their cultural backgrounds, life experiences, and community languages fit with test makers' assumptions. Data sets come from NCES' NAEP science and mathematics assessments administered in 2005 and include performance results from grades 4 and 8, along with the 2005 survey data collected as part of the National Indian Education Study (NIES) designed to tap the educational experiences of indigenous students of American Indian, Alaska Native, and Pacific Islander descent. The differential item functioning (DIF) method using generalized Mantel-Haenszel procedure was first used to identify items that showed performance differences between American Indian students and white students. Next, these DIF items (along with some other selected non-DIF items) were further examined through linguistic and cultural analyses to identify possible reasons why DIF did or did not occur. We view this work as a key step toward developing testing instruments that are designed to engage students in demonstrating what they do know and that have a robust ability to glean representative samples of student knowledge from learners of all groups.

Engaging Middle School Students in Student-directed Inquiry through Virtual Environments for Learning

Grant #	0628264
NSF Program	IMD
PI	Susan Pedersen
Co-PI(s)	Janie Schielack, Douglas Williams, Scott Slough
Institution	Texas A&M University
NSF Program Manager	Mike Haney
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Science
Deliverables	Instructional Materials

Research establishes an urgent need to improve the cultural validity of large-scale tests across diverse contexts. Understanding how aspects of cultural knowledge can become visible within the formats of large-scale testing is essential to making assessment more equitable for all students. This exploratory study seeks to develop a model for "elicitory test design" based on identification of test features that extract student knowledge, allowing students to reveal what they know, regardless of how well their cultural backgrounds, life experiences, and community languages fit with test makers' assumptions. Data sets come from NCES' NAEP science and mathematics assessments administered in 2005 and include performance results from grades 4 and 8, along with the 2005 survey data collected as part of the National Indian Education Study (NIES) designed to tap the educational experiences of indigenous students of American Indian, Alaska Native, and Pacific Islander descent. The differential item functioning (DIF) method using generalized Mantel-Haenszel procedure was first used to identify items that showed performance differences between American Indian students and white students. Next, these DIF items (along with some other selected non-DIF items) were further examined through linguistic and cultural analyses to identify possible reasons why DIF did or did not occur. We view this work as a key step toward developing testing instruments that are designed to engage students in demonstrating what they do know and that have a robust ability to glean representative samples of student knowledge from learners of all groups.

Engaging Youth in Engineering Module Study

Grant #	0918769
NSF Program	NSF
PI	Susan Pruet
Co-PI(s)	Robert Foley, Martha Peek
Institution	Mobile Area Education Foundation
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School
Target Audience	Students, Inservice, Administrators
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Middle-Grades Engineering Modules

The Engaging Youth in Engineering (EYE) Module Study is developing, pilot testing, and field testing two engineering modules for middle school science and mathematics classes: Bioengineering the Future, with a focus on seventh-grade life science, and Engineering Clean Energy, targeting eighth-grade physical science. Each module addresses an engineering design challenge of relevance to industries in the region and fosters the development of engineering habits of mind. The approach integrates technology and other resources to engage and meet the diverse needs of children in a large, urban school district, and deepens student understanding of selected middle-grades mathematics and science content. The theoretical foundations for the module development are grounded in contemporary learning research. Instructional design of the materials emphasizes contextual learning, collaboration, content integration, and embedded assessments within the framework of the backward design process.

Teacher professional development materials are being developed, and participating mathematics and science teachers from the collaborating middle schools engage in at least one week of professional development each summer. An EYE coach assists with professional development and supports the teachers on site during the implementation of the modules. The field-testing sites offer opportunities to assess the impact of the instructional materials across diverse groups of students.

This project explores the workability of incorporating engineering-design experiences into standards-based courses to move toward an integrated STEM middle school curriculum in science, technology, engineering, and mathematics, with an emphasis on mathematics. This approach has potential to strengthen middle school STEM programs through the integration of engineering experiences.

Engineering is Elementary: Engineering and Technology Lessons for Children

Grant #	0454526
NSF Program	IMD
PI	Christine Cunningham
Co-PI(s)	Kate Hester, Ioannis Miaoulis, Nancy Yocom de Romero
Institution	Museum of Science, Boston
NSF Program Manager	Gerhard Salinger
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Technology, Engineering
Deliverables	Curriculum, PD, Research

The Engineering is Elementary: Engineering and Technology Lessons for Children (EiE) project aims to promote the learning and teaching of engineering and technology by elementary school students and teachers in grades 1-5. At its core, the EiE project is creating research-based curriculum materials that integrate engineering and technology concepts and skills with elementary science lessons.

Each set of EiE lessons integrates an elementary school science topic with a specific field of engineering. Each of the 20 units is designed to engage students in the engineering design process and includes the following:

- a storybook narrated by a child character from around the world. As the child tries to solve a problem, he or she is introduced to what engineering is, some basic engineering concepts, and some related science content. The problem the child character engages with is the same one that readers will engage with in their classrooms.
- lessons plans with detailed instructions for teachers.
- duplication masters: ready-to-photocopy activities and handouts for students available in two levels: basic (suggested for grades 1 and 2) and advanced (suggested for grades 3-5).
- assessments rubrics and multiple-choice and open-ended questions that teachers can use to gauge their students' understanding and learning of engineering, technology, and science concepts.
- background information and additional reference resources for teachers.

All materials are designed to meet the national Standards for Technological Literacy and connect with literacy, social studies, and mathematics. Close collaboration and feedback of a cadre of local pilot teachers and a larger set of national field-test teachers in five states guide development. Data from students and teachers inform revisions of materials.

EiE materials are grounded in ongoing research and assessment of student and teacher conceptions, learning, and attitudes and of teachers' perceptions of the EiE curriculum. We are collecting qualitative and quantitative data from students and teachers nationally to better understand how children best learn about engineering and how our materials impact their understandings. National, statistical, controlled studies indicate that children who engage with EiE materials have a much better understanding of engineering and technology concepts than children who do not.

Engineering is a new discipline for elementary school teachers. To support the teaching of engineering and technology, EiE offers professional development workshops for elementary school educators. These sessions provide teachers with an overview of engineering concepts and skills, introduce teachers to the curriculum materials, and engage the teachers in the activities in the lessons.

Through the EiE Hub Site Initiative, EiE project staff work with professional development providers from across the country to familiarize them with the program and its methods so they can offer workshops and support for local teachers, educators, and afterschool providers in their states. To this end, the project has developed the EiE Handbook for Professional Development. As of April 2009, over a million students and 15,500 students in 50 states were using our materials.

Enhancing Engineering Education with Computational Thinking

Grant #	0918449
NSF Program	NSF
PI	Qian Xie
Co-PI(s)	
Institution	Concord Consortium
NSF Program Manager	Dan Householder
Grade Level Band	
Target Audience	
STEM Content Area	Science, Engineering
Deliverables	Software, Hardware, Curriculum, Research

This project will investigate the educational value of scientific simulations for learning engineering through engaging high school students to design and build an energy-efficient scale-model house with the aid of computer simulations and probeware measurement. In partnership with the Center for Engineering Education and Outreach at Tufts University, this project will test the assertion that simulations and hands-on projects are mutually beneficial. The project will develop an education-oriented, student-friendly simulation tool, SimEng, which will be capable of accurately modeling the engineering problems students will encounter in this project. More importantly, it will have unique features needed to ensure the success of this research. To scaffold the design activities and facilitate the research, four instructional units that integrate science concepts, engineering principles, simulations, and hands-on projects will be developed. A controlled study with approximately 600 students using the materials, in which the control group will use only a hands-on kit and the experimental group will use the complete set of engineering tools—a hands-on kit plus SimEng—will be conducted. Data will be collected extensively through various research instruments and analyzed statistically. The proposed research will shed light on potential learning enhancements using simulations, which are critically important in design-based learning, engineering education, and cyberlearning. Results will be published in peer-reviewed journals, presented at related conferences, and disseminated through teacher networks and through collaboration with the Boston Museum of Science, Tufts University, Purdue University, and Hofstra University.

Equity and Access to High-Quality Instruction in Middle School Mathematics

Grant #	0830029
NSF Program	NSF
PI	Kara Jackson
Co-PI(s)	Paul Cobb
Institution	Vanderbilt University
NSF Program Manager	Julio E. Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Preservice, Higher Education, Policy Makers
STEM Content Area	Mathematics
Deliverables	Instructional Quality Rubrics, Articles

This research focuses on issues of equity and access in middle school mathematics instruction in the context of a currently funded project, Designing Learning Organizations for Instructional Improvement in Mathematics (DLO). Our overall goal in the DLO project is to test and refine a series of hypotheses about school and district institutional structures that might support mathematics teachers' development of high-quality instructional practices at scale. We are conducting this study in four large urban districts that are attempting to achieve a vision of high-quality mathematics instruction that is broadly compatible with NCTM's (2000) recommendations. Issues of equity are central to the districts' efforts to improve middle school mathematics instruction, particularly the challenge of supporting African American students and English language learners (ELLs) to participate substantially in academically rigorous mathematics instruction.

We have two goals in the Equity and Access project. Our first goal is to develop an instrument for assessing the quality of mathematics instruction that focuses specifically on the needs of African American and ELL students. To this end, we are in the midst of completing a set of rubrics that compliment the Instructional Quality Assessment (IQA) (Crosson, Junker, Matsumura, & Resnick, 2003). The IQA focuses on (1) the cognitive demands of the instructional tasks used in lessons, (2) the clarity of expectations for students' learning, and (3) the nature of classroom discourse. The IQA was designed to align with the Mathematical Tasks Framework (Stein, Smith, Henningsen, & Silver, 2000); however, it does not assess the quality of the task-as-set-up phase of instruction. We have developed a set of rubrics that focuses on this phase of instruction and measure (1) the establishment of students' familiarity with the problem scenario (i.e., the non-mathematical context) and (2) the development of students' situation specific images of what is to be mathematized (i.e., the mathematical context). We are developing another set of rubrics that focuses on the extent to which ELLs are supported to participate in mathematical discussions.

Our second goal is to develop analytic methods for analyzing interview data collected in the DLO project specific to an equity focus. To this end, we have developed a coding scheme that focuses on the following:

- categories participants used to describe groups of students and the characteristics they ascribed to those categories,
- pedagogical actions teachers described taking to meet the needs of low-performing students,
- the extent to which participants took responsibility for student learning,
- instructional leaders' instructional expectations, and
- school- and district-level supports specific to issues of equity (e.g., professional development).

We recently used this coding scheme to assist in an analysis that shows how aspects of the institutional setting (e.g., quality of professional development, opportunities to collaborate with colleagues, relations of accountability and assistance) mediate the extent to which middle school teachers who account for students' performance in terms of instructional opportunities actually support students' learning equitably in the classroom.

The development of these two tools will allow us to identify and investigate school and district institutional structures that support mathematics teachers' development of equitable instructional practices at scale.

Evaluation of the Cognitive, Psychometric, and Instructional Affordances of Curriculum-Embedded Assessments: A Comprehensive Validity-Based Approach

Grant #	0732090
NSF Program	NSF
PI	James Pellegrino
Co-PI(s)	Susan Goldman, Louis DiBello, Kimberly Gomez, James Minstrell
Institution	University of Illinois at Chicago
NSF Program Manager	James Dietz
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Mathematics
Deliverables	Report, Assessment Model, Evaluation Design

This project has the goal of improving our practical and theoretical understandings of standards-driven elementary school mathematics curricula by investigating their embedded assessments and evaluating their structure and role within the curriculum. We focus on three fundamental questions: (1) What constitutes high-quality curriculum-embedded assessment in K-8 school mathematics? (2) How does it support student learning in an ongoing instructional process tied to nationally defined standards (NCTM, 2000)? (3) What do teachers need to know to make effective use of such assessments in their practice? To address the project goals and questions, we focus on in-depth analyses of a substantial subset of assessment cases embedded within the Everyday Mathematics (EM) and Math Trailblazers (MTB) curricula with a specific focus on grade-4 materials within the two curricula. Our research is situated in the ethnically and linguistically diverse Chicago Public Schools, and our results will contribute to multiple literatures relevant to ensuring high-quality, equitable, and principled opportunities for all students in mathematics learning.

As part of developing our research approach we have elaborated a specific validity model that takes into account the various forms of validity that are typically discussed for large-scale, standardized tests (e.g., Messick, 1989; AERA, APA, NCME, 1999; including recent work by Kane, 2004; Moss, 2006). We focus on separate and complementary aspects of validity for embedded assessments—those specifically designed to support teaching and learning.

Our three components of validity, their rationale, and what they are designed to address are as follows:
• Cognitive Validity: Given what we know about the nature of student cognition and mathematical understanding (e.g., Donovan et al., 2005; Kilpatrick et al., 2001), to what extent does an assessment tap important forms of mathematical knowledge and skill and in ways that are not confounded with other aspects of cognition such as language or working memory load? To address cognitive validity, we evaluate the cognitive underpinnings for curriculum-embedded assessments, including what they reveal about student learning and understanding of critical mathematical concepts and procedures.
• Instructional Validity: Given what we know about the nature of assessment use as a guide to instruction (e.g., Black et al., 2004; Wiliam, 2007), to what extent does an assessment support teaching practice and provide valuable and timely instructional information? To address instructional validity, we evaluate the instructional backing and support of embedded assessments, including their alignment with curriculum and instructional practice. This requires that we also evaluate teachers' understandings and judgments about the appropriateness and utility of the assessments for instruction, and the support provided for teachers' incorporation of the assessment information into daily practice.
• Psychometric Validity: Given what we know about multivariate measurement and statistical inference (e.g., Pellegrino et al., 2001), to what extent does an assessment reliably yield model-based information about student performance, especially for diagnostic purposes? To address psychometric validity, we need to evaluate the statistical properties and scoring approaches of assessments with regard to their informativeness for (a) purposes of instructional decision making, (b) improving student learning, and (c) projecting performance on external summative assessments.

There will be three substantive outcomes of this project:
(1) A detailed description of the strengths and limitations of the assessments found within the Everyday Mathematics and Math Trailblazers curricula accompanied by a blueprint for their improvement and redesign
(2) An empirically and theoretically driven model for how the embedded assessment component of a standards-based mathematics curriculum should be designed, implemented, and evaluated.
(3) A comprehensive research-based evaluation design that is comprehensive and provides specific methods for investigating the "validity" of embedded assessments, and is adaptable to multiple curricula and in content areas besides mathematics.

Evolution Readiness: A Modeling Approach

Grant #	0822213
NSF Program	NSF
PI	Paul Horwitz
Co-PI(s)	Carolyn Staudt, Laura O'Dwyer
Institution	The Concord Consortium
NSF Program Manager	David Campbell
Grade Level Band	PreK
Target Audience	Students
STEM Content Area	Science
Deliverables	Software, Curriculum, Assessment, PD

This project is using computer-based models of interacting organisms and their environments to support a learning progression leading to an appreciation of Darwin's theory of evolution and the evidence that supports it. Starting with materials suitable for the fourth grade, we are creating hypermodels: curriculum activities and formative assessments that link manipulable models to text and multimedia materials. In later projects, we hope to extend the reach of our materials to middle and high school grades. As our title "Evolution Readiness" suggests, we do not expect that fourth graders will achieve an in-depth understanding of every facet of this most encompassing of theories. However, we hope that they will come to appreciate evolution as an emergent behavior—the remarkable outcome of a series of elementary processes that they have learned about through observation of natural phenomena as well as the direct manipulation of computational models.

Evolution is perhaps the most challenging subject in the K-12 life science curriculum. This project will create a research-based curriculum, starting at very early grades and centered on progressively complex models that exhibit emergent behavior. Taking advantage of technology created in prior NSF-funded research, we will track students' actions as they interact with computer models, collecting extremely fine-grained performance data. In previous research, we have found that such data are a robust predictor of subsequent learning gains as measured by conventional question-and-answer assessments, even on items that do not relate directly to the experiments performed. By continuing this line of research, our project will help to improve the teaching of complex scientific topic areas and provide a reliable means of directly assessing students' conceptual understanding and inquiry skills, as opposed to their recall of science "facts."

In a global economy that is increasingly dependent on advances in science, it is unacceptable that only a quarter of the American public believes that humans evolved through "natural causes." Nor can the widespread disbelief in evolution in this country be attributed to the opposition of religious groups alone. Evolution is a particularly daunting subject to understand: the evidence, for it is indirect and the theory rests largely on phenomena that cannot be directly observed, including some that are poorly understood to this day. By combining advances in educational technology with improved understanding of young children's cognitive development, this project will produce an empirically validated learning progression for teaching evolution. We anticipate that students who follow this progression will better understand both the implications of the model and the evidentiary and theoretical basis for it.

Examining Coaching in Elementary (K-8) Mathematics Classrooms

Grant #	0918326
NSF Program	NSF
PI	David Yopp
Co-PI(s)	Elizabeth Burroughs and John Sutton
Institution	Montana State University
NSF Program Manager	Jim Fey
Grade Level Band	PreK, Middle School
Target Audience	Inservice, Other
STEM Content Area	Mathematics
Deliverables	Coaching Knowledge and Instruments

The Examining Coaching in Elementary (K-8) Mathematics Classrooms (ECEMC) project will conduct research on knowledge that contributes to successful coaching in two domains: coaching knowledge and mathematics content knowledge. The influence of these knowledge domains on both coaches and teachers will be examined in two ways: (1) by investigating correlations between assessments of coach and teacher knowledge and practice in each domain and (2) by investigating causal effects of targeted professional development for coaches. To control for different coaching characteristics and experience levels across settings, all participants will engage in the same coaching model. The impact of coaches' knowledge will be measured through the lens of teacher change in the domains of content knowledge (focusing on number and operations), reform and standards-based practice, attitudes and beliefs, self-efficacy, and perceptions of coach effectiveness. Research findings will be used to develop, modify, and apply tools to assist schools and STEM professional developers in areas of coaching, such as selection, training, and assessment of impact.

The goals for ECEMC are to (1) determine the degree to which coaching knowledge contributes to coaching effectiveness; (2) determine the degree to which mathematics content knowledge contributes to coaching effectiveness; and (3) contribute to research on knowledge for coaching through an experimental design studying the impacts of coaching knowledge and mathematics content knowledge on teachers' knowledge, attitudes, and classroom practice.

The methods employed are (1) a non-experimental correlative study of knowledge for coaching and change in teacher practice and (2) an experimental causal cross-over design measuring the effects of increased knowledge for coaching on teacher practice. The study will also yield data about the environmental characteristics of effective coaching.

This partnership-driven project will enhance the knowledge and understanding of mathematics coaching as it contributes to developing teacher quality. The findings from this project will enhance the research base on domains and depth of knowledge for effective coaching in mathematics. The project employs an experimental statistical design that will yield results with generalizability.

This project will advance the understanding of coaching effectiveness and add to multiple knowledge bases for coaching, while promoting teaching, training, and learning through coaching as a professional development model. Existing and new instruments will be reviewed, developed, pilot tested, validated, refined, and field tested to provide a set of tools that can be used in multiple educational settings, including Mathematics and Science Partnerships. The results promise to inform and improve the understanding of what constitutes best practices for the hiring and training of coaches. The settings for the study are diverse, including rural, urban, and suburban school districts along with districts whose student populations are predominantly Native American. The results will be broadly disseminated through peer-reviewed journals and publications, as well as presentations at multiple venues.

Examining Different Curricular Approaches and Their Impact on High-School Students' Understanding of Algebra: Phase 1 - Studying the Intended Curriculum

Grant #	0901311
NSF Program	NSF
PI	Mary Ann Huntley
Co-PI(s)	Cos Fi
Institution	Cornell University
NSF Program Manager	Spud Bradley
Grade Level Band	High School
Target Audience	Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Refereed Papers, Conference Presentation

This project involves analyzing three curricular approaches to school algebra in the United States. For each approach, we are analyzing those materials that have the greatest market penetration.

1. Curricula developed with major funding from the NSF
    a. Core-Plus Mathematics Program (CPMP)
    b. Interactive Mathematics Program (IMP)
2. Single-subject curricula developed through extensive field testing
    a. University of Chicago School Mathematics Project (UCSMP)
    b. Key Curriculum Press (Discovering Mathematics)
    c. EDC's Center for Mathematics Education (CME)
3. Commercially-generated curriculum materials
    a. Glencoe
    b. McDougal Littell
    c. Pearson Prentice Hall

The analysis is based on two dimensions frequently used for curriculum analysis: a content dimension (the subject matter dealt with in a field of study) and a cognitive dimension (the sets of cognitive processes expected of students as they engage with the content).

The following research question and two sub-questions are guiding the study.
Research Question: What are the characteristics of different curricular approaches to algebra?
- What is the content, including the breadth, sequence, and depth of topics covered?
- What sets of behaviors are expected of students as they engage with the content?

This project is the first of three phases of a larger project that is being planned to examine how different curricular approaches to algebra impact students' understanding of algebra and functions near the end of their high school mathematics experience. The second phase of the larger project involves developing reliable and valid instruments to assess student learning and curriculum implementation. The third phase of the larger project involves examining students' understanding of algebra, and how their performance is related to curriculum implementation and background variables (e.g., gender, race/ethnicity, SES, English proficiency, and prior mathematics course work and knowledge). The expected product of this project (i.e., phase 1) is a comparative map that will tap the content and the cognitive demands both across and within the three curricular approaches to algebra. This map will guide our developing the necessary instruments to evaluate the impact of the different curricular approaches on students' learning.

Examining Teacher Discourse and Whole-Class Interaction: A Social Semiotics Model for Mathematics Lesson Study Groups

Grant #	0822223
NSF Program	NSF
PI	Betina Zolkower
Co-PI(s)	Elizabeth de Freitas
Institution	Brooklyn College
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School, High School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Teacher Development Models

Our project consists of a three-year, exploratory, qualitative case study of a mathematics Lesson Study group for beginning mathematics teachers working in under-resourced sixth- through ninth-grade classrooms in New York City.

Our Lesson Study model relies on social semiotics to examine the intersection between language and learning in mathematics classrooms. Social semiotic analysis applied to mathematics education focuses on the function of multiple semiotic systems (symbolic notation, oral and written language, graphs and visual displays) and grammatical patterns (technical vocabulary, dense noun phrases, being and having verbs, logical conjunctions, implicit relationships) in spoken and written texts (Halliday, 2004; Fairclough, 2003). Participant classrooms serve as laboratories for researchers to study the discursive practices of school mathematics and for teachers to learn how to use semiotic tools for analyzing and improving classroom discourse and student learning.

This project aims to demonstrate how social semiotics can increase our understanding of the function of language and diagrams in mathematics teaching and learning. In addition, this project aims to develop and implement new instructional tools derived from social semiotics for improving teacher quality and enhancing the mathematics Lesson Study model of professional development. Our main research questions are as follows: (1) How does a social semiotic framework illuminate the complexities of mathematics teaching and learning in classrooms located in high-poverty middle schools? (2) To what extent does a Lesson Study group engage beginning teachers in the social semiotics of problem solving and lesson design? Does it (a) strengthen their content knowledge? (b) increase their pedagogical-content knowledge? (c) enhance their ability to orchestrate whole-class conversations?

In training beginning teachers in collaborative lesson study, and in the development of on-site Lesson Study groups in high-poverty schools where English language learners predominate, we aim to have a broad impact on mathematics education within NYC. Examining the social semiotic challenges of mathematics instruction is essential in these schools in that teachers working in these settings are often ill-equipped to negotiate the extreme disparities between students' informal language and the formal language of school mathematics. While strengthening the pedagogical-content knowledge and research capacity of beginning teachers, our project explores the viability of a new model for studying and transforming (or improving) discourse and interaction in high-poverty urban mathematics classrooms.

Exploring Engineering Design Knowing and Thinking as an Innovation in STEM Learning

Grant #	0918621
NSF Program	NSF
PI	Kurt Becker
Co-PI(s)	Natahn Mentzer
Institution	Utah State University
NSF Program Manager	Gerhard Salinger
Grade Level Band	High School
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Technology, Engineering
Deliverables	Presentations at National Conferences, Research Bulletins, Articles

The purpose of this exploratory study is to clarify engineering design as a construct and to perform empirical preparatory research on engineering design as a STEM learning experience for high school students. This three-year project will test the reasonableness of comparing high school student engineering-design thinking with that of experts and investigate the feasibility of these research methods by addressing two research questions: (1) How does high school student engineering-design thinking compare to that of experts in terms of engineering-design performance and knowledge? (2) Does student participation in a multiyear sequence of courses focused on engineering correlate with changes in performance or design knowledge?

Understanding engineering and its role in society is critical for all Americans, though few will pursue engineering as a career. Our vision is to improve the STEM learning and teaching environment for all high school students through their understanding of engineering design. Engineering serves as a STEM integrator by employing principles of math and science to create technologies. Using an exploratory triangulation mixed-methods design to gather multiple forms of data and utilize quantitative and qualitative analysis strategies, 60 high school students engaged in a sequence of engineering-design courses will be identified. Each will be given a design performance challenge in which they will face a familiar yet open-ended and complex design problem. Students will be presented with a list of design activities that they will prioritize by order of importance. The sample will be representative of a diverse group in terms of ethnicity, gender, economic background, and first-generation college bound.

Evaluation efforts will be conducted by an advisory team, external to the project, comprising content expert, pedagogical expert, and methodological expert. Formative evaluation will parallel the work plan, providing informative feedback with a summative evaluation at the conclusion of the project. The advisory team will review and inform the dissemination plan and verify follow-through on project goals and synthesize the findings during formative evaluation. A summative report will be the impact of this work and the logical next steps as it expands to a larger research and development effort.

Increasing our national STEM literacy and workforce readiness includes intensifying and diversifying student participation in the STEM learning experiences. Efforts are currently in place to develop an understanding of engineering among high school students through formal and informal educational experiences. Developing students' understanding of engineering design is needed to understand technological design, which shares many attributes of the engineering design process. This research will be situated in a formal learning environment associated with the independent engineering outreach efforts of the University of Colorado at Boulder and University of Maryland Baltimore County. These exemplary outreach programs have developed extensive relationships with local schools to establish engineering education for secondary education students. Outcomes of this research are essential to inform developers of instructional materials and curricula, as well as teachers planning classroom strategies and designers of initiatives in formal education.

Dissemination will focus on two aspects of this project: results and research methodology which includes the design tasks used for data collection. Results of this project will include addressing the guiding research questions which are: (1) How does high school student engineering design thinking compare to that of experts in terms of engineering design performance and knowledge? and (2) Does student participation in a multiyear

sequence of courses focused on engineering correlate with changes in performance or design knowledge? Research methodology involves adapting design tasks which have been used on the collegiate and expert levels to younger learners. This adaptation process is a significant element of the study to share with other researchers who are considering a similar challenge of broadening the study of engineering education to include high school learners. Piloting these design tasks on the high school level may lead to using other design tasks as treatments and data collection opportunities.

Exploring the Effects of Teacher Research Experiences on Classroom Inquiry

Grant #	0553769
NSF Program	TPC
PI	D. Ellen Granger
Co-PI(s)	Sherry Southerland, Pat Dixon
Institution	Florida State University
NSF Program Manager	David Hanych
Grade Level Band	PreK, Middle School, High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Research Presentations and Reports

According to national reforms, scientific inquiry should be a central principle of science teaching and learning (NRC, 1996); however, much remains to be known about how to best prepare teachers to use inquiry. The NRC has posed the following questions:

- What do teachers need to know and be able to do to use inquiry effectively?
- What kinds of professional development can help prospective and practicing teachers both develop and use inquiry effectively? (NRC, 2000, p. 87)

Research Experiences for Teachers (RET) programs have been designed to give teachers authentic scientific inquiry experience, but their results have remained largely unexamined. This research focuses on analyzing RET programs through description of their essential features, their efficacy in fostering teachers' understanding and enactment of inquiry, their interaction with the personal characteristics of participating teachers, and the influence of teaching through inquiry on student learning in science.

Florida State University (FSU) finds itself well positioned to conduct this research in a rigorous, systematic fashion within one institution as two separate groups at FSU have developed two distinct RET models, each with at least six years of experience implementing its program. The National High Magnetic Field Laboratory (NHMFL) at FSU developed a traditional-format RET program in which teachers are placed in individual NHMFL faculty laboratories to participate in ongoing, authentic research projects. The CIRL RET model closely resembles the structure of many RETs nationwide. In contrast, the College of Arts and Sciences at FSU employs a very different RET model, in which two scientists and two master teachers devote full time to a group of teacher participants, engaging them in scientific research of each individual teacher's own devising. Concurrent with this research is "inquiry on the process of inquiry," in which each teacher engages in a concurrent pedagogical research project on the essential features of inquiry. A third, separate unit at FSU, the Science Education Program in the College of Education, has not participated in the development of either of these programs and has expertise in research into teacher change, the influence of inquiry teaching on science learning, and the requirements of second order change in schooling. This unit conducts the research on the two RET programs.

The existence of three, separate units at one institution, each embedded in separate, in-depth work on teacher inquiry and pedagogical change, presents a perfect opportunity for rigorous, systematic, yet economically feasible, research into the NRC's questions. Thus, our goals and the intellectual merit of the project are to generate a deeper, more generalizable knowledge of the necessary features of RETs and similar-type inquiry programs for teachers in terms of their influence on teachers' knowledge and practices, on the influence such knowledge and newly acquired practices have for the teacher professional development and retention, and to describe how inquiry practices as employed through these teachers shape student learning. The broader impact the findings from this research are anticipated to have will be to inform RETs and similar-type programs of optimal program design to maximize the role of inquiry in classroom teaching and student learning.

Exploring the Frontiers of Science with Online Telescopes

Grant #	0733252
NSF Program	NSF
PI	Roy Gould
Co-PI(s)	
Institution	Smithsonian Institution Astrophysical Observatory
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Students, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Curriculum and Web Site

Exploring Frontiers of Science with Online Telescopes addresses one of NSF's Grand Challenges in education: bringing cutting-edge science into the classroom in the service of the national science education standards. The project, now in its early stages, is engaging students and their teachers in the search for solar systems beyond our own, culminating in the discovery and confirmation of an earth-like planet. The project is designed as a supplement to existing curricula in middle- and high-school earth science, physical science, and astronomy courses. The broad target audience reflects the highly interdisciplinary nature of the project and its integration of key standards from these fields. The project uses the MicroObservatory network of five telescopes, which are accessed online from the classroom.

A key goal of the project is to develop new methods for using the cyberinfrastructure to help students assess their own learning in a timely fashion, and to help teachers uncover and address students' misconceptions. We are also developing new ways to involve the scientific research community in productive collaborations with students, with emphasis on the nature of authentic scientific inquiry. This includes a new model for integrating data from students' own investigations, with the burgeoning archive of astronomical research data. In Exploring Frontiers, students contribute to a national database of measurements on extrasolar planets; every student's data are important to the overall community of observers.

The project materials are being developed and piloted with teachers from Massachusetts and Illinois, and will be field-tested nationally. The materials are expected to find wide use as a supplement to existing and forthcoming NSF-sponsored curricula.

Facilitating a Deeper Understanding of Change in the Earth System on Multiple Time Scales

Grant #	0807575
NSF Program	NSF
PI	Tamara Ledley
Co-PI(s)	
Institution	TERC
NSF Program Manager	Jill L Karsetn
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Parts of EarthLabs module on cryosphere

There is an increasing need for today's students to sufficiently understand how the Earth system changes and the processes that cause those changes so they can address the environmental challenges of the future as scientists, decisions makers, and citizens. However, grasping change over time, especially on multiple time scales ranging from daily to ice age variations, is a challenge. The Facilitating Student Understanding of Change in the Earth System on Multiple Time Scales is pilot project in which we are developing a week-long unit of labs focused on the cryosphere, providing professional development to teachers on the use of the activities, having those teachers implement the labs with students, and studying their effectiveness in helping students understand concepts of change over time on multiple and embedded time scales. The results of the study will be used to refine the labs developed in this project and to serve as a foundation for the development of a larger scale high-school capstone Earth science course. In addition, we are developing a teacher professional development program to provide training to high-school teachers on the use of these materials. The overarching goals of this project are:

- To build, mainly with existing resources, a sequence of scaffolded activities and investigations that will help students more fully understand how the cryosphere changes on multiple time scales and how it impacts and is impacted by the other components of the Earth system.
- To investigate the effectiveness of the developed sequence of activities and investigations at helping students understand how and why a component of the Earth system varies over time, to apply that knowledge to improve the unit of activities used in this study, and to make that knowledge and materials available to the broader educational community.

The Facilitating Student Understanding of Change in the Earth System on Multiple Time Scales project will help us to understand more clearly the difficulties high-school students have in comprehending how the Earth system changes on multiple time scales, and to design activities and materials that can help them and their teachers overcome these challenges. In addition, the results of this work will 1) provide a firm foundation on which to develop a full high-school capstone Earth system science course that will include the broader range of complexity and time scales present in the Earth system – a course which is now on the books in Texas; 2) make these materials available to high-school teachers and students across the country through the EarthLabs web site, and 3) move the efforts of the Revolution in Earth and Space Science Education forward by establishing reviewed and tested components of this course in Texas and make it possible to promote the establishment of this course in other states.

Project partners include TERC (project lead and materials development), Michigan State University and Mississippi State University (evaluation and research), University of Texas-Austin (Texas Earth and Space Science Revolution Project – materials review and implementation).

Formative Assessment Delivery System (FADS)

Grant #	0733334
NSF Program	NSF
PI	Mark Wilson
Co-PI(s)	
Institution	UC Berkeley
NSF Program Manager	Larry E. Suter
Grade Level Band	Middle School, High School
Target Audience	Students, Students - Special Population, Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Mathematics
Deliverables	Formative Assessment Delivery System

The benefits of using high-quality formative assessment data to inform teachers' day-to-day and longer-term classroom decisions have been rigorously established in the landmark meta-analysis by Black & Wiliam (1998). Researchers have come a long way towards agreeing on what "good" assessment looks like, with clear connections between what is taught and what is assessed (NRC, 2001b).

Emerging evidence suggests that the most profitable designs for classroom formative assessment allow teachers to tap and interpret the rich source of evidence about critical thinking skills that students generate while engaging in performance activities or developing constructed responses (Black, Harrison, Lee, Marshall & Wiliam, 2003). A number of research efforts have demonstrated that advanced psychometric techniques (e.g., explanatory item response modeling) can utilize this extensive evidentiary base to provide valid and reliable measures of student knowledge and performance on multiple dimensions of learning (Wilson & Scalise, 2003). Moreover, recent developments in presenting such information to teachers in an interpretive framework that reports student knowledge with respect to targeted learning progressions indicate that teachers are able to use these assessment data to plan next instructional steps (Gearhart, Nagashima, Pfotenhauer, Clark, Schwab, Vendlinski, Osmundson, Herman & Bernbaum, 2006).

The benefits of these advances in assessment practice are limited, however, by the capacity of classroom teachers to gather and score the type of data that is generated when students engage in activities that elicit evidence of deep knowledge and critical thinking skills. If measurement results are to be useful to inform teachers' immediate teaching decisions, then, the results need to be available quickly; however, in the current state of things, teachers must score this relatively complex student work by hand, which will likely require more time than teachers have available.
Dozens of online assessment products with automated scoring already exist, either contained within e-learning systems, executed as standalone products that accompany textbooks, or within classroom management systems. Rarely do these products take advantage of the recent development of learning progressions, incorporate complex item formats that evaluate constructed responses, or take advantage of sophisticated item response modeling techniques, although the incorporation of these features could dramatically improve the quality and usefulness of assessment data.
This presentation will report on development and use of tools in the UC Berkeley Formative Assessment Delivery System that are intended to make it easier for teachers to engage in high quality formative assessment for their classrooms, with feedback and automated scoring.

In the first FADS trial of signature item types this past spring, teachers were exhibiting engagement. We completed our first validity study in March, to be followed by a second validity study next fall; however after seeing the first assessment objects, the teachers requested access to and use of the objects be made possible more frequently, even in the initial year. "The students are going to enjoy this," one teacher commented, "They are going to want to do more and more of this."

Formative Assessment in the Mathematics' Classroom: Engaging Teachers and Students

Grant #	DRL-0918438
NSF Program	NSF
PI	Fred E. Gross
Co-PI(s)	
Institution	Education Development Center
NSF Program Manager	Dr. Elizabeth VanderPutten
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	website and web-based resources

Formative Assessment in the Mathematics Classroom: Engaging Teachers and Students (FACETS)
The FACETS project will develop a 2-year, intensive professional development model to build middle grades mathematics teachers' knowledge and implementation of formative assessment. Using a combination of institutes, classroom practice, and ongoing support through professional learning communities and web-based resources, this model will help teachers internalize and integrate a comprehensive understanding of formative assessment into daily practice. As part of the professional development model, we will create a variety of products:

- a facilitator's guide describing the components of the professional development model and suggestions for using the model to provide a professional development program,
- cyberlearning products such as interactive forums and a vetted resource library, and
- video and other materials for the professional development activities and resource library.

FACETS includes a formative research component centered on the following questions:
1. How do mathematics teachers' knowledge and practice of formative assessment change as a result of participation in the proposed professional development?
2. What learning trajectory describes teachers' learning about formative assessment, and what are common barriers to successful implementation?

Reports of research findings will include journal articles on teachers' learning trajectory for formative assessment and common barriers to successful implementation faced by teachers.
Our fieldwork, supported by existing research, has shown that math teachers have difficulty fully implementing formative assessment in their classroom. Existing professional development programs either present a comprehensive understanding without a focus on mathematics, or focus on mathematics but only emphasize some of the critical aspects needed to bring out the full potential of formative assessment. This project will develop a professional development model that both presents a comprehensive understanding of formative assessment and focuses specifically on mathematics. Furthermore, this project proposes to contribute to the field of mathematics teacher education through a deeper insight into mathematics teachers' learning and practice of formative assessment. This insight can be used by professional developers and teacher educators in mathematics to make decisions that help teachers progress more effectively in their learning.
We anticipate that the professional development will have an immediate impact on participating teachers, and on their students, as they learn about and implement formative assessment in their classrooms. Research results regarding teachers' learning trajectories for formative assessment will be crucial to inform future professional development and teacher education programs, and to help teachers reflect on, and guide, their own learning. Data regarding the major barriers to teachers' learning of formative assessment will also impact future professional development by identifying issues needing additional focus, as will data regarding the effect on those barriers of factors such as teaching experience and mathematical knowledge for teaching. The resource library will make resources, such as video widely available to teachers grappling with understanding and implementing formative assessment in mathematics classrooms in a practical way.

Fossil Finders: Using Fossils to Teach about Evolution, Inquiry and Nature of Science

Grant #	0733223
NSF Program	NSF
PI	Barbara Crawford
Co-PI(s)	Robert M. Ross, Warren Allmon
Institution	Cornell University
NSF Program Manager	David Campbell
Grade Level Band	PreK, Middle School
Target Audience	Students, Students - Special Population, Inservice
STEM Content Area	Science
Deliverables	Inquiry-based curricula; Web site

The Fossil Finders full-scale resources and tools project (subcategory-Instruction of K-12 Students and Teachers) will engage children in classrooms across the country in an authentic investigation of Devonian fossils, as well as other fossils; and will enable children to contribute their own data to an online database of an actual paleontological study and to learn about the nature of science (NOS). The project is a collaboration of Cornell University Department of Education and the Paleontological Research Institution (PRI) in Ithaca, New York. The primary goal is to enhance understanding of NOS and evolutionary concepts as well as to motivate children to learn more about science. Stratigraphically constrained samples of layers of shale from an Upstate New York outcrop will be shipped to classrooms (urban and rural) in New York State and to schools across the country. Classrooms with a high proportion of underrepresented groups of children (English language learners, [ELL] and children whose race and gender are not well represented in the sciences) will be targeted for active involvement. Classrooms who join the Fossil Finders project can use identification keys and diagrams on the interactive Web site and compare their identifications of fossils with museum-based specimens. The goal is to actively engage students in grades 5/6 and 7/8, and their teachers, in the use of evidence in constructing explanations of natural phenomena.

Intellectual Merit: The Fossil Finders project will help children and teachers understand how scientists gather and use evidence to build theory, enhance abilities to do inquiry, and stimulate interest in paleontology, biology, and geology in target demographics (females, low SES, and ELL students). The project will also provide access to professional development materials to support teachers. An understanding of evolutionary theory is directly tied to scientific literacy and an understanding of NOS. As citizens, we need to understand NOS and evolutionary theory in order to make informed decisions. The research component will contribute to our knowledge of the impact of inquiry-based learning environments on scientific understandings of NOS of diverse groups of children.

Broader Impacts: The Fossil Finders project will provide a viable national model for natural history museums to connect with classrooms and provide inquiry-based, authentic science experiences for children and teachers across the country. Through these experiences children and teachers can learn about NOS, inquiry, the role and importance of theory and evidence, and key biological and geological concepts. The project will serve as a model for showing how informal science education organizations can work with schools and use local natural resources. By targeting certain populations of students (e.g., ELL), the project potentially broadens participation among several underserved and underrepresented groups of students. Deliverables will include an interactive Web site: a place where students can learn how to identify the fossils they find and add their own data to an emerging database, and where teachers can access educational and support materials to help students develop understandings of NOS and evolutionary concepts.

Fostering Mathematics Success in English Language Learners

Grant #	0821950
NSF Program	NSF
PI	Mark Driscoll
Co-PI(s)	Daniel Heck
Institution	Education Development Center, Inc.
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	
Target Audience	
STEM Content Area	
Deliverables	Research Instruments, Research Reports

Education Development Center, Inc. (EDC), and Horizon Research, Inc., are conducting the DR-K12 research project, Fostering Mathematics Success of English Language Learners (ELLs): An Efficacy Study of Teacher Professional Development (FMSELL), a study of the effects of the Fostering Geometric Thinking Toolkit professional development materials (FGTT) for teachers of ELLs. It will address four research questions:

1. Does participation in FGTT increase teachers' geometric content knowledge?
2. How does teachers' participation affect attention to students' thinking and mathematical communication?
3. How does participation affect instructional practices?
4. What impact on ELLs' problem-solving strategies is evident when teachers participate in FGTT?

FGTT is a 40-hour professional development intervention focusing on properties of geometric figures, geometric transformations, and measurement of length, area, and volume. The project tests the hypothesis that geometric problem solving invites diagramming, drawing, use of colloquial language, and gesturing to complement mathematical communication and affords teachers opportunities to support ELL learning. The research design uses a randomized block design, with 25 pairs of professional development facilitators matched according to their district's demographic information.

Foundation Science: A Comprehensive High School Science Curriculum

Grant #	0439443
NSF Program	IMD
PI	Jacqueline Miller
Co-PI(s)	
Institution	Education Development Center, Inc
NSF Program Manager	Gerhard Salinger
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Student and Teacher Editions, PD

Foundation Science is the working title of a new curriculum for grades 9 through 12 under development by EDC's Center for Science Education at Education Development Center, Inc., with funding from the National Science Foundation. The curriculum is designed to support several specific goals for students, including
• achievement of specified learning outcomes;
• deep understanding of fundamental concepts;
• appreciation of the relevancy of science in the everyday lives;
• acquisition of critical-thinking and problem-solving skills;
• enhancement of reading, writing, and communication skills about science; and
• development of decision-making skills grounded in knowledge, evidence, and logic.

The curriculum consists of eight volumes, two in each discipline of physics, chemistry, biology, and earth science. Each volume contains material for a one-semester course. The first volume in each discipline explores concepts that are developmentally appropriate for grades 9 and 10 and develops skills in critical thinking, problem solving, communication, and laboratory techniques. The second volume in each discipline builds upon the concepts and skills introduced in the first volume, and provides deeper, more-extended learning experiences in specific concepts in these disciplines in later grades. The two volumes together constitute a full-year equivalent of an introductory course in each of the disciplines.

To achieve these goals, Foundation Science contains several special features that reflect essential tenets about effective high school teaching and learning. These include
• the use of "big ideas" that provides ways of organizing learning and identifying those ideas, concepts, and principles that students should retain for a fundamental understanding of the science;
• concept development within lessons that builds upon prior knowledge and permits exploration of concepts at increasingly greater depth;
• concept development across disciplines that demonstrates the connections and interrelatedness among the different disciplines and highlights essential ideas that transcend them;
• ongoing processing of investigations, readings, and discussions that enables students to synthesize their learning experiences and achieve new understandings of the concepts being developed through carefully crafted questioning and encourages students to develop communication skills;
• use of "story" to engage and motivate students by presenting the content in real-life contexts that have significance to students' lives and to pique their curiosity; the story also presents a challenge and a structure around which students build conceptual understanding on a "need-to-know" basis;
• contexts and experiences in technology that demonstrate the relationship between the principles of science and the application of these principles to solve real-world problems; and
• educative curriculum that embeds within the instructional materials support to help the teacher implement the materials and incorporate inquiry-based, innovative teaching strategies into their practice.

Foundations of Algebra in the Elementary and Middle Grades: Supporting Students to Make, Represent and Justify General Claims about Operations

Grant #	0550176
NSF Program	TPC
PI	Susan Jo Russell
Co-PI(s)	Deborah Schifter, Virginia Bastable
Institution	TERC
NSF Program Manager	Paola Sztajn
Grade Level Band	PreK, Middle School
Target Audience	Students, Students - Special Population, Inservice
STEM Content Area	Mathematics
Deliverables	PD materials: book and on-line course

Foundations of Algebra in the Elementary and Middle Grades: Supporting Students to Make, Represent, and Justify General Claims about Operations

Susan Jo Russell, Deborah Schifter, and Virginia Bastable

Over the past five years, in projects that focused on the development of student curriculum and professional development materials, we have been working with teachers to bring algebraic thinking into the elementary grades. Part of this work is focused on creating opportunities for students to articulate, represent, and justify general claims about numbers and operations. Teachers have found this work deepens students' understanding of arithmetic, the heart of the K-5 mathematics program. Teacher collaborators report that students who tend to have difficulty in mathematics become stronger mathematical thinkers through this work and that students who generally outperform their peers in mathematics find this content challenging and stimulating.

The work of generalizing and justifying in the elementary classroom has the potential of enhancing the learning of all students. However, many elementary teachers find this content especially challenging and unfamiliar and, even after working on these ideas in the context of professional development, have many questions about how to put these ideas into play in the classroom. In the middle grades as well, many teachers who teach algebra are concerned about helping their students understand the reasoning that underlies the manipulation of symbolic notation.

The central purpose of this project is to develop professional development materials that not only support teachers in learning how elementary and middle school students come to recognize, verbalize, represent, and justify general claims about operations, but also help them make the critical and difficult leap from their own learning to sustained, coherent implementation of these ideas with students.

A primary goal of the project is to develop, in collaboration with experienced teacher-writers, readable and informative classroom accounts as students in grades 1-6 develop, represent, and justify general claims across a full school year. These accounts will be synthesized into a written resource ("The Sourcebook") that provides insight into how students learn to articulate, represent, and reason about general claims. We will also develop an online course in which teachers use the Sourcebook as a text, implement practices illustrated in the text, and share their own students' related work across a full school year. The Sourcebook and online course will support teachers to: recognize general claims that arise in their students' work; choose general claims that can be productively pursued at that grade level; pose questions that engage students in thinking about the idea of a general claim for an infinite class of numbers; help students develop and share representations that can be used to reason about general claims; engage a range of students, including students who have more difficulty in mathematics than their peers and students who often need more challenge than their peers, in this work; and support students to apply their work on generalization to their reasoning about numbers and operations.

Geometry Assessments for Secondary Teachers (GAST)

Grant #	0821967
NSF Program	NSF
PI	William Bush
Co-PI(s)	Carl Lee, Elizabeth Jakubowski, Robert Ronau
Institution	University of Lousiville
NSF Program Manager	James Fey
Grade Level Band	High School
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Teacher Assessments

Geometry Assessments for Secondary Teachers (GAST) represents a collaborative partnership among the University of Louisville, the University of Kentucky, Florida State University, Alpine Testing Solutions, and Horizon Research, Inc. to develop a knowledge framework and assessments for secondary mathematics teachers' knowledge of geometry. The validation framework for the assessments will be designed to collect validity evidence for predicting effective geometry teaching and improving student achievement in geometry. Over three years, two teams of mathematics educators, mathematicians, and classroom teachers will develop assessments for high school geometry teachers. In particular, the assessments will focus on similarity/congruence and area/volume.

Helping Teachers Become Cultural Relevant Teachers: Developing New Tools for a New Generation

Grant #	DRL 0929816
NSF Program	NSF
PI	Martin L. Johnson
Co-PI(s)	Stephanie Timmons Brown
Institution	University of Maryland College Park
NSF Program Manager	Ferdinand Rivera
Grade Level Band	PreK, Middle School, High School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Final Report

The goals of the conference, Helping Teachers become Cultural Relevant Teachers: Developing New Tools for a New Generation, are to bring together the very best researchers/ practitioners in this field to present a clear theoretical underpinning of Culturally Relevant Teaching (CRT), present the most recent rigorous research to support the theory, and to clearly show how CRT theory translates directly into classroom action. The participants, mainly inservice teachers, will represent a national audience and a variety of research and teaching interests, however special emphasis will be placed on teachers who teach in schools with high levels of diversity. Workshops within the conference will allow teachers the opportunity to learn about and develop model for planning and teaching using the Culturally Relevant Teaching philosophy. A small working group of researchers will be formed and encouraged to continue their deliberations beyond the conference and with support and organization from the Maryland Institute for Minority Achievement and Urban Education, develop new research thrusts. Participating teachers will be encouraged to move aggressively to implement CRT into their classrooms in all appropriate ways. Thus, the ideas presented at this conference will have immediate impact on the teaching and learning of mathematics in our schools.

High Adventure Science

Grant #	0929774
NSF Program	NSF
PI	Amy Pallant
Co-PI(s)	
Institution	The Concord Consortium
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Videos, computer models, curriculum

HIGH ADVENTURE SCIENCE: SUMMARY
Overview. The goal of this exploratory DRK12 proposal is to investigate a new, replicable, and sustainable strategy for increasing student interest in science and science careers and result in learning of important science concepts. The High Adventure Science project will inject contemporary science into the classroom, engaging students in important unanswered questions that scientists around the world are actively exploring. This idea will be tested in diverse class-rooms using three fascinating and accessible topics from contemporary research that can be related to typical content in the earth and space sciences at the secondary level.
The project will produce computer-based learning activities that rely on student inquiry. The structure and assessments used in the activities will use the knowledge integration framework. Teachers will be introduced to these materials using an online course based on the Concord eLearning Model design.
The project will study the use of the High Adventure Science materials in classrooms of 20 teachers over two years. Half the teachers will delay their implementation by a year to serve as a control. An instrument will be developed to measure student attitudes about science and science careers and their acquisition of science content. This instrument will be administered at the beginning and end of both years in classrooms of all participating teachers.
Transformative Research. This project explores a fresh approach to bringing science into the classroom in a way that is true to the spirit of science, uses modern technology, is based on cur-rent research in effective cyberlearning, and could be easily scaled up to have a major impact on science teaching and learning. The project is important because it will explore a practical approach to teaching science and motivating young scientists by engaging them in current research. This general strategy is widely recognized but rarely implemented because of the lack of appropriate student activities and the pressure of tests. If the research reveals gains in student interest in STEM topics and careers, while also generating standards-based science content gains, the strategy could have a major impact on the content and teaching in secondary science nationwide.
Intellectual Merit.. The team designing these activities provides a nationally recognized leadership in the use of computational models in education. They have 25 years experience in teacher professional development and the management of innovative, projects. The student materials are derived from NSF-funded projects and are, consequently, innovative, high quality, standards-based, and classroom tested. The project will have a balanced, diverse, and expert Advisory Committee.
Broader Impacts. The project research will examine the scalability of this approach and its po-tential for large-scale utilization. The project will create a rich legacy of materials: workshop materials, student activities and modules, and teacher resources. All these materials will be available in electronic form on the HAS project website at no cost. All project-developed software will be open source and available free. In addition, the findings of the project could easily spawn the development of additional activities and further research.

Honing Diagnostic Practice: Toward a New Model of Teacher Professional Preparation and Development

Grant #	0822342
NSF Program	NSF
PI	Stamatis Vokos
Co-PI(s)	Eleanor Close, Pam Kraus, Jim Minstrell, Lane Seeley
Institution	Seattle Pacific University
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Science
Deliverables	Formative Assessment Instruments

The Physics Department and the School of Education at Seattle Pacific University, FACET Innovations LLC, in partnership with Seattle Public Schools, Spokane School District, Bellevue School District, Everett School District, and the Office of Superintendent of Public Instruction of Washington State are pursuing a five-year, multifaceted research and development effort. In particular, the effort seeks to impact the in-depth preparation and enhancement of teachers of physics and physical science in grades 5-12 and serve as a national model for reconceptualizing rigorous discipline-based teacher professional preparation with a focus on formative assessment (FA) of student ideas.

This project leverages the findings of several recent successful NSF-funded projects. These are Improving the Effectiveness of Teacher Diagnostic Tools and Skills (NSF TPC grant), Applied Research on Implementing a Diagnostic Learning Environment (NSF applied research grant to FACET Innovations), Assessing Teacher Competency in Formative Assessment (NSF grant to FI), Assessments to Support the Transitions to Complex Learning in Science (NSF IERI grant to UCLA with a sub-award to FI to build the Diagnoser Project Tools).

Research suggests that formative assessment is a powerful instructional practice for promoting learning among all students in all disciplines. Findings and products from this project have the potential to transform the professional preparation of science teachers by investigating the development of a national model of teacher education, which focuses on the establishment of a diagnostic learning environment in the classroom.

The project has four major objectives.
(1) Produce, deliver over the web, and refine iteratively research-based classroom tools on Energy using the Diagnoser Tools (www.diagnoser.com)
(2) Produce research tasks and instrument(s) to probe teacher understanding of 1) content, 2) student ideas, and 3) instructional responses to formative student data in the topic of Energy.
(3) Document case studies of teachers' formative assessment practices in the classroom in order to identify the components of, and obstacles to, effective practice.
(4) Disseminate the products and findings from the activities associated with Objectives 1, 2, and 3.

The intellectual merit of the project consists in (1) identifying and categorizing widespread modes of reasoning employed by both precollege students and teachers on the foundational topic of Energy; (2) developing and implementing research-based internet diagnostic tools that provide detailed, real-time information about student thinking to teachers (and teacher educators) to guide further instruction; (3) developing tasks to probe (a) teachers' knowledge of common student thinking in Energy, (b) teachers' skill in selecting appropriate strategies for diagnosing these student ideas, and (c) teachers' skill in selecting effective instructional interventions based on diagnoses of student ideas; and (4) characterizing teachers' development toward the use of FA through detailed study of teachers' real practices surrounding formative assessment.

The project will achieve its broad impact by a multi-pronged approach: (1) promoting deep and essential integration of research on student learning with teaching by facilitating the engagement of current and future teachers in the day-by-day practice of eliciting and responding productively to students' thinking, (2) promoting a greater awareness of the positive value of students' thinking and prior experiences for science instruction,

thus narrowing cultural gaps between students and teachers, (3) increasing the appeal of the teaching profession among potential future teachers by increasing the perceived intellectual rigor of teaching, (4) focusing on Energy, a topic of great difficulty for students and also of concern to teachers of all branches of science, (5) offering the internet resources freely to all users, and (6) conducting workshops and presentations in multiple professional arenas at state and national levels.

The project is being evaluated by Horizon Research Inc.

Identifying Critical Characteristics of Effective Feedback Practices in Science and Mathematics Education

Grant #	0822373
NSF Program	NSF
PI	Min Li
Co-PI(s)	Maria Araceli Ruiz-Primo, Yue Yin
Institution	University of Washington
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	PreK, Middle School, High School, Post Secondary
Target Audience	Students
STEM Content Area	Science, Mathematics
Deliverables	Manuscripts, Presentations, & Brochures

Although there is substantial evidence about the positive effects of feedback, a major lack is systematic knowledge about what kinds of feedback are needed by different students, in what forms, and for which types of learning tasks. This project will define and synthesize effective feedback strategies that can be linked to specific features of daily classroom assessment practices.

Instead of providing general evidence about effectiveness, the project will summarize, integrate, and interpret a range of feedback studies that are conceptually comparable based on particular mediators and moderators involved in feedback practices. These mediators and moderators would include, for example, difficulty of instructional tasks, cognitive demands tapped by tasks (e.g., declarative, procedural, schematic, or strategic knowledge), or student characteristics (e.g., low or high achievers, low or high motivation).

The project will be guided by three research questions: (1) What constitutes the range of feedback strategies that have been studied in science and mathematics education? (2) What constitutes the critical mediators and moderators of feedback practices (e.g., learning goals and student characteristics) in which such feedback strategies have been implemented? (3) What are the critical characteristics of feedback strategies that empirically have proved to have a positive impact on student learning?

The project will develop a framework, including a conceptual strand that will conceptualize feedback practice considering intrinsic and contextual dimensions, and a methodological strand that will be used to describe and evaluate the feedback studies and findings to be synthesized. The proposed framework will provide a language that can be shared within and across multiple forms of research in various disciplines to portray feedback practices. The framework and research questions will also lead to criteria for inclusion and exclusion to be used to identify eligible articles and reports for the synthesis. Based on the framework, we will develop and apply a two-level coding system to specify and evaluate the findings from each eligible study. Finally, the coded information will be summarized to identify patterns and trends across the studies, which in turn will be used for a narrative review and a quantitative summary in the form of a meta-analysis.

Intellectual Merit: The project will result in a substantially more complete and detailed theoretical framework than what currently exists for characterizing effective feedback strategies in science education. This understanding will allow for (1) refinement of a theoretical framework that explains the feedback process and its quality, and (2) concrete, easy-to-apply recommendations for science teachers to effectively and formatively use assessments in their daily work.

Broader Impacts: The study will help professional developers and teachers understand what is required to effectively implement feedback practices that have a positive impact on student learning. The research will also produce clearer criteria for improving, evaluating, and monitoring teachers' feedback practices in daily teaching as well as for designing professional development for pre- and inservice teachers of science and mathematics. Results from the project will also fill in the research gap, contribute to the literature on formative assessment, and help define research and development agendas. The project will create a toolkit for practitioners as well as articles for publication.

Improving Science Learning in Inquiry-based Programs (Collaborative Research - Ward)

Grant #	0733323
NSF Program	NSF
PI	Wayne Ward
Co-PI(s)	
Institution	Boulder Language Technologies
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	
Target Audience	
STEM Content Area	
Deliverables	Virtual Tutor Software and Content

The main goal of this work is to improve science learning by students who are not achieving their potential in high quality inquiry-based programs. While programs like FOSS, STC, and Insights have proven effective in improving science achievement within and across school districts, many children, especially underrepresented minorities and English language learners, fail to demonstrate proficiency on standardized tests of science achievement. The project will aim to achieve its goal by developing a computer program, My Science Tutor, which students will use immediately following classroom science investigations to reinforce and extend concepts embedded in the investigations. The program uses a lifelike animated character to engage students in scaffolded guided learning activities and tutorial dialogs that stimulate scientific reasoning. Tutorial dialogs are based on a proven technique, Questioning the Author, that challenges students to learn and integrate new concepts with prior knowledge to construct enriched mental models that can be used to explain and predict scientific phenomena. The work aims to produce and demonstrate the effectiveness of tutorial dialogs produced by human experts trained to use the Questioning the Author method. To evaluate the intervention, we will compare learning gains on standardized tests of science achievement by fourth- and fifth-grade students in four areas of science. Students will be randomly assigned to three groups: the computer treatment, human tutoring or continued classroom instruction. Formative assessments will analyze both student and teacher experiences.

The formative assessments should provide detailed insights about how learning tools designed to teach concepts through scaffolded learning and narrated animations, and to teach scientific reasoning through tutorial dialogs, influence the learning and achievement of elementary students. The program will also contribute new results about the effectiveness of tutorial dialogs incorporating advanced language technologies to emulate the learning strategies of expert tutors.

Successful outcomes of the project will include a program that is effective in improving science learning and achievement of elementary school students. The program will provide an effective supplement to FOSS, a high-quality science program that is already used by over two million students and one hundred thousand teachers in the U.S. A potentially profound advantage of the project arises from providing viable and accessible resources to help teachers implement high quality curricula in a much more individualized manner. In effect, curricula such as FOSS have fared well despite the difficulties that teachers have in helping to map its rigorous content to individual leaner cognition and in providing routine and high quantity feedback to each individual mastering a challenging domain. This project seeks to address this difficult problem by making such curricula more accessible, engaging, and effective for each individual learner.

Improving the Effectiveness of Teacher Diagnostic Skills and Tools

Grant #	0455796
NSF Program	TPC
PI	Stamatis Vokos
Co-PI(s)	Pamela Kraus, John Lindberg, Jim Minstrell, Lane Seeley
Institution	Seattle Pacific University
NSF Program Manager	Gerhard L. Salinger
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Science
Deliverables	Web-delivered formative assessment tools

This project is a collaboration between Seattle Pacific University and Facet Innovations, LLC, with Seattle Public Schools, Bellevue Public Schools, and Spokane Public Schools as partner school districts. The deliverables will include (1) the production, delivery over the web, and iterative refinement of research-based diagnostic classroom tools in the gateway areas for all sciences: Properties of Matter, Particular Nature of Matter,and Heat and Temperature, and (2) the development of a framework for using diagnostic classroom tools in the delivery of professional development to deepen the subject matter content knowledge, enrich the pedagogical content knowledge, broaden the curricular content knowledge, and hone the diagnostic skills of teachers of physics and physical science in grades 5-10, especially those who are new to the intentional use of assessment in science instruction.

The suite of web-based assessments is based on the Diagnoser Project tools (www.diagnoser.com). The Diagnoser Project tools include: Diagnoser sets of questions, learning goals, facet clusters, elicitation questions, developmental lessons, and prescriptive activities. These tools have been shown to be effective at deepening understanding of force and motion for both teachers and their students.

These materials and the accompanying professional development are being field tested primarily (but not exclusively) with teachers in our three partner school districts in Washington State. The work and evaluation plan includes (1) identifying through research and categorizing using facet clusters widespread productive and unproductive modes of reasoning employed by both precollege students and teachers on foundational topics; (2) developing, implementing, and evaluating the efficacy of web-based diagnostic tools that provide detailed, real-time, facet-based formative assessment to teachers (and teacher educators) to guide further instruction; and (3) contributing to the evidentiary base of teacher development and the teaching and learning of science through dissemination of our research and products.

The data that are collected in the investigation of the impact of these tools on teachers' teaching and student learning include content assessment of both teachers and students before and after use of the tools, and questionnaires and interviews to categorize how the tools are being used. Evaluation of the content of the resources and the pedagogy and PD design and delivery is being achieved by contracting with experts to review the materials and the implementation of the tools in pre- and in-service courses. Such reviews inform the design, delivery, and refinement of the deliverables.

Two types of deliverables are being disseminated: research and evaluation results and teacher and teacher educator resources. Research results are being disseminated via presentations, publications, and workshops at meetings of professional societies. Dissemination of resources is both formal and informal. Since the resources are web-based, they are available for use by any teacher or teacher educator.

Industry-Education Partnership: A Model for the Teacher Professional Continuum

Grant #	0353441
NSF Program	TPC
PI	Sandra Harpole
Co-PI(s)	Sue Minchew, Giselle Thibaudeau Munn
Institution	Mississippi State University
NSF Program Manager	John S. Bradley
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice, Higher Education, Administrators
STEM Content Area	Science, Technology, Mathematics
Deliverables	http://www.csmt.msstate.edu

Industry-Education Partnerships is designed to develop a model for building successful partnerships between industry and education that bridge the gap between the classroom and the real world to better prepare students to compete in today's knowledge-based, global economy. The project is researching factors contributing to the successful partnerships that attract support of business and industry and is developing learning communities that span the educational continuum and include STEM educators from elementary through community college as well as administrators and guidance counselors. This research is significant as the nation is challenged to provide a STEM workforce with sufficient skills required to remain competitive. Evidence gathered from sessions with both educators and representatives of business and industry point to a lack of communication and collaborative planning by both parties and to the need for an understanding by educators of the skills required by industry and the job opportunities that utilize STEM knowledge and applications.

Over five years, teams of mathematics, science, and technology teachers have been connecting with universities and industry to learn new ways of making their subjects more relevant and to renew their personal commitments to students and teaching. The goal is to connect academics to real-world applications through an integrated curriculum designed to strengthen the roles of teachers as leaders in preparing a workforce. Teachers learn to apply workplace skills and practical application of industrial processes to academic content. The project prepares them as leaders in their local districts to support workforce education, and serve as liaisons between industry and local school systems.

The Industry-Education Partnerships program has developed industry and education partnerships; facilitated participants' making connections between academics and real-world applications; and used professional development activities to connect industry to the classroom.

Topics addressed by this project include best practices for developing industry partnerships; integrating real-world applications into the curriculum; enhancing professional development; and better preparing students for success in a highly competitive workforce

A total of 226 teachers and 33 administrators from Mississippi and throughout the nation are contributing to the development of the model through participation in summer workshops of varying lengths, which include industry experiences at partner industries Northrop Grumman Ship Systems, Tennessee Valley Authority, Nissan, North American Coal, Aurora Flight Sciences, American Eurocopter, and NASA's Stennis Space Center. They incorporate their experiences with real-world applications into the existing curriculum by developing action plans.

An important finding from this project has been the degree of institutionalization of the project goals through incorporating IEP into classrooms and schools. Project impacts do not appear to fall off after the first year. Evidence supports the impact in the classroom of having teams of teachers from the same school/school district.

Inquiry into Practice

Grant #	0554652
NSF Program	TPC
PI	Cynthia Passmore
Co-PI(s)	Wendell Potter, Judi Kusnick
Institution	University of California, Davis
NSF Program Manager	Robert Sherwood
Grade Level Band	Middle School, High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Research Articles

"Inquiry into Practice" is a five-year sequence of research on teacher professional development that is documenting how middle and secondary school science teachers first develop a perspective on science learning, translate that perspective into their own teaching practice and finally make explicit links to their colleagues. The research is carried out in the tradition of design research in education that bridges theoretical research and educational practice. Specifically, it is investigating the impact of professional development based on model-based reasoning, supported by Lesson Study and an apprentice-like program in teacher leadership. The program consists of two cycles of professional development with selected teachers in California. A cohort of 30 teachers began the program in the Spring of 2007 and a second cohort will start in Spring of 2009. Each cycle includes two summer institutes in which teachers learn about modeling in science and consider how that perspective might inform their teaching practice. Each institute also includes modeling of effective pedagogical strategies and instruction in leadership skills. Over the two years, the emphasis gradually changes from primarily instruction in scientific models to primarily instruction in leadership skills. Each cycle also includes academic year support through Lesson Study groups. Multiple measures are used including teacher content knowledge and facility with models instruments as well as classroom observations, interviews and analysis of teacher writings and lesson plans. The key research questions of the project are: 1. What are teachers' understandings of critical science concepts and how do their understandings change when they approach science as a process of producing and testing models? 2. What are teachers' conceptions of effective pedagogical practices in the science classroom and how do those perspectives change through their own experiences with a modeling approach? 3. What roles do teachers currently play at their school sites and how does participation in the program affect their work with teachers at their school site and in other settings?

Integrating Computing Across the Curriculum (ICAC): Incorporating Technology into STEM Education Using XO Laptops

Grant #	0918216
NSF Program	NSF
PI	Shelia R. Cotten
Co-PI(s)	J. Michael Wyss, Michael Howell-Moroney, Jeff Gray, David Radford
Institution	University of Alabama - Birmingham
NSF Program Manager	Michael Haney
Grade Level Band	PreK
Target Audience	Students, Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	None to date

The Integrating Computing Across the Curriculum (ICAC) project seeks to extend the educational use of computers beyond the common tasks of word processing and Internet searches to the transformative function of integrating the sciences with mathematics, computational thinking, reading, and writing in the elementary school curriculum. In 2008, the City of Birmingham and the Birmingham City Schools (BCS) joined in a project to supply every student in grades 1-5 with his or her own XO laptop computer. For the XO laptops to realize their full potential as a tool for advancing STEM education, curricula must be developed and teachers trained in methods to bridge across the STEM disciplines.

The goal of ICAC is to provide teachers and students with computer resources and skills that will increase the number of students in the STEM pipeline. ICAC's focus is on an urban, predominantly African American, high poverty school system. ICAC will advance computing, science, and mathematics skills of 4th and 5th grade BCS teachers and students, work with teachers to develop curriculum, and provide professional development so that teachers can use the XO technology to assist their students' attainment of STEM education goals. ICAC will also train a cohort of students so that the students become resources for the teachers and their fellow students. It will also engage parents so that they understand the opportunities available for their children in STEM-centered careers.

ICAC has three Specific Aims: (1) Work with teachers and administrators to develop an optimal intervention that will ensure productive school, principal, teacher, and student participation; (2) Over a five-year period, deploy the intervention to ~160 teachers and ~8,000 students and their families to enhance the students' understanding of STEM and fundamentals of computation, communication skills, and interest in STEM careers; and (3) Assess the effects of ICAC on student STEM engagement and performance, teacher and student computing-specific confidence and utilization, student interest in technology and STEM careers, and parental attitudes toward STEM careers and use of technology in education.

ICAC will provide teachers throughout the US with insights into how computers can be used to engage students and integrate the STEM disciplines within the elementary curriculum. ICAC will provide a model that will be translatable to school districts around the nation, and potentially the world, advancing the use of computers to provide integrated STEM education.

ICAC will leverage this unique opportunity to decrease the digital divide by influencing over 8,000 children in the Birmingham area. There is substantial opportunity for vertical integration as this project meshes well with other projects that target older students. ICAC will also include a diverse group of undergraduate and graduate students who will develop research skills. UAB's partnership with school districts will be enhanced. Results will be disseminated broadly via (1) local, state, and national websites and resource repositories, (2) presentations and publications, across sociology, education, and STEM disciplines, and (3) to educators in the field, practitioners, Birmingham City residents, government officials, and OLPC.

Integrating Science and Mathematics Education Research into Teaching IV: Resources and Tool for Improved Learning

Grant #	0736967
NSF Program	NSF
PI	Susan R. McKay
Co-PI(s)	Owen P. Maurais, Stephen A. Norton, Eric A. Pandiscio, John R. Thompson
Institution	University of Maine
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice, Higher Education, Administrators
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	http://www.umaine.edu/center

This grant funded the conference "Integrating Science and Mathematics Education Research into Teaching: Resources and Tools for Improved Learning", which was hosted by the Center for Science and Mathematics Education Research (the Center) at the University of Maine on June 22nd – 25th, 2008. The grant also supported the Summer Academy, a collection of eight courses for science and mathematics educators, which took place from June 25th – 27th, and related follow-up events.

The purposes of this project are: (1) To bring together all participants in the STEM education enterprise (teachers, administrators, scientists, engineers, mathematicians, education faculty, future teachers, graduate students, and postdoctoral research associates in STEM education) to exchange ideas and research, curriculum innovation, and assessment in their fields; (2) To help teachers integrate research-based instructional strategies and materials, particularly those that depend upon innovative uses of technology, in their teaching; and (3) To build sustainable collaborations among teachers, STEM researchers, and education researchers, providing an infrastructure to bring cutting-edge STEM content into classrooms in ways that enhance learning and broaden participation in STEM disciplines.

Some of these Summer Academy groups have continued to meet throughout the academic year to discuss and refine implementation projects developed at the Summer Academy. Other Summer Academy participants have shared their experiences and maintained interactions with teachers implementing similar tools and practices through the Center's collaboratives. The Center organized three collaboratives during the first year following the conference: the High School Physics Teacher Collaborative, the Middle School Science and Mathematics Teachers Collaborative, and the Mathematics Cross-Tier Teaching Teams. A fourth collaborative has recently been added for ninth-grade Earth sciences teachers. The collaboratives meet approximately monthly for dinner and set their own program plans, based upon the interests and needs of each group's participants. Participants include pre- and in-service teachers, STEM and STEM education faculty, Center postdoctoral research associates and professional staff, many of whom attended the Conference and/or Summer Academy. These collaboratives encourage the use of common curricular materials and assessments, and the sharing of student learning data and other outcomes.

The project's events have established and strengthened connections to build a supportive community for teachers, linking them with others with related expertise. The connections, common framework, and trust established and strengthened through conversations and collaborations at this conference have led to collaborative projects and proposals, such as (1) a statewide partnership grant focused on physical science teaching and learning in grades 6-9 submitted to the NSF Targeted MSP Program in August, 2009; (2) a collaborative evaluation of an astrobiology curriculum pilot project involving ten schools, involving the Maine Department of Education and the Center for Science and Mathematics Education Research; (3) detailed investigations of student learning about modeling and climate change through an NSF ITEST project, a collaboration among the University's engineering and Earth sciences faculty and the Center for Science and Mathematics Education Research; and (4) ongoing studies of the impacts of professional development in physical sciences offered by the Challenger Learning Center of Maine on teacher practice and student learning.

Interactions in Understanding the Universe (I2U2)

Grant #	0736126
NSF Program	NSF
PI	Marjorie Bardeen
Co-PI(s)	Mark Subbarao, Mitch Wayne, Mike WIlde
Institution	Fermilab
NSF Program Manager	Kathy McCould
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Web-based e-Labs

Interactions in Understanding the Universe (I2U2) supports and strengthens the educa-tion and outreach activities of scientific experiments at U.S. universities and laboratories by providing the framework on which a rich portfolio of coherent, collaborative online science education laboratories can be developed. It maintains an "educational virtual organization" that supports participating teachers, students, and laboratory content developers, and is a sustainable, long-running program to enhance the outcome of K-12 science education. The I2U2 collaboration of scientists, computer scientists and educators directly addresses the urgent national priority to grow and sustain the scientific workforce, and to promote the public's appreciation of and support for the frontier scientific research and complex col-laborations of our national scientific programs.

Research Questions
Do students learn science practices through e-Lab—grid-enabled virtual investigations? Specifically, do they increase their skills in using technology as a tool for conducting sci-ence (skills that mirror real-world science)? Do they engage in scientific collaboration and increase their knowledge of related science and grid concepts? Does the I2U2 virtual learning community support teacher practices and development to enable students to learn science practices with the I2U2 cyber-enabled tools?

R&D Framework
While their education activities often hold tremendous promise, experimental collabora-tions generally struggle to find the proper balance between achieving broader impacts and succeeding at their core research programs. In many cases, there are insufficient re-sources for and/or participation in education and outreach activities within a given collabo-ration to achieve a "critical mass" of scientists who can contribute in meaningful ways to the broader impact mission. The I2U2 program is motivated and inspired by the challenges facing experimenters, computer scientists and educators involved in large-scale science projects to achieve broader educational impacts in both formal and informal settings.

I2U2 provides a platform leveraging and facilitating education and outreach efforts. It es-tablishes a "library" of science problems, topics and datasets that bring frontier science ex-perimentation to both classroom and informal settings. In this approach, suggested by re-searchers, educators and computer scientists in collaboration with the NSF, I2U2 subject matter could include cosmic-ray air shower detectors, data from particle physics test beams and experiments, analysis of galaxy data from the Sloan Digital Sky Survey, inte-gration of biomedical data into the high-school laboratory, and more. In all of these areas, teachers and students can be direct experimental participants.

I2U2 will enhance the educational efforts of large scientific ventures by creating and main-taining a common fabric and support process to develop hands-on lab course content and provide an interactive learning experience that brings tangible aspects of each experiment into an accessible "virtual laboratory" setting for education at different levels and in various venues. We term this support structure the I2U2 Education Virtual Organization. A pro-gram such as I2U2 does not materialize instantly and must be "grown" through the grass-roots support of the professional communities involved, through the testing and improve-ment of the technologies and processes involved, and from interdisciplinary collaboration within the NSF. The research process begins with product development then tests imple-mentation.

Interactive Ink Inscriptions in K-12 (INK-12) (Collaborative Research - Koile)

Grant #	0822278
NSF Program	NSF
PI	Kimberle Koile
Co-PI(s)	Andee Rubin
Institution	TERC / MIT
NSF Program Manager	Michael Haney
Grade Level Band	PreK, Middle School
Target Audience	Students, Inservice
STEM Content Area	Science, Technology, Mathematics
Deliverables	Software prototype for tablet use; research reports on pilot testing

This project is an exploration of the use of a wireless network of tablet PC's in elementary and middle school math and science classrooms. This technology is just beginning to appear in K-8 classrooms, and is likely not to be widespread for 5 to 10- years. But too many technologies find their ways into classrooms without any idea how they might be used, what will be the advantages and barriers for teachers, whether they are more useful for some students than others. This project hypothesizes that several aspects of a network of tablets may be beneficial for all students and, perhaps, especially beneficial for some students with learning challenges. The two main features we examine are: 1) Because the tablets have a pen-based interface, students and teachers can draw and handwrite on them (create "ink"), annotate text, indicate locations on maps, draw graphs and other mathematical objects. 2) Because the tablets are connected in a wireless network, teachers and students can easily send ink to one another. This provides teachers the opportunity to look at all the students' work at the same time on his or her tablet (even anonymously), choose one or two to look at in more detail and have those appear on every student's screen to support a classroom discussion. This technology may have additional potential to help lower-performing students in particular, as teachers can provide appropriate resources for students "just in time" via wireless as they walk around the room.
These hypotheses are based on only a small amount of preliminary research, done in university classrooms so, while they are plausible, any of the research results this project generates will be new. Through classroom observations, student interviews, teacher interviews and student artifacts, this project seeks to understand the role that a network of tablets may plan in elementary and middle school math and science classrooms, to identify its advantages and disadvantages, to understand what challenges and benefits it offer to the teachers, and to offer recommendations for future development.

Interactive Ink Inscriptions in K-12 (INK-12)(Collaborative Research - Rubin)

Grant #	0822055
NSF Program	NSF
PI	Andee Rubin
Co-PI(s)	Kimberle Koile
Institution	MIT, TERC
NSF Program Manager	Michael Haney
Grade Level Band	PreK, Middle School
Target Audience	Students, Inservice
STEM Content Area	Technology, Mathematics
Deliverables	Web Site, Papers, Design Documents

This project is an exploration of the use of a wireless network of tablet PC's in elementary and middle school math and science classrooms. This technology is just beginning to appear in K-8 classrooms, and is likely not to be widespread for 5 to 10- years. But too many technologies find their ways into classrooms without any idea how they might be used, what will be the advantages and barriers for teachers, whether they are more useful for some students than others. This project hypothesizes that several aspects of a network of tablets may be beneficial for all students and, perhaps, especially beneficial for some students with learning challenges. The two main features we examine are: 1) Because the tablets have a pen-based interface, students and teachers can draw and handwrite on them (create "ink"), annotate text, indicate locations on maps, draw graphs and other mathematical objects. 2) Because the tablets are connected in a wireless network, teachers and students can easily send ink to one another. This provides teachers the opportunity to look at all the students' work at the same time on his or her tablet (even anonymously), choose one or two to look at in more detail and have those appear on every student's screen to support a classroom discussion. This technology may have additional potential to help lower-performing students in particular, as teachers can provide appropriate resources for students "just in time" via wireless as they walk around the room.
These hypotheses are based on only a small amount of preliminary research, done in university classrooms so, while they are plausible, any of the research results this project generates will be new. Through classroom observations, student interviews, teacher interviews and student artifacts, this project seeks to understand the role that a network of tablets may plan in elementary and middle school math and science classrooms, to identify its advantages and disadvantages, to understand what challenges and benefits it offer to the teachers, and to offer recommendations for future development.

Interactive Virtual Intelligent System for Scientific Inquiry in a Biology Learning Environment (Project INVISSIBLE)

Grant #	0454715
NSF Program	IMD
PI	Brian Butz
Co-PI(s)	Susan Miller
Institution	Temple University
NSF Program Manager	David A. Hanych
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Software Modules

The Interactive Virtual Intelligent System for Scientific Inquiry in a Biology Learning Environment (INVISSIBLE) produced an intelligent, interactive, multimedia software environment to help high school students better understand and apply scientific methodologies to biology problems. Using INVISSIBLE, a student interacts in scenarios that reflect authentic experiences of a scientist engaged in using scientific inquiry methods. Two learning modules were developed over three years in which students must use scientific inquiry skills and reasoning patterns necessary for the reconstruction of past events. The first module deals with a crime investigation and places the student in the role of the investigator. The second module deals with the origin of man and places the student in the role of an anthropologist examining an archeological dig to determine information about the origins of man.

The goals of the project are to:
A. Develop an innovative curricular approach for scientific literacy in biology that is driven by national standards and by the absence of content on non-experimental scientific inquiry. The curriculum is based on the three pillars of scientific understanding to increase student learning regarding: (a) knowledge acquisition of content concepts and principles (i.e., relevant to genetics, forensic science, and the biology of evolution), (b) relevant scientific process skills and knowledge, and (c) knowledge of nature and methods of science.
B. Develop an intelligent agent system which has the capacity to (a) create authentic multimedia scenarios for inquiry learning, (b) monitor a student''s performance and modify pedagogical strategies based on a dynamic assessment of the learner and (c) provide adaptability to bridge interactions between teacher and learner understandings.

International Conference on Assessment for Learning in Mathematics and Science 2008 (CAESL2008)

Grant #	0711579
NSF Program	NSF
PI	Michael Timms
Co-PI(s)	
Institution	WestEd
NSF Program Manager	Janice Earle
Grade Level Band	PreK, Middle School, High School
Target Audience	Students, Preservice, Inservice, Administrators
STEM Content Area	Science, Mathematics
Deliverables	Conference on Assessment for Learning

The conference targeted American and international researchers and practitioners in mathematics and science assessment. This year, the timing of the CAESL conference also allowed participants from the Culture, Context, and STEM Education Conference to attend and share learning from their own initiatives. Sessions were practice-oriented, demonstrating ways of developing such assessments and pointing out the likely challenges that will be encountered.

International Polar Year Symposia and Web Seminars at NSTA Conferences on Science Education: Collaboration between NSF, NOAA, and NASA

Grant #	0829225
NSF Program	NSF
PI	Albert Byers
Co-PI(s)	
Institution	Natioanl Science Teachers Association
NSF Program Manager	Renee D. Crain
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice
STEM Content Area	Science, Technology
Deliverables	Conference symposia, Symposia archive, Web seminars, Web seminar archives, Podcasts

Since 2003, the National Science Teachers Association (NSTA) has been offering Symposia workshops at its national and area conferences designed to provide participants with in-depth looks at emerging topics of interest in science and education. These face-to-face sessions have included opportunities to follow up with session presenters within online “live” Web Seminars during the month following each conference. Web Seminars have been available as follow-up experiences for Symposia participants and other teachers who did not have the opportunity to attend the face-to-face sessions.

As part of the celebration of the International Polar Year (IPY) and in collaboration with an interagency team composed of scientists and educational specialists from the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and other scientists funded by the National Science Foundation (NSF), NSTA designed, delivered, and evaluated two Symposia workshops at the conference, and four follow-up Web Seminars that reached science teachers across the country and shared with them the science content and educational resources available through the IPY initiative. The Symposia took place at the NSTA area conference in Birmingham, Alabama, and at the national conference in Boston, Massachusetts. Including the related one-hour sessions scheduled at the conference as face-to-face follow-up to the Symposia, the online follow-up Web Seminars, and the Web Seminar archives and podcasts, the programs reached hundreds of science educators. The topics for the programs came from the existing IPY themes and interagency member institutions. The Symposia and Web Seminars’ topics were aligned to the topics found in the National Science Education Standards. The topics supported the curriculum at the middle and high school levels and reflected the science research produced by NASA, NOAA, and other scientists funded by NSF.

A third-party evaluation conducted as a follow-up of the supported opportunities indicated the programs were well received by participants. Over 98% of educators indicated a desire to have similar future opportunities available for their professional development. The IPY-supported activities are part of a larger NSTA initiative to provide teacher professional development (PD) via the NSTA Learning Center, NSTA’s e-PD portal with over 4,000 resources and tools available to all teachers, K-12. The Symposia and online seminars and seminar archives are integrated with the other NSTA resources and services to optimize improvements in U.S. science education, a goal shared by NASA, NOAA, the NSF, and the NSTA membership.

Investigating the Effect of Professional Development, Mathematical Knowledge for Teaching, and Instruction on Student Outcomes

Grant #	0918383
NSF Program	NSF
PI	Heather C. Hill
Co-PI(s)	
Institution	Harvard Graduate School of Education
NSF Program Manager	John Bradley
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Reports, journal articles

In this research, we propose to shed light on twin problems facing efforts to improve teacher quality in mathematics. The first problem is theoretical: What mathematical knowledge do teachers need to effectively instruct children? Does teacher basic, advanced, or profession-specific knowledge (e.g, mathematical knowledge for teaching, or MKT) matter most to student outcomes? The second problem is more practical: Can a particular professional development program, Math Solutions, improve teachers' mathematical knowledge for teaching, their instruction, and student outcomes?

To address these twin problems, we will conduct a cluster randomized trial to examine the efficacy of Math Solutions on elementary teachers' MKT, their instruction, and their students' learning. We chose to embed the study of teacher MKT in an evaluation of professional development because it is not possible to randomly assign teachers to different levels of MKT. Instead, we will randomly assign teachers to Math Solutions with the goal of examining the contribution of changes in teachers' MKT, as it develops in and through the professional development, to instruction and student achievement.

Data collection will take place in the Albuquerque Public Schools over three years and will involve 80 fourth and fifth grade teachers in approximately 12 schools. Half the eligible teachers will be randomly assigned to the professional development and half will receive "as is" professional development offered by the district. Longitudinal data will be collected on teachers' mathematical knowledge, instruction, and their student gains, allowing us to examine the effect of Math Solutions on these outcomes.
If no program effects occur, we can still use data collected from this study to build more complete models of student achievement than exist to date. These including testing different forms of teacher knowledge as well as various facets of mathematics instruction (errors, richness of mathematics, cognitive demand) on student outcomes.

Investigating the Meaningfulness of Preservice Programs Across the Continuum of Teaching (IMPPACT) in Science Education

Grant #	0455819
NSF Program	TPC
PI	John Tillotson
Co-PI(s)	Scott Samson
Institution	Syracuse University
NSF Program Manager	Joan Prival
Grade Level Band	Post Secondary
Target Audience	Preservice, Inservice
STEM Content Area	Science
Deliverables	Research articles, Web site, instrument guide, and a project DVD

The IMPPACT project is a multi-university, collaborative research study targeted at investigating the longitudinal impact of preservice science teacher education program experiences on middle and secondary science teachers across critical developmental stages within the teacher professional continuum.

Increasing national attention has been placed on the role that teacher education programs play in addressing the changing needs of teachers throughout their professional lives. The goal of this project is to study the formal and informal learning experiences of cohorts of science teachers (N=120) at four critical points in their professional careers: (1) upon entry into science teacher education; (2) during the candidacy stage of science teacher education programs, including the associated field experiences; (3) during the early induction years as a new science teacher (years 1-4); and (4) during the post-induction stage of science teaching (years 5+). Using a mixed methods design, interdisciplinary research teams at Syracuse University, the University of Iowa, and North Carolina State University will collaborate to empirically investigate the role that science teacher preparation experiences play in helping recruit, prepare, and support 7-12 grade science teachers.

This research project will generate information on how individuals develop pedagogical and content knowledge in science throughout their preservice programs and professional careers, and how their professional development needs evolve. This study will also help determine the linkages between science teachers' beliefs and practices over time and how they impact student achievement scores in grade 7-12 science classrooms. Thus, the results will have direct implications for how exemplary, evidence-based science teacher education programs can be created to better support science teacher development and student learning across all stages of the teacher continuum.

The IMPPACT project dissemination plan is multi-dimensional, beginning with the production of a detailed instrumentation package and accompanying instructional guide. These documents will be made available to educators and policy makers through both print and electronic means via an IMPPACT project Web site. A DVD will be produced that highlights key study outcomes using a series of multimedia cases. Each case will include information about the specific research question(s) being explored, the data gathered, the analysis protocols used, and the results obtained using sample video and data from the university and K-12 classrooms involved in the study. The three research teams will also collaborate to produce several peer-reviewed journal articles, conference presentations and workshops, as well as on-campus colloquia at each institution. Finally, the doctoral associates involved in the IMPPACT study will focus their doctoral research on one or more elements of the overall project resulting in the generation of several high-quality dissertations reporting on specific elements of the overall project in greater depth.

Investigating the Needs of Elementary School Teachers of Mathematics at Different Points During Sustained Professional Development

Grant #	0455785
NSF Program	TPC
PI	Randolph Philipp
Co-PI(s)	Victoria Jacobs
Institution	San Diego State University
NSF Program Manager	John (Spud) Bradley
Grade Level Band	PreK
Target Audience	Preservice, Inservice, Higher Education, Other
STEM Content Area	Mathematics
Deliverables	Research Articles

There is a growing consensus that to support teachers in developing new ways of thinking, professional development needs to be sustained over years, not weeks or even months (Darling-Hammond & McLaughlin, 1996; Hawley & Valli, 1999; Richardson & Placier, 2001). However, there is little practical or research-based knowledge to help facilitators plan and implement professional development from a long-term perspective. Our goal is to map a trajectory for the evolution of elementary school teachers engaged in sustained professional development.

We are studying professional development focused on children's mathematical thinking because research has shown that such professional development can (a) help teachers create rich instructional environments with documented improvement in student achievement and (b) lead to continued learning by teachers even after formal professional development support ends (Franke, Carpenter, Levi, & Fennema, 2001; Wilson & Berne, 1999).

A major assumption of our project is that it is meaningful and beneficial to study teachers at different points in time that are defined by how long teachers have been engaged in sustained professional development focused on children's thinking, not by how long they have been teaching.

Study 1. We used a cross-sectional design to explore the knowledge, beliefs, and practices of the following groups of teachers: (a) teachers beginning professional development focused on children's thinking, (b) teachers who have engaged with professional development focused on children's thinking for at least 2 years, and (c) teachers who have engaged with professional development focused on children's thinking for at least 4 years and have begun to emerge as teacher leaders. The teachers (30 per group) were drawn from three districts that have engaged more than 400 elementary school teachers in professional development focused on children's mathematical thinking and that have teachers meeting our selection criteria, with some emerging teacher leaders engaged in this professional development up to 9 years. These districts reflect our ethnically and linguistically diverse urban setting. To provide an anchor for the trajectory, we have also studied the knowledge, beliefs, and practices of 30 prospective teachers drawn from a comprehensive university. Data were collected through multiple measures including a content assessment, a beliefs survey, a noticing instrument, focus-group discussions of classroom artifacts, and videotapes of the participants interviewing students. Video and written-student-work artifacts have served prominent roles in our measures, analytic lenses, and professional development contexts.

Research Question. What are the similarities and differences among elementary school teachers at three points during sustained professional development in terms of their knowledge, beliefs, and practices?

Study 2. We are collaborating with professional developers from a variety of projects to better understand how our Study 1 findings can inform their work with prospective and practicing teachers.

Dissemination. Our goal is to reach multiple audiences through conference presentations and journal

publications that will be written for five (sometimes overlapping) audiences: mathematics education researchers, mathematics teacher educators, college mathematics instructors, professional development facilitators, and teachers. To reach these audiences, we are also hosting two preconferences to national conferences.

Investigations in Cyber-enabled Education (ICE)

Grant #	DRL-0918340
NSF Program	NSF
PI	Kathryn Berry Bertram
Co-PI(s)	
Institution	University of Alaska Fairbanks Geophysical Institute
NSF Program Manager	Michael Haney
Grade Level Band	Middle School, High School
Target Audience	Inservice
STEM Content Area	Science, Technology, Mathematics
Deliverables	CyberEnabledEducation.org

Investigations in Cyber-enabled Education (ICE) strives to provide a professional development design framework for enhancing teacher ability to provide science, technology, and math (STM) instruction for secondary students. Exploratory research will clarify ICE framework constructs and gather empirical evidence to form the basis of anticipated further research into the question: Under what circumstances can cyber-enabled collaboration between STM scientists and educators enhance teacher ability to provide STM education?
The Intellectual Merit of ICE lies in creating a potentially transformative framework for involving scientists in meaningful, sustained collaboration with teachers. The ICE Framework goal is to promote virtual scientist-teacher collaboration that is (1) sustainable, (2) affordable, (3) replicable, and (4) broadly accessible to teachers in all parts of the U.S. Under the ICE a framework, scientists are involved in a continuum of professional development. Scientists share in creating cyber training, collaborate with teachers online as they work through training, and provide a network of support as teachers transfer training to class instruction. Exploratory research begins with the development and testing of a prototype course based on the ICE Framework, and then moves to assessment of efficacy. The PI and a Development Team of 13 scientists, a master teacher and technology experts, will create a course that taps the scientific resources and expertise at the University of Alaska Fairbanks Geophysical Institute. The PI has implemented several programs aligned with the proposed initiative and has established a diverse network of scientific expertise to draw upon. The PI will guide formative research that clarifies ICE Framework constructs and informs course creation. PI leadership will be informed by input from a 40-year education researcher and an Advisory Board of scientific, pedagogical, and methodological experts. The course will consist of research-aligned cyber-learning activities and a Sustainable Learning Community that provides multiple venues for cyber-enabled scientist-teacher collaboration. Virtual collaboration will endure after course end while teachers transfer training into class instruction. Experimental methods with control group comparison will be used in summative research. External Evaluators will examine the extent to which the project has met its goals. Objectives include gathering empirical evidence to determine if (how, why, and to what extent) course cyber-enabled scientist-teacher collaboration enhanced teacher STM instructional ability.
Broader Impacts lie in advancing discovery and understanding of cyber-infrastructure that provides sustainable scientist-teacher collaboration accessible from anywhere in the U.S. Ex-ploratory research focuses on climate and its affects on Alaska Natives. However, the initiative is intended to build a framework that can be adapted by any community with shared STM research concerns. Professional development courses designed using the ICE Framework promote 21st Century learning and incorporate workforce skills needed to conduct research in a global society. Affordable, flexible, online training that enables teachers to tap scientific expertise is expected to be beneficial for educators in disadvantaged and rural areas of the U.S. Exploratory findings and anticipated contributions to research will be broadly disseminated to a diverse audience of policymakers, education researchers, teachers, teacher educators, schools, and scientists via journals, conferences, and national web-based databases and networks.

Knowledge Synthesis on STEM Teachers in Professional Learning Communities

Grant #	0822013
NSF Program	NSF
PI	Kathleen Fulton
Co-PI(s)	Ted Britton, WestEd
Institution	National Commission on Teaching and America's Future
NSF Program Manager	Julia Clark
Grade Level Band	Middle School, High School, Post Secondary, Other
Target Audience	Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	none yet, will use www.nctaf.org & other

The National Commission on Teaching and America's Future, in partnership with WestEd, is conducting a comprehensive synthesis of the literature on the effectiveness of professional learning communities (PLCs) in K-12 education, with special attention to their impact on science, math, engineering and technology (STEM) teaching and learning. This synthesis is particularly timely because learning communities have been promoted as vehicles for addressing teaching quality by supporting teacher learning and enhancing professional satisfaction, leading to greater teacher retention and improved student achievement.

Because experiments with STEM teacher PLCs are proliferating faster than formal research into the phenomenon, the project not only comprehensively synthesizes peer-reviewed research but also examines additional types of knowledge that are influencing the field. The synthesis considers the evidence base for and gaps in each type of knowledge when analyzing both congruent and conflicting relationships between them. Researchers evaluate the methodological integrity and evidentiary utility of each research study or knowledge claim. The proposed knowledge synthesis takes into account four classes of knowledge that bear on the phenomenon: (1) empirical and descriptive studies published in peer-reviewed education and policy journals; (2) empirical and descriptive studies published (including online) in venues other than peer-reviewed journals (e.g., research funded by a state agency that is published on their Web site; primary studies conducted published by stakeholder organizations, or secondary analyses focused on policy issues); (3) published expert opinion/advice (not research) located in periodicals or on Web sites; and (4) current practice-based knowledge collected through the use of an Expert Practitioner Panel.

The project evaluates the existing knowledge about STEM teachers across grades K-12 in PLCs, typically made up of a minimum of three teachers. While research on PLCs that are exclusively for teachers of science, mathematics, engineering or technology (or combinations of STEM subjects) will be addressed, the synthesis also will look for research on cross-subject PLCs where data about the experiences and effects for their participating STEM teachers is disaggregated. PLCs at both the preservice and inservice level of educators' learning will be considered. The synthesis will look at the range and frequency of PLCs for STEM teachers, what is known about implementation issues around different models (i.e. online vs. face-to-face; PLCs for induction vs. those involving more experienced teachers, within or across schools, etc.), and their effects. Both face-to-face and virtual PLCs (e.g. online communities of teachers) will be examined. Guiding questions include reviews of the effects of STEM teacher participation in PLCs on teachers' math and science content knowledge? on teachers' mathematics and science instructional practice? on students' mathematics and science achievement? on teachers' attitudes toward teaching, feelings of preparedness, professional and collegial interactions, and retention?

The study is entering the second year of the two-year grant. Results will be disseminated using NSF's DR-K12 Resource Network, as well as NCTAF's state partnership network.

Learning and Teaching Geometry: VideoCases for Mathematics Professional Development

Grant #	0732757
NSF Program	NSF
PI	Nanette Seago
Co-PI(s)	Mark Driscoll
Institution	WestEd
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School, High School
Target Audience	Preservice
STEM Content Area	Mathematics
Deliverables	Published Video Case PD Materials

The Learning and Teaching Geometry project (LTG) will create five video case modules focused on classroom instruction for use in professional development of middle school mathematics teachers. The materials will be designed to support teachers in developing an understanding of the mathematics knowledge for teaching the concept of similarity in geometry and beyond. Module I, the foundation module, will focus on a thorough grounding of similarity and will contain six to eight video case sessions. The four extension modules (containing three or four video case sessions each) will offer options for further exploration on related topics depending upon teachers' interests and needs. The five modules are:

I. Conceptualizing, Defining, and Representing Similarity (Foundation Module)
II. Definitions and Theorems: What Is the Difference?
III. Similar or Merely Alike? The Role of Language in Geometry
IV. Choosing and Using Technological Tools to Enhance the Learning of Similarity
V. From Inductive to Deductive Reasoning: Bridging to High School Geometry

Overall learning goals include supporting teachers (1) to understand links to congruence, isometries, and dilation, (2) to think of similarity in terms of scale factor—for strengthening proportional reasoning and generalizing about geometric measurement in one, two, and three dimensions, and (3) to realize the essential role that similarity of triangle plays in understanding linear functions and slope. These video case modules, consisting of 18-24 total video case sessions, will provide a coherent sequence of professional development materials that can be used within a variety of institutes and workshops for teachers. Each module will comprise two major sets of resources: (1) video case materials and (2) facilitation resources. Video case materials include video segments and other records from classroom lessons (e.g., samples of student work, teacher notes, curriculum materials). Facilitation resources will provide support for the professional developers' use of the video case materials with teachers (e.g., detailed agendas, mathematical commentaries, facilitation notes, and other resources that field test sites deem important).

This five-year project will contribute innovative professional development materials that will aim to (1) foster the mathematical knowledge needed for teaching specifically to middle grades geometry; (2) foster pedagogical knowledge related to middle grades geometry; and (3) influence teachers' knowledge and classroom practice.

Learning Assistant Model of Teacher Education in Science and Technology

Grant #	0554616
NSF Program	TPC
PI	Valerie Otero
Co-PI(s)	Steve Pollock, Mike Klymkowsky, Derek Briggs
Institution	University of Colorado at Boulder
NSF Program Manager	Keith Sverdrup
Grade Level Band	PreK, Middle School, High School, Post Secondary
Target Audience	Students, Preservice, Inservice
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Web Site, CD Resources for Program Repli

The Learning Assistant Model for Teacher Education in Science and Technology (LA-Test) project is a research project designed to examine the efficacy of the STEM Colorado Learning Assistant (LA) program for recruiting and preparing mathematics and science teachers. In addition to our research, we have developed a suite of materials to assist other colleges and universities in implementing a Learning Assistant program at their universities, including an full-semester pedagogy course for STEM majors who serve as LAs and could be recruited to teaching careers. We have three research teams, each answering one of the questions below. Research teams consist of faculty, post-doctoral scholars, and graduate students from five STEM departments (Physics; Chemistry; Astrophysics; Applied Mathematics; and Molecular, Cellular, and Developmental Biology) and from the School of Education.

Three research teams are investigating content, pedagogy, and practice at different stages in the teacher professional continuum: as undergraduate students before making decisions to become teachers, as undergraduates/post-baccalaureate students after having made the decision to become teachers and enrolled in a teacher certification program, as student teachers, and as early-career teachers. Research questions are listed below.

Discipline-Based Educational Research (DBER) Team: (a) How do LAs compare to other STEM majors in terms of their content understanding, beliefs about the discipline, and beliefs about learning in the discipline? (b) What effects can be observed on student achievement in courses that are supported by LAs?

Conceptions of Teaching and Learning (CTL) Team: (a) What is the effect of the LA model on the sophistication of LA pedagogical understanding? (b) Does sophistication of pedagogical understanding vary by length of exposure to the LA model? (c) How is the pedagogical sophistication of STEM LAs different from the sophistication of STEM non-LAs who become teachers?

K-12 Team:
• How do teachers and teacher candidates who participated as LAs compare to those who did not in terms of (a) practicum-based coursework? (b) their teaching practices? (c) K-12 student attitudes and beliefs about mathematics and science? (d) retention and attrition rates?
• What is the difference between those who apply to be LAs and are accepted, those who apply and are not accepted, and those who do not apply in terms of their interest in teaching, conceptual understanding, and interest in the topic?
• How does the LA program impact STEM majors' decisions to become teachers, their content knowledge, and their interest in the topic?

Synthesis: These questions are answered individually by small teams. Each team meets weekly and all teams meet monthly. By the end of the project, data and findings will be synthesized to better understand the efficacy of the LA program on addressing multiple challenges in recruiting and preparing STEM teachers.

Learning Progressions for Scientific Inquiry: A Model Implementation in the Context of Energy

Grant #	0732233
NSF Program	NSF
PI	Fred Goldberg
Co-PI(s)	David Hammer, Janet Coffey, Sharon Bendall, April Maskiewicz
Institution	San Diego State University
NSF Program Manager	Janice Earle
Grade Level Band	PreK, Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Papers and exemplary curriculum modules

Our major project goals are (1) to understand how teachers may progress in attending and responding to student thinking, (2) to understand how students may progress in their abilities to engage in scientific inquiry, and (3) to develop curriculum materials that support inquiry-oriented science classrooms. During the first year of our project, we worked with 8 elementary teachers, and their classrooms of students (approximately 240 students, grades 3-6). We are now working with 20 teachers, in two public school systems.

We started our work with the assumption that elementary students have resources for engaging in scientific inquiry – we define that to mean the pursuit of coherent, mechanistic accounts of natural phenomena (Hammer, 2004) -- but that they do not necessarily apply these resources reliably or deliberately. Through close analysis of videotaped classroom interaction and artifacts of student work, we seek to identify episodes of scientific reasoning, describe their nature, and then understand the dynamics that led students into and out of attending to mechanism and coherence. Over time, we seek to establish what more stable and deliberate commitments to scientific reasoning look like, and from what conditions they arise.

Through research on our professional development activities and teachers' classroom teaching, we seek to better understand what scaffolding, instructional activities, and professional development activities support teachers' attention, awareness, and responsiveness to the substance of students' ideas and reasoning. We have collected and analyzed baseline data from teachers on key-aspects of reform-oriented teaching and will continue to track teachers' practice throughout the project. This data is primarily videotape of classroom teaching (both within the project module and in non-module teaching), of summer and bi-weekly professional development sessions, and of interviews. We analyze this video for what teachers are attending to while teaching and in reflection on teaching, for what they notice and pursue, as well as for what their moves in this class appear to promote in students' reasoning and understandings.

The project supports the teachers in their classroom practices through both the modules and professional development activities. We are designing modules for four grade levels in four different content areas: motion (3rd grade), electric circuits (4th grade), water cycle (5th grade), and ecology (6th grade). Each module consists of an opening question aimed at generating substantive student conversation, anticipations of what ideas might arise in that conversation, and suggestions for ways the teacher might respond, including ideas for topics or activities that would follow-up on students' reasoning. In the end the module will be augmented with embedded video vignettes.

For professional development we have focused both on engaging teachers in scientific inquiry and in examining scientific inquiry in their classrooms. The inquiry engagement activities are aimed at helping teachers develop 'images' both of what scientific inquiry is and how it may play out in a classroom. The classroom video activities are aimed at helping teachers practice attending to students' ideas and reasoning and considering responsive moves.

Learning Science as Inquiry with the Urban Advantage: Formal-Informal Collaborations to Increase Science Literacy and Student Learning

Grant #	DRL-0918560
NSF Program	NSF
PI	Jim Short
Co-PI(s)	Suzanne Wilson
Institution	American Museum of Natural History
NSF Program Manager	Robert Gibbs
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	none at this time

The American Museum of Natural History and Michigan State University plan to conduct a research and development project focused on DR-K12 challenge #2 and the hypothesis that learners must have access to the real work of scientists if they are to learn both about the nature of science and to do inquiry themselves. The overarching questions that drive this project are: How can informal science education institutions best design resources to support teachers, school administrators, and families in the teaching and learning of students to conduct scientific investigations and better understand the nature of science? How are these resources then used, and to what extent and in what ways do they contribute to participants' learning? How are those resources then used for student learning? Answering these questions will involve the use of existing and new resources, enhancement of existing relationships, and a commitment to systematically collect evidence. Urban Advantage (UA) is a middle school science initiative involving informal science education institutions that provides professional development for teachers and hands-on learning for students to learn how to conduct scientific investigations. This project will (1) refine the UA model by including opportunities to engage in field studies and the use of authentic data sets to investigate the zebra mussel invasion of the Hudson River ecosystem; (2) extend the resources available to help parents, administrators, and teachers understand the nature of scientific work; and (3) integrate a research agenda into UA. Teaching cases will serve as resources to help teachers, students, administrators, and families understand scientific inquiry through research on freshwater ecosystems, and—with that increased understanding—support student learning. Surveys, observations, and assessments will be used to document and understand the effects of professional development on teachers, students, administrators, and parents. The study will analyze longitudinal, multivariate data in order to identify associations between professional development opportunities for teachers, administrators, and parents, their use of resources to support their own learning and that of students, middle school teachers' instructional practices, and measures of student learning.

Learning to RECAST Students' Causal Assumptions in Science Through Interactive Multimedia Professional Development Tools

Grant #	0455664
NSF Program	TPC
PI	Tina Grotzer
Co-PI(s)	
Institution	Harvard University
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Preservice, Inservice
STEM Content Area	Science
Deliverables	Interactive Web site, video, books and guide/support materials

Understanding the nature of causality is critical to learning a range of science concepts from "everyday science" to the science of complexity. The Understandings of Consequence (UC) Project, funded by NSF, established that students hold default assumptions about the nature of causality that hinder their science learning and that curriculum designed to restructure students' causal assumptions while learning the science leads to deeper understanding. The UC team and the Science Media Group (SMG) of the Harvard-Smithsonian Center for Astrophysics are collaborating in a five-year iterative design process to develop and test interactive, multimedia professional development tools. These tools are designed to guide middle school physics and biology teachers in assessing the structure of their students' scientific explanations and in using existing curricula and developing their own curriculum to restructure or RECAST students' understandings to fit with scientifically accepted explanations.

The project has developed a professional development web site that includes: documentary footage of real-life classrooms; interviews with teachers describing challenges and obstacles they faced introducing the curricula, how these were overcome, and, the benefits they obtained from using the materials; comments by students, which demonstrate the wide range of student prior thinking about specific causal forms as embedded in the science concepts; discussion questions, suggested hands-on activities, and short videotaped "content explorations," design guides and questions to help teachers understand the features of and how to design RECAST activities, assessments, and assessment rubrics related to causal understanding in science. We are currently testing the materials with 60 teachers (30 controls who have access only to the UC curriculum materials and 30 intervention teachers who have access to the curriculum and the Web site support). The site will launch in Jan. 2010. Education Development Center, Inc. (EDC), is conducting the external evaluation.

Linear Algebra and Geometry: Advanced Mathematics For More Students

Grant #	0733015
NSF Program	NSF
PI	Albert Cuoco
Co-PI(s)	
Institution	Education Development Center, Inc.
NSF Program Manager	John Bradley
Grade Level Band	High School
Target Audience	Students
STEM Content Area	
Deliverables	Three Semesters of Curriculum Material

Linear Algebra and Geometry will produce materials for a high school linear algebra course. The materials will consist of a core semester that introduces students to vectors and matrices, and twelve stand-alone modules devoted to applications of this mathematics. The main goal is to increase participation in rigorous, advanced mathematics courses. There's ample evidence that we are not tapping the potential of American high school students:

- International comparisons show that the proportion of U.S. students taking courses like Linear Algebra and Geometry is smaller than in most industrialized countries.
- Within the US, the demographics of students taking advanced courses show marked underparticipation from African American, Latino, and other minority groups.

The courses will use the approach of the NSF-funded CME Project high school curriculum with features that include a synthesis of problem-based, open-ended investigations with more direct instruction, basic use of current and emerging technology, a focus on central mathematical themes, and careful attention to student thinking. Resources for teachers include a yearly two-week course in modern linear algebra and its applications and the creation of a national community devoted to linear algebra in high school. Collaborators include mathematicians, mathematics educators, high school teachers, school districts with an ethnically and racially diverse student population, Pearson Publishing Group, The MathWorks, and Texas Instruments.

Linking Middle & Early High School Science & Mathematics Assessment Items to Local, State & National Content Standards

Grant #	0352473
NSF Program	IMD
PI	George DeBoer
Co-PI(s)	Jo Ellen Roseman
Institution	American Association for the Advancement of Science (AAAS)
NSF Program Manager	Janice Earle
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science
Deliverables	Test Items Aligned to AAAS Benchmarks and NRC Standards

Project 2061 is developing clusters of high-quality middle school and early high school science assessment items that are linked to core ideas in AAAS's Benchmarks for Science Literacy and the National Research Council's National Science Education Standards (NSES). A variety of strategies are being used to design items with high construct validity and precise alignment to interrelated sets of content standards. Items are also designed to test for common misconceptions that have been identified in the research literature.

As a first step in creating these clusters of high quality assessment items, Project 2061 developed criteria to determine the content alignment of items to learning goals in Benchmarks and NSES and to identify features of the items that obscure what students really know. We also use one-on-one interviews with students and pilot testing in which students are asked to give reasons for their answer selections. During both interviewing and pilot testing, the students' answer choices are compared to the explanations they give for their answers to detect false negative and false positive responses.

We have now written and pilot tested hundreds of items covering sixteen science topics. Based on what we have learned about the items, some were discarded and others were revised for national field testing. The national field testing results are used to determine various psychometric properties of items and of clusters of items, and they are used to provide us with difficulty scores, item discrimination indices, and differential item functioning scores. This and other information, such as the misconceptions that students hold, will become part of each item's profile in the collection.

The field test results allow us to use clusters of items to model student understanding of related science ideas at the topic, key idea, and sub-idea levels, thus making the items and sets of items useful as diagnostic tools for teachers, science specialists, and district assessment personnel. The items are also useful in curriculum and assessment development and in education research aimed at identifying and empirically testing how students' understanding of science ideas progresses from simpler to more complex levels of comprehension.

Linking Teacher Preparation to Student Learning in Mathematics and Science

Grant #	0554486
NSF Program	TPC
PI	Marcy Singer-Gabella
Co-PI(s)	Jen Cartier, Ellice Forman
Institution	Vanderbilt University
NSF Program Manager	Joan Prival
Grade Level Band	PreK
Target Audience	Preservice, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Other

This project examines relationships among preservice teachers' developing understandings of mathematics and science learning, the enactment of these understandings as they begin teaching, and the learning outcomes of their students. The objectives are (1) to inform the design of teacher preparation program, pushing beyond craft to evidence-based design choices based on models of teacher learning trajectories, and (2) to support the development of appropriate tools to assess the impact of teacher preparation program features on elementary and middle school student learning. Over the course of five years, research teams at Vanderbilt University and the University of Pittsburgh will document and analyze undergraduate and graduate students' developing conceptions of mathematics and science concepts, practices, and pedagogies—as they move from undergraduate coursework in mathematics and science, through their teacher preparation programs and into their first teaching assignment. Analyses of participants' performances on a range of assessments, supplemented by interviews and observations, will be used in a longitudinal design to articulate trajectories of change in participants' understandings. The research teams will follow a subgroup of participants into the first two years of teaching, using structured observations and interviews to characterize their teaching of target ideas in mathematics and science. Finally, the research teams will assess the learning of participants' grade 2-6 students, using tasks that tap understanding of these targeted ideas.

Given the impossibility of examining the many things teachers must learn, our strategy is to begin by pursuing a rich, but bounded section of the problem space: teachers' understanding of learning and learners within the domains of science and mathematics. Tightening the focus further, longitudinal investigation is organized around a small number of "linchpin" concepts in mathematics and science that are associated with a well-articulated research base on student learning. Drawing on this research base and informed by other efforts to assess teacher and student learning, the project team is developing measures to complement standardized measures of achievement, providing more detailed information about students' and teachers conceptual development in these areas.

The effort addresses a well-documented gap in scholarship on the development of teachers' pedagogical content knowledge and the impact of this knowledge on both teaching practice and student learning. It is intended to provide a model for conducting research on teacher preparation in a comparative manner. We anticipate that the assessments of teacher and student learning will support a broader effort to understand the "value added" of teacher education programs for student learning. Indeed, we envision the project as a first step toward developing a network of scholars in university-based teacher preparation programs that vary in size, duration, and approach. We hope that this network will pursue coordinated research on the typical trajectories of development in university-based teacher preparation programs and on how variations in learning affect teachers' later effectiveness in supporting student learning. The goal is not to establish the "best" way to prepare teachers, but instead to provide empirical findings on the implications of different program design choices and thus enable the optimization of key variants.

The research teams at each site bring deep experience and scholarship in mathematics and science teaching and learning. Both have extensive experience working with urban schools that serve high concentrations of low-income students. Both teams participate in teacher education programs that emphasize an approach to teaching that is guided by strong knowledge of both disciplinary content and student thinking.

Logging Opportunities in Online Programs for Science (LOOPS): Student and Teacher Learning

Grant #	0733299
NSF Program	NSF
PI	Kimberlie Koile
Co-PI(s)	Robert Tinker, James Slotta, Marcia Linn
Institution	The Concord Consortium
NSF Program Manager	Mike Haney
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Technology, curriculum units, professional development

LOOPS is a national program that uses the cyberinfrastructure to provide innovative resources that support inquiry in the middle school science classroom. The project makes innovative use of technology to create timely, valid, and actionable reports to teachers by analyzing assessments and logs of student actions generated in the course of using online curriculum materials. The reports allow teachers to make data-based decisions about alternative teaching strategies, and are especially important in identifying under-performing students who might otherwise be overlooked.

Project Goal. In a busy classroom using computer-based materials it is hard for a teacher to distinguish between a student who is learning intently by exploring a model or experiment and one who is just going through the motions or is confused. As materials get more sophisticated, it is increasingly difficult for teachers to play an active role in planning their delivery and enacting it in the classroom. LOOPS addresses this challenge by providing teachers with timely formative feedback that provides insights into student learning and gives teachers instructional options that are data-driven.

Project Objectives. The project will put teachers squarely in feedback LOOPS based on a variety of data streams that inform their choices of assessments, actions, and curriculum customizations. These feedback loops will be classroom-tested with materials focused on eighth grade physical science standards. The principles derived from this research will inform design of new materials and supporting technologies. These will be general and portable, so that our approach will have immediate connections with other STEM resources.

The project is a collaboration among physical scientists, computer scientists, and learning scientists at Concord Consortium, University of California Berkeley, and University of Toronto. Project members are working closely with teacher-developers to create materials for eighth grade topics of Force and Motion, and Chemical Reactions. The materials are being field-tested in California and Massachusetts.

Making Sciences: Data Modeling and Argumentation in Elementary Science

Grant #	0733233
NSF Program	NSF
PI	William Sandoval
Co-PI(s)	Noel Enyedy
Institution	Graduate School of Education & Information Studies, UCLA
NSF Program Manager	David Hanych
Grade Level Band	PreK
Target Audience	Students
STEM Content Area	Science
Deliverables	curriculum model and research products

Making Science will develop an elementary level curriculum focused on data modeling and scientific argumentation, using scientific data and sensor technology from the Center for Embedded Networked Sensing (CENS, NSF CCR-0120778). The project leverages the principal investigator's ongoing NSF-funded Instructional Materials Development project, CENSEI (NSF ESI-0352572). This will be a 3 year Exploratory project in component B.2 of the DRK-12 solicitation: Resources and Tools for Instruction of K-12 Students and Teachers. This project addresses two of the solicitation's grand challenges, to improve elementary science education, and to bring cutting edge science to K-12 classrooms. Making Science will work collaboratively with 2nd and 3rd grade teachers at UCLA's Corinne A. Seeds University Elementary School (UES) and scientists affiliated with CENS to develop a coherent science curriculum on ecosystems that includes students' investigation and analysis of sensor data collected by CENS networks. The project team will develop a year-long curriculum, study its implementation in the combined 2nd-3rd grade classrooms at UES in the project's second year, and field test instructional materials in the third year with elementary teachers in Los Angeles, the second largest school district in the country.

Intellectual Merit. Making Science will advance two important goals for elementary science education. First, research on cognitive development convincingly demonstrates that young children are capable of much more ambitious science instruction than they typically receive. Making Science will provide such instruction, which is necessary to improve science learning throughout the school years, and beyond. The investigators have significant experience developing innovative learning environments, and the project team brings several areas of teaching and scientific expertise to the project. Second, the project will advance developmental research specifically in the area of children's ideas about and abilities for scientific argumentation. As argumentation becomes a more central focus of research in science education, there is a need for accounts that ground children's argumentation in their science classroom contexts. The investigators' experience in studying argumentation by older students and in organizing and studying classroom learning interactions makes them well poised to contribute to a developmental account that could lead to a learning progression for scientific argumentation throughout the K-12 years.

Broad Impact. This project will capitalize on cyberInfrastructure developed by CENSEI to make anticipated products widely available. Instructional products will include lesson plans, software tools, student materials, as well as implementation strategies for teachers, and will be field-tested with a diverse urban student population. The project will demonstrate young children's capacities for ambitious science instruction and provide resources for teachers. This project will add value to existing cyberInfrastructure, promoting its sustainability. Research products will include evidence of student learning of ecological concepts and scientific argumentation, and an empirical account of young children's practices of argumentation and their development. This will support the development of learning progressions of core epistemic practices of science around the construction, representation, and interpretation of data and their use in scientific arguments.

Making Sense of Global Warming and Climate Change: Model of Student Learning via Collaborative Research

Grant #	0822181
NSF Program	NSF
PI	Anita Roychoudhury
Co-PI(s)	Dan Shepardson, Dev Niyogi, Andrew Hirsch, Brenda Capobianco
Institution	Purdue University
NSF Program Manager	Julia Clark
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Science
Deliverables	Research Articles and Presentations

This project is grounded in a crucial issue of our time—global warming and climate change. The National Research Council's Grand Challenges in Environmental Sciences (NRC, 2000a) identified eight "grand challenges" for the 21st century. Four of these are directly linked to climate (assessment, variability, dynamics, and functioning). Despite its importance, very few individuals have an understanding of the issue. This is not surprising since an adequate understanding of the issue requires an understanding of various domains of science.

It is vital that today's students and tomorrow's citizens be educated about the issues related to climate changes. We have selected middle school students as the target since arresting the downward trend in student performance in high school science needs to begin before students reach high school. Grounded in these two needs, this project has two goals: (1) Development of a model of middle school student learning in a complex domain requiring a coherent understanding of several disciplines; (2) development of a model of teacher learning of student learning.

The PI and co-PIs of the project will work collaboratively with classroom teachers from seventh and eighth grades in Lafayette School Corporation (LSC), a metropolitan district in Indiana. Together the project team and the teachers will collect quantitative and qualitative data from three cohorts of students. This data will help in constructing models of student learning in the area targeted by the project. In addition, the collaborative action research conducted by teachers will help in developing new insights into how they view teaching and learning.

Intellectual Merit: The intellectual merit of the project stems from several characteristics of the project. First, it addresses an area of need, and the findings are likely to provide new insights about student learning related to global warming and climate change. Second, the model of student learning developed from the project would help researchers understand learning in complex domains. Third, the mixed methodology will help researchers understand general trends (from the quantitative data) in student learning as well as get a detailed picture of it (from the qualitative data). Fourth, the project will provide insights into learning from researchers' as well as teachers' perspectives.

Broader Impact: The project activities will engage students in issues related to their personal lives and are, therefore, likely to enhance their interest in and attitudes toward science. This proposal targets students that are, typically, underserved and underrepresented in the STEM fields. Students in LSC represent underserved groups from several perspectives: (a) they perform below state averages (where the state's average performance has declined relative to the nation); (b) a large portion (55%) of the LSC students come from low-income families; and (c) the percentage of minority students in LSC has been increasing for the past 15 years and currently stands at 33.5% compared to 23.2% in the state. This means the findings from the project can have useful implications for instruction of students who come from groups underrepresented in the STEM fields elsewhere in the United States.

Mapping Developmental Trajectories of Students' Conceptions of Integers

Grant #	00047678
NSF Program	NSF
PI	Lisa Lamb
Co-PI(s)	Jessica Pierson, Randolph Philipp
Institution	San Diego State University
NSF Program Manager	James Fey
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Mathematics
Deliverables	integers assessment, dev. trajectories

Mapping Developmental Trajectories of Students' Conceptions of Integers
Lisa Lamb (PI), Randolph Philipp (co-PI), and Jessica Pierson (co-PI)
San Diego State University

In this research and development project, we propose to map developmental trajectories of students' conceptions of integers that could serve to support students' increasingly sophisticated reasoning with integers. Two questions frame and guide our line of proposed research:

1. What are students' conceptions of integers and operations on integers?
2. What are possible developmental trajectories of students' understandings?

To address Question 1, we propose to conduct a set of interviews across three groups of students (those who have yet to have instruction on integers, those during instruction on integers, and those after instruction on integers), and one group of specialized adults (those who have revisited their notions of integers by drawing from one of four perspectives: a formal mathematics perspective, a historical mathematical perspective, a children's mathematical thinking perspective, and a mathematics teacher perspective). We view these groups as having different, but useful forms of mathematical expertise. Collectively, the conceptions identified across these specialized adults will help to map the terrain of endpoints for integers conceptions.

To address Question 2, we propose to use findings from Question 1 to create a framework to identify problem types as well as problem-solving strategies for solving them, as related to student thinking about integers and integer operations. Because we will identify increasingly sophisticated conceptions of integers, teachers and researchers can use the developmental trajectories to understand students' thinking about integers and to plan next steps to support students' reasoning. To broaden the applicability of our findings, we will use the results from the interviews and subsequent framework to develop a paper-pencil integers assessment that can be used by teachers and researchers.

In Academic Year 2009-10, we will begin piloting interview items and from June 2010-June 2011 we will interview 150 participants (30 specialized adults and 120 students in grades K-12) about their understanding of integers. Beginning September 2011, we will have 10 teachers administer a written assessment to their students (each teacher will administer the assessment to one class).

Math Pathways and Pitfalls: Capturing What Works for Anytime Anyplace Professional Development

Grant #	0918834
NSF Program	NSF
PI	Carne Barnett-Clarke
Co-PI(s)	Alma B. Ramirez, Joan I. Heller
Institution	WestEd
NSF Program Manager	John Bradley
Grade Level Band	PreK, Middle School
Target Audience	Preservice, Inservice
STEM Content Area	
Deliverables	10 professional development modules

Math Pathways & Pitfalls: Capturing What Works
For Anytime Anyplace Professional Development

Project Summary
Math Pathways & Pitfalls (MPP) lessons, developed previously with funds from NSF, boost student mathematics achievement with minimal professional development. An experimental study of MPP found significantly positive effects (ESS = 0.43 to 0.66) for diverse students, as well as for English learners and native English speakers, in all grades of the study. Companion qualitative studies documented the spontaneous transfer of key MPP practices to non-MPP mathematics lessons. Building on this research, this project develops modules that further increase teachers' capacity to employ the principles of effective and equitable practice embodied by MPP lessons and to apply these practices to any mathematics lesson.
This 4-year project develops, field-tests, and evaluates 10 online professional development (PD) modules, 5 modules each for K-3 and 4-7 teachers. These modules bring research-based principles to life through brief, media-rich, highly interactive learning experiences. Each module exemplifies a principle of effective and equitable classroom practice and provides background (what works), demonstrates classroom practice through video (how it works), and shares compelling rationale (why it works). During and after each module, teachers implement the principle through an MPP lesson and then apply the same principle to their regular mathematics lessons.

Research and Evaluation Objectives and Methods
The research and evaluation components of this project address three primary goals: (a) provide formative information to guide development and revision of the modules; (b) document teachers' implementation of the modules, and the characteristics of the online environment that teachers experience as they work through the modules; and (c) describe the impact of the MPP online PD modules on teachers' views about teaching and learning and on their classroom teaching practices. The evaluation will include a national field test and a classroom observation study and will use both qualitative and quantitative methods

Intellectual Merit
This project contributes an innovative model of PD to support the application of practices that have been shown to be effective for improving student achievement in large-scale, scientifically-based research.
This project challenges common assumptions about professional development design and delivery, while providing unique content for teachers that draws on theories in cognitive science and psychology.

Broader Impacts
These scalable professional development modules can be produced and sustained for widespread dissemination and implementation resulting in broad impact on mathematics teaching and learning. The modules' intrinsic emphasis on scaffolding mathematical language development and equitable discourse

Math Snacks: Addressing Gaps in Conceptual Mathematics Understanding with Innovative Media

Grant #	GR0003080
NSF Program	NSF
PI	Dr. Karin Wiburg
Co-PI(s)	Dr.Ted Stanford, Dr. Barbara Chamberlin
Institution	New Mexico State University
NSF Program Manager	Jim Fey
Grade Level Band	Post Secondary
Target Audience	Students, Inservice, Other
STEM Content Area	Mathematics
Deliverables	Math Games Which Address Conceptual Gaps

Math Snacks: Addressing Gaps in Conceptual Mathematics Understanding with Innovative Media

Project Summary
This Research and Development project addresses Discovery Research-K12 Program Challenge 2: How can all students be assured the opportunity to learn significant STEM content? The project focuses on developing educational media to aid students in understanding core mathematics concepts that researchers have found are misunderstood as students reach middle school. The project will also provide instructional tools to assist teachers in using these media, and thus secondarily addresses DR-K12 Program Challenge 3: How can the ability of teachers to provide STEM education be enhanced?
In spite of general gains in mathematics learning in the United States (NAEP, 2007) and successful mathematics progress for students in many of the math reform efforts, (MSP Impact Report, 2008), researchers have noticed critical gaps in conceptual understanding of core mathematics concepts and processes in students. These misunderstandings cause problems for students as they move through school. By high school, achievement scores drop dramatically, and the gap in test scores between mainstream and culturally and linguistically diverse students can be as much as 30 points (NAEP, 2007). Our research question is: In what ways can innovative media be used to help students learn significant mathematics content? Designed by mathematics educators, mathematicians, learning specialists and game developers, the media in this proposed project are organized around math concepts that are often misunderstood. The Math Snacks modules are meant to be easy to access and use, focused on one concept at a time. They provide rich nourishment for the middle-grades curriculum. The project focuses on math concepts, that for some reason, students have found hard to master using a traditional text-based mathematics curriculum. Funny scenarios, comical characters, and memorable vocabulary are used to help students see mathematics as entertaining as well as understandable.

Mathematicians Writing for Teachers Conference, Mt. Holyoke College

Grant #	0736305
NSF Program	NSF
PI	Susan Jo Russell
Co-PI(s)	DEborah Schifter, Virginia Bastable, Ben Ford, William McCallum
Institution	TERC
NSF Program Manager	Spud Bradley
Grade Level Band	PreK, Middle School, High School
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Mathematics
Deliverables	Conference report

Mathematicians Writing for Teachers Conference

The Mathematicians Writing for Teachers Conference took place at Mount Holyoke College on November 14-15, 2008. The purpose of the conference was to consider issues in the professional development of K-12 teachers in mathematics by enacting and debriefing instructional sessions in which the perspectives of mathematicians, mathematics educators, and classroom teachers were brought together to create a professional development experience. A key purpose was to investigate further how the expertise of these three groups can build on each other to support the education of teachers. A particular focus was on the role that essays written by mathematicians for a teacher audience can play in broadening teachers' views of the mathematics they teach and how it connects to core ideas of the discipline.

The conference was structured around four instructional sessions, each based on a combination of an essay written by a mathematician, related classroom cases written by teachers, and mathematics activities. Each session was followed by a debriefing session in which the participants reflected on the session.

The data collected included notes taken during each session, feedback from participants on comment cards after each session, documentation of the post-conference debrief meeting, and evaluations submitted by staff and participants.

As there are a number of well-known approaches to professional development organized around classroom cases and mathematics activities, it is fairly clear what the roles of these two elements are. It is the mathematicians' essays that are the most innovative element in these sessions, and it was the potential place of these essays as a tool for professional development that we were most curious to learn about. The following points about the role of the mathematicians' essays were culled from the data:

a. The essays provide an accessible disciplinary perspective, linking classroom mathematics to a larger view, placing the work of students within the discipline, and connecting their ideas to core mathematical ideas.

b. The essays connect teachers to mathematicians as people with voices, emotions, and ideas.

c. The essays are a resource that teachers can continue to learn from as they have more experiences in mathematics.

d. In providing glimpses of higher mathematics, the essays help teachers understand that their work is significant, even if the higher mathematics itself is not accessible.

e. The essays can act to engage teachers in or reawaken teachers to the joy and excitement of doing mathematics.

Overall, the combination of the essay written by a mathematician, the cases written by teachers, and participatory mathematics activities combined to create a strong learning context. The essays introduced large

themes of mathematics to readers, including glimpses of mathematics beyond what the participants are going to be able to grasp fully, and a focus on mathematical coherence emerged across sessions. However, this approach to professional development must be understood by participants as not providing particular teaching strategies. Rather, as one mathematician said, it "expands the capacity to make good judgments" by giving participants more knowledge about coherence and connections in mathematics.

Mathematics and Culture in Micronesia: Integrating Societal Experiences (Macimise)

Grant #	0918309
NSF Program	NSF
PI	Alexander Dawson
Co-PI(s)	Tom Craven
Institution	Pacific Resources for Education and Learning
NSF Program Manager	Julio E. Lopez-Ferrao
Grade Level Band	PreK, Middle School
Target Audience	Other
STEM Content Area	Mathematics
Deliverables	Curriculum units, MA & PhD dissertations

The Mathematics and Culture in Micronesia: Integrating Societal Experiences (Macimise) Projectseeks to build on the experience gained through the previously NSF funded Projects Delta (ESI: 9819630) and Mentor (ESI:0138916). A research and development undertaking, the Macimise Project is a collaborative effort between Pacific Resources for Education and Learning (PREL) and the College of Education, University of Hawai'i—Manoa (UHM) with PREL as the lead organization. The most important outcome of the previous NSF projects underscored the viability of indigenous mathematics educators successfully mentoring novice teachers of mathematics. The critical aspect that contributed to the success of the two NSF projects was the building of trust and respect among the Project's principal investigator, mentors, and novice teachers (Dawson 2008b). As these relationships developed, mentors began to uncover and conceptualize mathematical knowledge and practices extant in their cultures but
which have not been shared within or between cultures. This proposal builds on that work by enhancing the opportunity for children to learn significant indigenous mathematics using materials developed by indigenous informants who are mathematics educators and implemented by teachers mentored in STEM education during the previous projects.

Research in the area of Ethnomathematics (e.g., Ascher, 1991, 2002; D'Ambrosio, 1985, 2006; Zaslavsky, 1973) has demonstrated how non-Western cultures developed interesting, non-trivial mathematics without having any formal concept of Western mathematics. This research indicates that cultural processes that appear naturally in everyday life have mathematical content. This Project proposes to build on that research base with the creation of culturally based units of mathematics derived from the knowledge and practices of eight language groups in the U.S.-affiliated Pacific islands.

The setting for the project is the northern Pacific Ocean from Hawai'i across Micronesia west to the Republic of Palau, and south of the equator to American Samoa. The U.S.-affiliated Pacific islands have traditionally been underserved and grossly underrepresented in the STEM fields including mathematics. The region encompasses a population of approximately 1.7 million underrepresented and underserved people living on 110 islands spread across 4.9 million square miles of the Pacific Ocean, presenting
unique challenges to curriculum development issues and research on indigenous mathematics.

The Project addresses three important needs evident in region. The first goal of the Project is the development of elementary school mathematics curricula sensitive to local mathematical thought and experience. A necessary prerequisite for the achievement of this first goal is to recapture and honor the mathematics indigenous to the various communities; that is the Project's second goal. The recapture of indigenous mathematical thought and its transformation into school curricula requires credentialed local experts in the teaching and learning of mathematics who are cognizant of the mathematics extant in their own cultures and who in the years ahead will provide leadership in the development of curricula sensitive to local mathematical thought. In order to maximize (Macimise) its impact the goals of the Project are to:

- develop and assess local mathematics curriculum units for grades one, four, and seven;
- rediscover/uncover the indigenous mathematics of seven Micronesian language communities as well as the territory of American Samoa;
- build local capacity by educating indigenous mathematics educators.

In summary, the dynamics of how these goals are to be achieved consists of three phases: the first will be to educate the indigenous informants to be socio-cultural researchers so that, second, they can document the mathematics extant in their language and culture, and third to develop the culturally based curriculum units

that will be implemented and assessed in schools on the noted island communities.

The intellectual merit of the Project lies in assessing the effects of using indigenous mathematical units to increase the engagement and enhance the learning of mathematics by Pacific island children providing insights as to how STEM education can be fostered by culturally based mathematics.

The broader impacts of the research and development is that indigenous mathematical practices will be recovered and encapsulated in curriculum units that enrich the mathematical and pedagogical base of ethnomathematical research world wide, and support further research in this area.

Mathematics Discourse in Secondary Classrooms: A Case-based Professional Development Curriculum

Grant #	0918117
NSF Program	NSF
PI	Beth Herbel-Eisenmann
Co-PI(s)	Michael D. Steele, Michelle Cirillo
Institution	Michigan State University
NSF Program Manager	Jim Fey
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Professional development materials

The purpose of the proposed project is to develop, design, and test innovative materials to assist professional development leaders (e.g., teacher educators, district mathematics specialists, secondary mathematics department chairs) support secondary mathematics teachers in negotiating classroom norms that promote productive discourse practices. More specifically, the materials will help professional development leaders: a) increase mathematics teachers' understanding of classroom discourse and its relationship to supporting student learning; b) raise teachers' awareness of the discourse patterns at work in their own classrooms; c) assist secondary mathematics teachers in identifying discourse patterns that are either undermining goals they have for student learning or discourse patterns that could be used more purposefully to support student learning; and d) support teachers in more purposefully negotiating classroom discourse patterns that can help students develop increasingly complex discourse practices involving high-level mathematical explanation, justification, and argumentation. The M-DISC (Mathematics Discourse) curriculum materials that will be developed and tested will center on narrative and video cases of teaching, in which teachers and students are observed engaging in these discourse practices, making the practices and their impact on student learning an object of inquiry for teacher learning. The materials will be comprised of an introductory module, 5 constellations of activities each built around a case, and a module to help professional developers support secondary mathematics teachers to do action research on their discourse practices. Each constellation (set of activities anchored around the five "talk moves" described by Chapin et al., 2003) will consist of professional learning tasks that engage teachers in: solving mathematical tasks of high cognitive demand featured in the case; analyzing the case with respect to the five talk moves and the ways in which the talk moves supported the learning of mathematics; reading and discussing relevant literature on classroom discourse; analyzing student work; and field-based assignments of small and large scale. Additional field-based tasks designed to connect the analyses afforded by the professional development materials to teachers' classroom practice will provide a capstone for the teachers to study their evolving discourse patterns.

The intellectual merit of the proposed M-DISC project lies in the creation of new materials for use in a range of professional education settings that have the potential to help teachers develop new understandings of classroom discourse. Although we know that inquiry-based discourse practices are beneficial for student learning, mathematics teachers continue to engage students in forms of discourse that focus on the transmission of information. This is likely because many secondary mathematics teachers have not learned about, considered, or been exposed to these alternative interaction patterns. Hence, the M-DISC materials will assist professional developers in working with secondary mathematics teachers on alternative discourse patterns with the goal of helping them promote productive classroom discourse.

The M-DISC project has the potential to have a broad impact on mathematics education because unless teachers become more purposeful about their classroom discourse, they will continually undermine some of the intended goals they have for their students (Herbel-Eisenmann & Cirillo, in press). Because discourse practices are contextual, practice-based professional development is the most appropriate approach because it allows teachers to learn from artifacts from others' classroom practice as well as their own classroom settings.

Mathematics Instruction Using Decision Science and Engineering Tools

Grant #	0733137
NSF Program	NSF
PI	Robert Young
Co-PI(s)	Karen Keene, Ken Chelst, Tom Edwards, David Royster
Institution	North Carolina State University
NSF Program Manager	John Bradley
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Mathematics
Deliverables	New Curriculum and Textbook

Mathematics INstruction using Decision Science and Engineering Tools (MINDSET) is a collaboration among educators, engineers, and mathematicians at three universities to create, implement, and evaluate a new curriculum and textbook to teach standard mathematics concepts using math-based decision-making tools for a non-calculus fourth-year mathematics curriculum that several states now require and others may require in the near future. MINDSET has three goals: (1) enhancement of students' mathematical ability, especially their ability to formulate and solve multi-step problems and interpret results; (2) improvement in students' attitude toward mathematics, especially those from underrepresented groups, thereby motivating them to study mathematics; and (3) adoption of the curriculum initially in North Carolina and Michigan, then in other states. Using decision-making tools from Operations Research and Industrial Engineering, we will develop a fourth-year high school curriculum in mathematics and support materials to teach standard content. Through a multi-state, multi-school district assessment, we will determine if a statistically significant improvement in students' mathematical ability, particularly in multi-step problem solving and interpretation of results, and in motivation and attitude toward mathematics, has occurred. Participating teachers will receive professional training, help to create a knowledge-based online community for support, and in-person and online technical assistance. Through extensive data collection and analysis, we will determine if this infrastructure is sustainable and sufficiently flexible to be reproduced and utilized by others.

Mentored and Online Development of Educational Leaders for Science (MODELS)

Grant #	0455877
NSF Program	TPC
PI	Marcia Linn
Co-PI(s)	Michele Spitulnik
Institution	University of California - Berkeley
NSF Program Manager	Sherwood
Grade Level Band	Middle School
Target Audience	Students, Inservice, Policy Makers
STEM Content Area	Science
Deliverables	Research articles, conference proceedings

Mentored and Online Development of Educational Leaders in Science (MODELS) investigates a school based mentor approach to professional development in technology enhanced science instruction and its impacts on teacher and student learning. Prior studies demonstrate improvements in teaching with technology as a function of participation in professional development. Yet little empirical evidence links professional development to student leaning outcomes.

MODELS takes advantage of powerful technology enhanced science modules developed using the Web-Based Inquiry Science Environment. These standards-based modules address complex scientific ideas such as chemical reactions, thermodynamics, climate change, and mitosis. The modules implement the knowledge integration framework where students test their own ideas, learn new ideas, develop criteria for distinguishing ideas, and sort out their views. Each module meets design criteria informed by current research that include an inquiry focus, incorporation of a powerful scientific visualizations, as well as links between microscopic or abstract ideas and personally relevant contexts.

The middle and high school science departments in schools located in 2 minority-serving districts participate in this research. All teachers participate in MODELS professional development that involves a 40-hour WISE summer institute, and collaboration with the school based mentor during the school year. The summer institute focuses on collaborative, evidence based customization of the WISE curriculum modules and reflection on research based dilemmas of WISE instruction. The mentor-led professional development is adapted to address teachers' challenges. In all cases, the mentor meets with teachers prior to and after enactment of the WISE unit. For novice teachers, the mentor supports the teacher in the classroom during enactment. MODELS provides buyout time for one period of the day for the teacher mentor.

The 3-year longitudinal study focuses on teachers' participation in MODELS professional development with technology-inquiry curriculum and its impact on teachers' growth and student learning in sixth grade science. Delayed and immediate post test assessment data from 855 students collected each year for 3 consecutive years and teacher interviews serve as the data sources. Results suggest that teachers' continued participation in MODELS professional development led to instructional change and cumulatively greater gains in student learning. The impact of professional development on instructional change and student learning was greatest after teachers had 1 year of customizing and teaching the technology-inquiry curriculum. Implications for designing professional development are addressed.

Multimodal Science: Supporting Elementary Science Education through Graphic-Enhanced Communication

Grant #	0733217
NSF Program	NSF
PI	Eric Wiebe
Co-PI(s)	James Minogue, Michael Carter
Institution	North Carolina State University
NSF Program Manager	Michael Haney
Grade Level Band	PreK
Target Audience	Preservice, Inservice
STEM Content Area	Science
Deliverables	Professional Development Materials

Graphic-Enhanced Elementary Science (GEES) is a two-year project to create and assess teacher professional development materials that support effective use of student-generated graphics for science learning in grades 2 -5. The primary context of use is with science notebooks and inquiry-based activities in the classroom. The materials will help teachers support the creation and use of graphics by students during inquiry activities and as a formative assessment tool for teachers.

The central aims of this project are to:

1. Provide an overarching vision—guided by learning sciences research—for the use of student-produced scientific graphics in inquiry-based activities through elementary science notebooks.
2. Create a series of individual case studies demonstrating how graphics can be used effectively as part of inquiry-based science activities at the elementary school level.
3. Model effective strategies for instruction through and with graphics, leading to improved teacher pedagogical content knowledge (PCK).
4. Provide the professional development modules in a form that can easily be integrated into existing professional learning communities and are scalable at a national level.

In spring of 2008, the project team partnered with an elementary school and conducted a series of observations on current use of science notebooks in grades 2 through 5. In addition, sample student notebooks were collected and photographed. This data, along with teacher interviews and feedback from our advisers, guided the development of the first iteration of teacher development materials that were used in a series of workshops this past summer with teachers from six different elementary schools. Teachers from four of these schools participated in a workshop designed around the project's "graphic-enhanced" approach while the remaining two schools received general training on science notebooks. Teachers from these schools will now be part of a study looking into the efficacy of our "graphic-enhanced" approach.

Based on findings from the continued work with our schools and advisory board, on-line professional development materials will be developed that model best practices for supporting student-produced scientific graphics. These will include video vignettes and annotated sample science notebooks along with resource materials on scientific graphics and graphic production.

NanoTeach: Professional Development in Nanoscale Science

Grant #	0822128
NSF Program	NSF
PI	John Ristvey
Co-PI(s)	Anne Tweed
Institution	McREL
NSF Program Manager	Robert Gibbs
Grade Level Band	High School
Target Audience	
STEM Content Area	
Deliverables	Teacher's Guide, Facilitator's Guide

Mid-continent Research for Education and Learning (McREL) along with ASPEN Associates, Stanford Nanofabrication Facility, and the National Nanotechnology Infrastructure Network (NNIN) will develop NanoTeach. The project will develop and test professional development that combines an instructional design framework with nanoscale science content using multiple delivery methods for high school science teachers. The project has two research questions:

RQ #1 Does the NanoTeach facilitated professional development improve teachers' ability to integrate NS&T content into their classes in an inquiry-based manner?
RQ #2 To what extent is the approach utilized in the NanoTeach project a viable approach to the development of professional development materials and experiences that support integration of nanoscale science in high school science?

Methods: The research design includes a formal pilot test and field test with random assignment treatment and control groups. The NanoTeach Teacher's Guide will be designed for self-study (control group) and for use in a facilitated (80 hours plus significant follow-up) professional development model (treatment group). The results of the pilot test will inform revisions to NanoTeach prior to the field test. The research design and evaluation include ongoing structured data collection and reporting to support the development team in formal reflection about the viability of the design process and the quality of the resulting products.

Intellectual Merit: NanoTeach builds on the significant investments that the NSF has made in NS&T and on the existing findings and resources generated from these projects, including NanoLeap, NanoSense, and the NanoEd Resource Portal at the National Center for Teaching and Learning in Nanoscale Science and Engineering (NCLT). NanoTeach will test both self-guided and facilitated professional development and advance the field by studying how a carefully designed framework can help teachers learn NS&T content and integrate this content into existing curricula in a way that is essential to meeting their local curricular goals. While bringing current, cutting edge science into K-12 classrooms, NanoTeach also tests a cyber enabled learning tool (Versatile Classroom) to deliver high quality video in real time as part of distance-learning professional development for teachers.

Broader Impact: NanoTeach will significantly contribute to the pool of teachers trained in NS&T, reaching over 200 teachers directly and preparing them not only to teach NS&T but also to become ambassadors and mentors for teaching NS&T in high school classrooms. The project targets teachers from in and around large urban centers who teach traditionally under-represented groups and helps them form a learning community that includes NS&T scientists, researchers, and educators, as well as K-12 teachers. Following the study, the NanoTeach professional development model will be widely disseminated through the cadre of participating teachers and the project partners' national networks, including NSTA, NCLT, and NNIN. The successful demonstration of the Versatile Classroom as a vehicle for professional development will engage teachers in lifelong learning and improve their practice in a timely and inexpensive manner.

Nurturing Multiplicative Reasoning in Students with Learning Disabilities in a Computerized Conceptual-Modeling Environment (NMRSD-CCME)

Grant #	0822296
NSF Program	NSF
PI	Yan Ping Xin
Co-PI(s)	Luo Si & Ron Tzur
Institution	Purdue University
NSF Program Manager	Dr. Jim Fey
Grade Level Band	PreK
Target Audience	Students, Students - Special Population
STEM Content Area	Mathematics
Deliverables	NMRSD-CCME System

The threefold purpose of the Frontier Challenge, full R&D, Nurturing Multiplicative Reasoning in Students with Learning Difficulties in a Computerized Conceptual-Modeling Environment (NMRSD-CCME) project is to: (a) create a research-based model of how students with learning disabilities/difficulties (LDs) develop multiplicative reasoning via constructivist-oriented instruction, (b) convert the model into a computer system that dynamically models every student's evolving conceptions and selects/adjusts tasks to promote her/his advancement to higher level, standard-based multiplicative structures and operations, and (c) study how this computerized teaching tool impacts student outcomes, including diminishing the gap between students with LDs and their normal achieving peers (NAPs).Using a universal design approach, the interdisciplinary project team will draw on three research-based frameworks: machine (or statistical) learning from computer sciences, conceptual model-based problem solving facilitated by word problem story-grammar from special education, and a constructivist view of learning from mathematics education. The NMRSD-CCME project will consist of eight phases: (1) Conduct a teaching experiment, with 7-10 students with LDs, to identify stages/transitions in and tasks conducive to their construction of multiplicative reasoning conceptions; (2) Create an Alpha version of the computerized modeling system; (3) Pilot the Alpha version with 5 students with LDs and 5 NAPs; (4) Revise the Alpha version into a Beta version; (5) Field test the Beta version with 15 students with LDs and 15 NAPs; (6) Revise the Beta version and finalize the computer system; (7) Implement the final version while conducting a pre-post-repeat measure study that compares among learning processes and outcomes of 15 students with LDs taught by the computer,15 students with LDs taught by a human, and 15 NAPs taught by the computer; (8) Analyze data and disseminate findings.

Intellectual Merit. The No Child Left Behind Act brought national attention to the severity of students with LDs' underachievement in mathematics. Yet, the prevalent, inadequate, behaviorist practices for teaching students with LDs remained focused on lower-expectation, remedial work marked by memorization and execution of algorithms/rules. The NMRSD-CCME project will provide a radically different, empirically grounded model of how students with LDs develop conceptual understanding in the fundamental and very difficult-to-grasp domain of multiplicative reasoning. It will demonstrate how teaching can be assigned to intelligent machines capable of producing dynamic profiles of student thinking, developing adaptive, student-fitting, recommendation algorithms, and how such machines nurture students with LDs' achievements at the level of their NAPs via genuine discourse among all learner types.

Broader Impact. Successfully developing and testing intelligent machines' capacity for teaching the currently left-behind population of students with LDs will allow overcoming a critical impediment to their mathematical progress—the scarcity of highly qualified teachers. Such machines greatly broaden project impact due to immense flexibility in use—with an entire class during the day, with needy students after school, and with individuals at their homes. Through its extensive dissemination plan (professional/community meetings, teacher/researcher journal articles, website, structured teacher-word-of-mouth), the project team will share results with the wide community of educators (teachers, administrators, parents) responsible for nurturing students with LDs' growth.

Online Science Teacher Professional Development: Optimization of Asynchronous Learning Models

Grant #	0723433
NSF Program	NSF
PI	Nancy Moreno
Co-PI(s)	
Institution	Baylor College of Medicine
NSF Program Manager	Sue Allen
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Online teacher professional development

We are comparing and evaluating different models for the delivery of online science professional development for elementary teachers. We are focusing on asynchronous (any time, any where) and minimally facilitated models, because these approaches hold promise for reaching large numbers of teachers in a cost-effective way. Guiding questions are: 1) Which online professional development delivery methods contribute most strongly to teacher and student science learning? 2) What, if any, is the added value of linking classroom experiences and facilitated discussions to asynchronous online learning? 3) Does the effectiveness of different delivery models vary among subpopulations of teachers? Our process objectives are: 1) survey the types of asynchronous, online science teacher professional development activities currently available; 2) compare the effectiveness of four different online delivery modes for both life and physical science (delivery modes consist of—audio only [podcast]; video content presentation with slides; content embedded in an online interactive case; content embedded in video lesson demonstration); 3) investigate the added value, as reflected in teacher and student learning, of having teachers teach a classroom lesson related to the content and report back (via discussion forums) after completing a component; 4) disseminate outcomes to inform future offerings.

The first study trial was completed in May, 2009. For this portion of the study, we 1) refined and updated an existing genetics lesson appropriate for upper elementary students; 2) developed a core set of genetics understandings; 3) created a website with four different online learning modules; 4) developed a set of student assessments and three different, equated teacher content assessments on genetics; and 5) recruited and enrolled 131 Houston-area fifth grade teachers to participate in the study. Study participants were pre-assigned o treatment groups, so that when they logged onto the site, they immediately were directed to the homepage for their treatment group. Each treatment group home page contained tabs for participation in a discussion forum and an interactive timeline, in addition to the assigned professional development treatment.

Preliminary outcomes based on teacher discussion forums indicate that the participants in the audio podcast perceived the content as more difficult and reported having more difficulty teaching the lesson to students. Data analysis from the first trial is ongoing. We are in the process of building the assessments and modules for a second trial focused on physical science (rocketry) for late 2009.

Physical Science Comes Alive: Exploring Things that Go

Grant #	0733209
NSF Program	NSF
PI	Gary Benenson
Co-PI(s)	James L. Neujahr, Richard Lehrer
Institution	CUNY City College
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Curriculum, PD, Research

Elementary teachers often feel uncomfortable with science, particularly physical science, and science instruction may be seriously lacking, especially in communities that are urban, low-income, and/or ethnic minority. The problem is most acute in early childhood, Special Education and bilingual classrooms. A few studies suggest that engineering design could provide contexts for physical elementary science learning. Kinetic toys and games are of intrinsic interest to children and can offer rich opportunities for learning. This project seeks to develop seven half-semester physical science curriculum units that use design of toys as starting points for learning concepts of force, motion, and energy in grade bands K-1, 2-3 and 4-5.

Educational goals for these materials span the fields of engineering design, physical science (force, motion and energy), systems and modeling, literacy (thinking, talking and writing), and mathematics (pattern finding, spatial thinking, proportional reasoning, and measurement). Classroom implementation, professional development, and dissemination planning are tightly coupled with the development of the curriculum. The curriculum and professional development team consists of college faculty in engineering and education, plus five New York City elementary science teachers. Because research is lacking in engineering design in the elementary grades, a research team from Vanderbilt is undertaking microgenetic and sociogenetic studies to explore learning trajectories and outcomes, and to build a knowledge base that can inform curriculum and professional development.

The four Force and Motion curriculum units are ready for pilot testing in Fall 2009. The K-1 unit, "Mech-a-Blocks," engages children in distinguishing between structures and mechanisms, and making mechanisms from colored pieces of pegboard, cut into a variety of shapes. Children also learn to model existing mechanisms, such as fireplace tongs. "Levers, Linkages and MechAnimations," for grades 2-3, develops physical concepts of direction and quantity of motion and force; and systems concepts of input, output, and subsystem. "ArithMachines" extends these investigations to explore quantitative relationships between force, motion, and lever design, including direct and inverse proportion, at the fourth and fifth grade levels. “Pop-ups,” also for grades 4-5, develops systems and spatial reasoning, dimension, linear and angular measurement, and data analysis through analysis and design of paper pop-up mechanisms. The Energy Systems units, currently in development, will include "Playgrounds" (grades K-1), "Elastic Engines" (grades 2-3), and "Electric Vehicles" (grades 4-5).

Pilot and field tests of all materials will occur in largely African American or Latino elementary schools in New York, Los Angeles and Washington, D.C., and rural Minnesota schools with large Ojibwe populations. Teachers carrying out these tests will receive 30 hours of professional development, plus ongoing classroom support during the implementation period. The curriculum and teacher resource materials will subsequently be published in both print and electronic form. Additional products will include instructional on-line videos, supply kits, standards alignments for each unit, assessments, and materials for the professional development of teachers. The Science Source, based in Waldaboro, Maine, serves as the commercial partner for production and marketing of the materials.

Planting Science Research in Education

Grant #	0733280
NSF Program	NSF
PI	Claire Hemingway
Co-PI(s)	Carol Stuessy, William Dahl
Institution	Botanical Society of America
NSF Program Manager	Julia Clark
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	http://www.PlantingScience.org

The objectives of this project are to create new opportunities for students and teachers to learn how science works and how scientific research is conducted by engaging plant scientists as online science mentors, and to examine the impact of mentored open-ended plant investigations on classroom teaching and learning. Our primary target population is high school, where online scientist mentors and classroom teachers co-mentor student team experiments. The online platform (www.plantingscience.org) supports diverse, underserved classrooms across the country. This national network of plant scientists, science educators, and high school learners offers an innovative means to model and scaffold scientific inquiry, reasoning skills, and collaborative learning.

The project delivers standards-aligned, technology-supported instructional resources, with rich open-ended inquiry directions, that allow teachers to teach core biology standards in the context of doing science with plants. Teams of plant scientists and teachers collaboratively develop and field-test plant inquiry modules. The classroom intervention involves students working in research teams in their classrooms to generate research questions and conduct plant investigations. In asynchronous online discussions, students, scientists, and peer student teams talk together about ideas for research questions, how to design their experiments, and what their results mean. Scientists guide students through the discovery process and provide insight to what scientists know and how they think to support students' scientific reasoning, problem solving, technological, and communication skills while deepening their understanding of the processes and nature of science. Summer professional development experiences bring together teachers, plant scientists, and science education researchers in collaborative learning communities.

To examine what factors create effective support for teachers and students conducting open-ended inquiries with plants, the research plan includes case studies of classroom implementation and analysis of the online discourse and student work. Research questions focus on how teachers adjust their teaching strategies to meet the open-ended, student-centered approach of PlantingScience inquiry modules, how students develop and adjust their learning strategies, and what scientists offer students involved in the mentored inquiry projects.

Products planned for broad dissemination include: the online learning environment; the community of students, scientists, and teachers; the online instructional materials; a booklet of plant investigations; and results of science education research.

Policy Research Initiatives in Science Education (PRISE) to Improve Teaching and Learning in High School Science

Grant #	0455679
NSF Program	TPC
PI	Carol Stuessy
Co-PI(s)	James F. McNamara, Timothy Scott
Institution	Texas Engineering Exploring Station
NSF Program Manager	Julia Clark
Grade Level Band	High School
Target Audience	Policy Makers
STEM Content Area	Science
Deliverables	Generalizable research models and protocols, chart essays, monographs, research articles, Web site, newsletters

Policy Research Initiatives in Science Education (PRISE) to Improve Teaching and Learning in High School Science uses a systems approach to link educational research with policy development. The goal of the project is to provide the state of Texas and the nation with research findings that lead to the development of an articulated and coherent model of continuous professional career development that improves the quality of science teaching and makes significant contributions to reducing the current national shortage of qualified high school science teachers. This five-year project, consisting of five phases and a total of 36 tasks, answers three basic questions about the high school science teacher professional continuum in Texas: Where are we? Where do we want to go? How can we get there?

Research products completed at the end of the third year include (1) generalizable research models, protocols, and reporting formats of value to the nation and other states desiring to replicate the study; (2) two chart essays, which declare accurately the state-of-the-state in terms of science teachers who live out their careers in high school science classrooms, and in terms of high schools that provide teaching and learning environments for science teachers and their students; (3) two monographs, one providing case summaries of each of the 50 high schools describing the high school science environment for Texas teachers, and the other providing 3 case studies of exemplary Texas high schools (a small-, medium-, and large-sized school) within the sample that have provided the most positive work environments for high school science teachers. Projected for Year 5 is (a) an inventory of effective, efficient, and equitable policy alternatives that extend the most effective practices uncovered in the research process; and (b) a comprehensive research report that accurately illustrates how individual U.S. high schools and school districts can develop a single coherent Recruitment through Retention strategy that provides a program of continuous professional career development for improving the quality of science teaching.

Research methods supporting each phase of the project include (1) Specification Research, which develops the Sampling Plan and Specification Research Portfolio (including protocols for school interviews and classroom observations) developed and piloted for use in the completion of (2) Parameter Estimation Research, which collects and analyzes data from 50 sampled high schools to estimate the state-of-the-state; (3) Effectiveness Assessments, which employ intensive case study research methodologies to reveal best practice; (4) Policy Research Dialog, which engages 35 stakeholders in high school science to (a) review PRISE research documents produced in the first three phases of the research, and (b) use an electronic dialog system to nominate and select the most beneficial policy alternatives reflecting effectiveness, efficiency, and equity concerns; and (5) Final Synthesis, which (a) illustrates how individual schools and school districts can create an integrated system of effective practices that link recruitment, induction, professional career development, and retention strategies; (b) show how the integrated system can directly contribute over time to improving student success in science; and (c) document how the integrated system can make continuous progress toward reducing the critical shortage of quality science teachers.

Finally, the project selectively recruits eight PRISE scholars of color and other historically underrepresented groups to create a cadre of new-generation science education leaders who learn to lead by engaging in policy research and completing doctorates in science education.

Positive Learning Environments Aiming for Success in Science Education (PLEASSE)

Grant #	0732109
NSF Program	NSF
PI	Obed Norman
Co-PI(s)	Glenda Prime, Jonathan Williams
Institution	Morgan State University
NSF Program Manager	Julia Clark
Grade Level Band	Middle School, High School
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Research Reports

This research project is aimed at exploring the components and impact of a teacher professional development model (PDM) on teacher performance and student achievement and motivation in STEM disciplines at schools serving large numbers of minority students.

Broader Impact: The project addresses the National Science Board merit review criterion of broader impact by seeking a solution to the black-white test score gap which has been identified as one of the most pressing national problems in education. The research will help to develop and validate a teacher professional development model that can be used to produce teachers who will positively impact the learning and academic engagement of minority students.

Intellectual Merit: The criterion of intellectual merit is satisfied by the potential of this project to develop and provide a solid empirical basis for strategies aimed at reducing or even eliminating the 'achievement gap' in school contexts. It is also a measure of the intellectual merit of this project that is based on over two decades of widely recognized and groundbreaking empirical work. The work by Steele and his coworkers on stereotype threat has afforded Steele with membership in both the National Academies of Science and Education. As early as 1997, Steele called for an extensive research program to provide a “definitive test of wise schooling” to “stop or reverse a tenacious negative trajectory in the school performance of stereotype-threatened students” (p. 625). This project is a research program in that mold. Additionally, the theoretical constructs underlying the project have informed the scholarship on minority education for the last two decades and are based on work which earned Ogbu induction into the National Academy of Education. As a scale-up research project is ultimately anticipated, the project maintains intellectual merit and integrity in its design by identifying and controlling for key contextual variables in order to justify a claim for generalizability of positive student outcomes to similar school contexts serving large minority student numbers (see McDonald, 2006).

Research Questions:
1.Can a structured intervention aimed at fostering positive student academic attitudes be integrated with a quality inquiry science program to increase both student academic outcomes and positive achievement–oriented attitudes?
2. What is the impact of teachers with positive perceptions and expectations on the academic performance and motivation of all students but particularly minority students?

Professional Development Threading Content, Pedagogy and Curriculum: A Study of Classroom Impact

Grant #	0455811
NSF Program	TPC
PI	Jonathan Singer
Co-PI(s)	
Institution	University of South Carolina
NSF Program Manager	Campbell
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Research articles

The goal of this Research Studies (Exploratory Project) proposal is to investigate the impact of a professional development program that is grounded in the currently accepted “best practices” (Darling-Hammond & Mclaughlin,1995; Supovitz & Turner, 2000; Garet, et al., 2001; Loucks-Horsley, et al., 2003) on middle school science teachers’ ability to enact pedagogical strategies (e.g. inquiry-based, technology rich, meaningful content) that align with the current education reforms advocated by AAAS, NRC and ISTE. Intellectual Merit and Broader Impact: Six components of what constitutes “high quality” professional development are consistently described in the professional development literature (Supovitz & Turner, 2000; Loucks-Horsley, et al., 2003). However, while there is substantial agreement on the characteristics for professional development best practice, much of it is not grounded in classroom-based empirical research (Fishman, et al., 2002).

Despite the research findings supporting the benefits of alternative pedagogical approaches and the role that learning technologies can play in facilitating student learning in these environments significant changes in teaching strategies do not seem to be keeping pace with the current availability of new technologies (Becker, 2001; Mouza, 2002; Yildirum, 2000). A primary explanation for the lack of integrating new learning technologies and pedagogical practices is the lack of effective professional development (Mouza, 2002; Sparks & Hirsh, 2000; Trotter, 1999; Fatemi, 1999).

The prototypical professional development program consists of a 15-day summer institute plus sustained support throughout the following academic year. Approximately 24 teachers will be participating each year as part of this program. The mechanisms by which the summer institute is expected to cause change in teacher practice and ultimately student learning include: 1) model teaching by STEM faculty during the institute; 2) emphasis on pedagogical content knowledge application with actual middle school students during the Institute; 3) extensive use of appropriate technology-based innovative curriculum materials; 4) post-instructional reflection anchored with digital video; 5) intense, scaffolding begins with the practice teaching using technology -based units during the summer institute, continues with assistance in enacting those same materials in the classroom in the fall, and ends with transfer of pedagogical methods to a new unit not supported directly by the Institute.

The critical element of this proposal is its attempt to connect the effectiveness of the Institute to measurable changes in the classroom. Our proposal is driven by the following research questions. 1) To what extent does the teachers’ participation in the Institute influence their learning of the specified science content? 2) To what extent does the Institute facilitate the teacher participants’ integration of pedagogical practices, curricular materials, and learning technologies that align with the current science and technology education reform efforts advocated by the NRC, AAAS, NSTA and ISTE? 3) To what extent does the Institute facilitate the teacher participants to “transfer” pedagogical practices, curricular materials, and learning technologies that align with the current science and technology education reform efforts advocated by the NRC, AAAS, NSTA and ISTE? 4) To what extent does the teachers’ participation in the Institute influence their students’ learning of the specified science content? 5)What is the perceived effectiveness of the various Institute components on the professional growth of the participating teachers?

Project BEST: Better Education for Science Teachers

Grant #	0455846
NSF Program	TPC
PI	Janet Carlson
Co-PI(s)	Julie Gess-Newsome
Institution	BSCS
NSF Program Manager	David Campbell
Grade Level Band	
Target Audience	
STEM Content Area	
Deliverables	Research Findings

Project BEST was renamed Project PRIME (Promoting Reform through Instructional Materials that Educate) in its first year (2005). The BSCS Center for Research and Evaluation and the Center for Science Teaching and Learning at Northern Arizona University are working together to study the potential of educative science curriculum materials to support the development of content and pedagogical knowledge of science teachers. The ultimate goal of this work is to improve the quality of science teaching and learning. Our work is organized around these research questions:
1. In what ways does Project PRIME influence participants' development of pedagogical content knowledge (PCK)?
2. In what ways does Project PRIME influence participants' content knowledge (CK),pedagogical knowledge (PK),and context knowledge (CxK).
3. How is the whole of PCK similar to or different from its parts (CK, PK, CxK)?
4. How does PCK vary before, during, and after participation in the program?
5. How does student learning change over time?
6. What is the relationship between participants' PCK and their students' learning?
7. In what ways does Project PRIME influence the development and sustainability of a professional learning community?
8. What is the relationship between the development of PCK and implementing educative curriculum materials with fidelity?
9. What is the relationship between participants' fidelity of implementation and their students' learning?

We have recruited two cohorts of biology teachers from the state of Arizona. To participate in the project, the teachers had to agree to select one of two highly educative biology programs to use for the two years of their project participation: Insights in Biology and BSCS Biology: A Human Approach. These programs were deemed most educative by an expert external review panel at the University of Michigan. The teachers participate in intensive professional development for two to three weeks for two summers. They also meet for two to three collaborative lesson studies during the school year. In addition, they collect a wide range of data during the school year, including the following:
• Providing a baseline videotape of teaching science prior to PRIME
• Videotaping one section of classroom instruction daily during project years
• Collecting student achievement data (pre and post)
• Implementing the selected curriculum for two years
• Completing teacher data—reflections, content tests, PLC surveys at regular intervals each year

Project Delta: Digital Environments for the Learning and Teaching of Algebra

Grant #	0822034
NSF Program	NSF
PI	Catherine Fosnot
Co-PI(s)	
Institution	City College of New York
NSF Program Manager	Paola Sztajn
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Professional Development Materials

Over the past six years, faculty and staff in Mathematics in the City at CCNY, in collaboration with researchers at the Freudenthal Institute in the Netherlands, developed professional development materials (K-8) in the form of interactive digital learning environments on number and operation (NSF #9911841). A digital library of 17 CD-ROMS was developed, with 15 accompanying facilitator manuals, published by Heinemann Press. PROJECT DELTA builds on this work by extending the current library to include two DVDs for algebra and by studying their impact when used by inservice teachers alone at home or in face-to-face workshops. Two sequences will be filmed and used (grade 3 and grade 5), and focus questions and notepads will be built into the environments as with the prior materials. Horizon Research, Inc. will study their impact.

The development of teacher knowledge in three domains will be examined: (1) mathematical content specific to algebra; (2) pedagogy; and (3) the didactical use of context in designing problematic situations that support mathematical development. Three groups of teacher participants (each n=600) varying in their use of the digital environments and related student materials will be studied, testing the hypothesis that use of the digital environments as a professional development tool will deepen teachers' content knowledge and their ability to bring learners to a higher level of mathematization. Twelve case studies will also be completed to examine the longitudinal effects. The project duration is four years.

Project I.D.: Instrument Development for Exploring the Professional Growth Continuum

Grant #	0554468
NSF Program	TPC
PI	James Barufaldi
Co-PI(s)	Mary Hobbs
Institution	University of Texas at Austin
NSF Program Manager	David Hanych
Grade Level Band	PreK, Middle School, High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	survey of teachers' experiences

The purpose of this research is to identify those pivotal experiences of career science teachers that have promoted their advancement along the teacher professional continuum. The research uses behavior over time (BOT) graphing to capture the empowering professional growth opportunities teachers recall experiencing over the entire course of their careers, and looks for patterns in those teacher experiences. The study proposes that the professional development offered to teachers should recognize and address their needs, increase their sense of empowerment, and is specifically focused on the TPC goals of encouraging research on effective professional development models and on advancing the knowledge base on enhancement and retention of STEM teachers.

The primary outcome of this exploratory study has been the development and pilot testing of a quantitative instrument that can be used to identify pivotal experiences that contribute to long-term teacher retention in a larger teacher sample. Implications for use of the data include the identification and implementation of effective professional development models and experiences that enhance science teachers' retention and effectiveness at the appropriate career intervals.

Project M2: Maturing Mathematicians - Advanced Curriculum for Primary Level Students

Grant #	0733189
NSF Program	NSF
PI	M. Katherine Gavin
Co-PI(s)	Tutita M. Casa
Institution	University of Connecticut
NSF Program Manager	James Fey
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Mathematics
Deliverables	Six Math Curriculum Units for Grades K-2

The goals of Project M2 include the following: increase the mathematics achievement of all students in grades K -2; develop students' understanding of mathematical content and processes in the areas of geometry and measurement; and target the participation of traditionally underrepresented students in advanced mathematics curricula. These goals are being accomplished through the development of six curriculum units that engage students in critical thinking, problem solving, and communication at increasingly complex levels.

Project M2 builds upon the success of Project M3: Mentoring Mathematical Minds, a grades 3-5 curriculum development project conducted by the researchers. Studies investigating this curriculum found statistically significant gains on open-response, criterion-referenced, and standardized tests. In Project M2, experts in mathematics, mathematics education, and early childhood mathematics education are writing six units (two at each grade level; K, 1, and 2). The units focus on geometry and measurement concepts identified in the Curriculum Focal Points (NCTM, 2006) and Principles and Standards for School Mathematics (NCTM, 2000). Verbal discourse and written discourse/representation models are being developed to nurture young students' mathematical knowledge as they explore concepts in depth. There is a Student Mathematician's Journal for students to write about their mathematical understandings similar to practicing mathematicians.

At each grade level, Project M2 units will be piloted in diverse classrooms in urban and suburban settings during their initial year of implementation. Qualitative feedback will be gathered to revise the units for field testing. A field test will be conducted the following year involving 24 classrooms in diverse schools in Connecticut, Kentucky, South Carolina, and Texas. During the field test, teachers will be randomly assigned to the intervention or comparison groups. Professional development will be provided for teachers in the intervention group that includes a four-day summer institute, two inservice days, and weekly classroom visits. The classroom visits will serve to ensure fidelity of implementation.

The research questions for this experimental design focus on measuring students' change in mathematics achievement as measured by standardized tests, criterion-referenced unit tests, and open-response items after exposure to the intervention, and on measuring differences between the Intervention and Comparison Groups. Results to date are from the Grade 2 implementation and show significant gains from pre- to post-testing on unit tests, ITBS, and open response assessment for the intervention group. For the Grade 2 open-response assessment, hierarchical linear modeling indicated statistically significant differences in favor of the intervention group over the comparison group after controlling for pretest scores (?11 = -4.43, t = -5.44, p <.001 [differential is for comparison group]) with a large effect size (0.90). Project M2 students' achievement on the ITBS (an assessment with a primary focus on number) was no lower than the achievement of comparison students who were doing their school's regular mathematics curriculum without an extended focus on geometry, measurement, communication, and problem solving.

Project M2 units will be published nationally by Kendall/Hunt Publishing Company. A Web site, www.projectm2.org, has been developed to inform the public about the curriculum and teaching strategies developed during the project. It contains resource sections for teachers, students, and families.

Project NEXUS: The Maryland Upper Elementary/Middle School Science Teacher Professional Continuum Model

Grant #	0455752
NSF Program	TPC
PI	James McGinnis
Co-PI(s)	Spenser Benson, Scott Dantley, Jose Barata (Y1 & Y2)
Institution	University of Maryland
NSF Program Manager	Sharon Lynch
Grade Level Band	PreK, Middle School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Research Articles, Conference Proceeding

The overarching research question that Project NEXUS is investigating is: To what extent of success (and for what reasons) can undergraduate elementary teacher education majors, particularly those from currently underrepresented groups, with demonstrated interest and performance in science, be recruited and prepared to teach upper elementary/middle science in a manner consistent with standards-based recommendations? Other questions include (Year 1) To what level of success and for what reasons is it possible for undergraduate academic advisors to recruit undergraduate college students with academic majors and minors in content to be science specialist upper elementary/middle school teachers? (Years 2 and 3) Does participation in undergraduate science content courses that exemplify the use of an inquiry perspective affect the recruitment and preparation of teacher interns to be science specialist upper elementary/middle school teachers? Do field-based placements in after-school informal science education programs that serve adolescent students affect the recruitment (and preparation) of college students to be science specialist upper elementary/middle level teachers? (Year 4) Does participation in a transformative science methods course and a senior year PDS placement in an urban environment that includes an organizing theme of data collection and statistical analysis affect the recruitment (and preparation) of college students to be science specialist upper elementary/middle level teachers? (Year 5) Do new graduates of the science teacher preparation program teach upper elementary/middle science in a manner consistent with standards-based recommendations?

Significance of the Research: There is a demonstrated and imperative need to investigate how to entice and prepare more prospective teachers, particularly those traditionally unrepresented, to choose to become science specialist teachers in upper elementary and middle school contexts.

Model of professional development: Project Nexus will test a model of active recruitment and preparation of elementary teacher education majors with demonstrated interest and performance in science, particularly those traditionally unrepresented, to be specialist upper elementary/middle school teachers.

Theoretical underpinnings of the research: The key assumption is that science educational practices require systemic reform within the undergraduate science subject matter and education classes, prospective teachers' field-based experiences, and professional development during new teachers induction years (NSF, 1993; NRC,1997; Sunal, Wright, & Day, 2004).

Research methodology: Quantitative and qualitative methodologies are used. The sample includes undergraduate teacher interns, undergraduate departmental advisors, science instructors, science methods instructors, field-based supervisors and mentor teachers, and informal science education adult leaders. Data collection strategies include pre- and post-surveys (adapted from instruments developed earlier by McGinnis et. al in the NSF-funded CETP project Maryland Collaborative for Teacher Preparation, MCTP), interviews, observations, reflective journals, drawings, and artifact analysis.

Implications for future research, policy, and practice: Findings from this research project will apply to research, policy, and practice associated with the recruitment, preparation, and support of upper elementary/middle school science teachers, particularly those from traditionally underrepresented populations.

Dissemination: Dissemination include presentations (local and national), publications, and a Web site (www.projectnexus.umd.edu).

Promoting Science Among English Language Learners (P-SELL) within a High-stakes Testing Policy Context

Grant #	0353331
NSF Program	TPC
PI	Okhee Lee
Co-PI(s)	Walter Secada
Institution	University of Miami
NSF Program Manager	Julia Clark
Grade Level Band	PreK
Target Audience	Students, Students - Special Population, Preservice, Inservice
STEM Content Area	Science
Deliverables	Research articles, book, curriculum, Web site

Research questions: During this five-year study, the University of Miami (UM) and the Miami-Dade County Public Schools (M-DCPS) are examining and improving elementary school teachers' knowledge, beliefs, and practices involving their teaching of science to English language learners (or ELL students) within the policy context of high-stakes testing and accountability in science. The four major research and development areas are (1) teachers' initial knowledge, beliefs, and practices; (2) professional development intervention; (3) policy contexts; and (4) change over time in teachers and ELL students.

Significance of the research: The research addresses the intersection of science education, the education of ELL students, professional development, and educational policy. It examines how teachers grow in their use of reform-oriented practices and how they balance that with the demands of high-stakes testing and accountability.

Theoretical underpinnings of the research: The research draws from the literature on how to assist elementary teachers in enabling ELL students to (1) learn academic subjects, such as science, while also developing English language and literacy skills and (2) learn to think and reason scientifically while also performing well on high-stakes tests. Additionally, it draws from the literature on how high-stakes testing and accountability policies in science get interpreted by school personnel and implemented in classroom practices.

Design of the intervention: The professional development intervention occurs primarily through the provision of curriculum units, participation in teacher workshops, and participation in research activities. The intervention addresses science along with English language and mathematics for ELL students.

Research methodology:
• Sample size and description: All third- through fifth-grade teachers in selected M-DCPS elementary schools that enroll large numbers of ELL students (primarily Spanish-speaking or Haitian-Creole speaking) participate in a professional development intervention. Six original treatment group schools engage in the intervention for three years and then one year of follow-up without the intervention (sustainability). Three replication group schools engage in the intervention during their final three years (replicability). The project also involves six comparison schools that are matched to the six original treatment schools. Additionally, UM preservice elementary teachers participate in the project.
• Instruments, data collection, and analysis design: Instruments are developed for use with school administrators, teachers, and students. A key aspect of the research is a longitudinal design with cohorts of teachers and their ELL students. Quantitative and qualitative methods; patterns of change in teachers' knowledge, beliefs, and practices; and student achievement in science and literacy are analyzed. The research also examines how the conditions in urban schools in a large urban district influence the intervention and classroom practices. Furthermore, the research tests sustainability and replicability of the implementation and impact of the intervention within the high-stakes testing and accountability policy environment.

Results: The results of the questionnaire administered to all participating teachers indicated that they were generally knowledgeable of science topics at their grade level and that they taught science to promote students' understanding and inquiry. Specific organizational supports and barriers were identified at both the school and

classroom levels. The teachers rarely discussed student diversity in their own teaching or with other teachers at their schools.

The results of teachers in the intervention indicated that teachers' knowledge of science content was generally accurate within the bounds of the lesson content supported by the intervention. Teachers were at the emerging stage of being able to promote students' scientific understanding and inquiry as well as English language and literacy. Such knowledge and practices are short of the goal of reform-oriented practices. The results provide insights for our ongoing intervention efforts and contribute to the emerging knowledge base.

The results of third-grade students' science achievement led to three main findings. First, treatment students displayed a statistically significant increase in science achievement. Second, there were no statistically significant differences in achievement gains by English proficiency or literacy levels, indicating that achievement gaps remained consistent. Third, treatment students showed higher scores than comparison students on a statewide mathematics test, particularly on the measurement strand emphasized in the intervention. The results indicate that ELL students and others in the intervention learned to think and reason scientifically while also performing well on high-stakes assessment.

In addition to students' science achievement, we examined the reasoning complexity of ELL students who participated in the intervention. The results indicated three main findings. First, students demonstrated more robust reasoning in the context of home connections than in the context of school activities. Second, across all contexts, students' reasoning lacked complexity; they could generate and elaborate on ideas, which represented lower ability, more frequently than they could justify and explain the ideas, which required higher ability. Third, across all contexts, students who exited from English to Speakers of Other Languages programs (ESOL level 5) and those at intermediate levels of English proficiency (ESOL levels 3 or 4) demonstrated higher reasoning complexities than native speakers of English (non-ESOL) and those at entry levels of English proficiency (ESOL levels 1 or 2). The study has implications for the importance of focusing on reasoning in both home and school contexts as a component of inquiry-based science instruction.

We also examined writing achievement in terms of "form" (i.e., conventions, organization, and style/voice) and "content" (i.e., specific knowledge and understanding of science) in expository science writing. From six treatment schools, the study involved over 2,000 third graders during the three-year implementation of the intervention. Students displayed significant increases, and the gains were larger over the three-year period. Students who were currently enrolled in ESOL programs made achievement gains comparable to those students who had exited from ESOL or never been in ESOL.

Implications for future research, policy, and practice: The research targets traditionally underserved students—ELL and low SES students in urban elementary schools. Beyond increased student achievement in science and literacy, our professional development will have implications for scaling up with non-volunteer teachers in urban schools, and to states with a wide range of science and English language policies for ELL students. The results will help other districts use our professional development program and/or adopt their own policies so that their own teachers can better teach science in the forthcoming high-stakes testing environment.

Dissemination plans: research journals, book chapters, conferences, curriculum for teachers and students, website, popular media targeted for the public.

Quality Cyber-Enabled, Engineering Education Professional Development to Support Teacher Change and Student Achievement (E2PD)

Grant #	0822261
NSF Program	NSF
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Co-PI(s)	Sean Brophy, Johannes Strobel, Monica Cardella
Institution	Purdue University
NSF Program Manager	Gerhard Salinger
Grade Level Band	PreK
Target Audience	Students, Inservice, Administrators
STEM Content Area	Engineering
Deliverables	Teacher Professional Development

Incorporating engineering into elementary classrooms has many benefits but requires professional development for teachers. The goal of this project is to develop a learning progression for elementary school teachers that increases their ability to adopt and refine engineering learning materials in their classroom. The initial face-to-face workshops currently used by INSPIRE (Institute for P-12 Engineering Research and Learning) at Purdue University will be extended with a cyber infrastructure of video-based mentoring in real time and an asynchronous learning experience. A video and audio network will link teachers with each other and with researchers/educators at Purdue to establish a community of practice dedicated to increasing the potential of teachers to implement engineering education. We will identify attributes of face-to-face and cyber-enabled teacher professional development and community building that can transform teachers into master users and designers of engineering education for elementary learners. We will engage in rigorous evaluation of teacher professional development (TPD) with engineering that looks at the impact of our TPD on teacher and student knowledge, attitudes, and behaviors (KAB) about engineering and engineering education. The design of our face-to-face and increasingly cyber-enabled TPD builds on prior research that identifies quality TPD as (a) delivered just-in-time to the teachers' setting (b) tailored to teachers' individual needs (i.e., answers very specific questions in specific contexts), and (c) developing point-to-point and guided online communities. We see the cyber infrastructure for professional development with learning and assessment resources as potentially transformative, able to manage and deliver large-scale professional development across the nation.

We will employ a feedback mechanism for advancing teacher KAB about engineering and engineering in their classrooms. Teachers' KAB about engineering and teaching with engineering guides their implementation of engineering in their classrooms. Assessment of students' KAB about engineering drives reflection and continued face-to-face and cyber-enabled TPD and community engagement that supports the integration of engineering in classrooms. The research questions are (1) Student KAB: What is desired student KAB (achievement) as a result of integrating engineering in formal (elementary) education? Clear articulation of student learning outcomes is necessary to ascertain the impact of TPD and community building around engineering. A related question is: How should student achievement be measured to provide evidence of successful TPD and teacher community around engineering? (2) Teacher KAB: What teacher KAB are necessary for successful and sustained integration of engineering in (elementary) classrooms? How should teacher KAB be measured to provide evidence of successful TPD and community building around engineering? (3) TPD and Teacher Community: What attributes of quality (face-to-face and cyber-enabled) TPD and teacher community support and sustain integration of engineering for desired student achievement? We wish to describe the "what and how" of successful TPD, community building, and sustainability around engineering integration into elementary education. The framework and associated research questions will produce compelling evidence of new knowledge around teacher pedagogical content knowledge, student learning and engagement in STEM education, and development and sustainability of effective teacher enhancement programs by means of face-to-face and cyber-enabled mechanisms.

Radford Outdoor Augmented Reality (ROAR) Project: Immersive Participatory Augmented Reality Simulations for Teaching and Learning Science

Grant #	0822302
NSF Program	NSF
PI	Matt Dunleavy
Co-PI(s)	Walt Heinecke
Institution	Radford University
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School
Target Audience	Students
STEM Content Area	Science
Deliverables	Augmented reality curricula

In an attempt to anticipate the needs of learners in 10–15 years, the Radford Outdoor Augmented Reality (ROAR) project will develop, test, and study immersive, interactive, and participatory augmented reality (AR) outdoor learning simulations using wireless handheld computers equipped with global positioning system (GPS) receivers to enhance middle school science teaching and learning. AR is an emerging area of educational technology, which uses GPS-enabled handheld computers to create outdoor science-based simulations. The narrative-driven, inquiry-based AR simulations developed by the ROAR team will be played on an HP iPAQ Travel Companion rx5910 handheld computer and use GPS technology to correlate the students' real-world location to their virtual location in the simulation's digital world.

As the students move around a physical location, such as their school playground or sports fields, a map on their handheld computer displays digital objects and virtual people who exist in an AR world superimposed on real space. When students come within approximately 10 feet of these digital artifacts, the AR and GPS software triggers video, audio, and text files, which provide narrative, navigation, and collaboration cues as well as academic challenges. This capability parallels the new means of information gathering, communication, and expression made possible by emerging interactive media (such as Web-enabled, GPS-equipped cell phones with text messaging, video, and camera features). This type of mediated immersion embeds digital resources throughout a real physical environment, augmenting students' experiences and interactions and providing interactive, situated, collaborative problem-solving affordances. The cyber-enabled learning made possible by location-aware AR expands the current understanding of classroom boundaries by embedding the physical environment outside of school with digital scientific inquiry challenges.

Within a design-based mixed methods approach, researchers will develop and field test AR simulations to examine the relationships between augmented reality, science content knowledge, scientific inquiry, socio-emotional outcomes such as academic engagement and self-efficacy, and the demographic characteristics of rural, underserved, middle, and high school students in participating classrooms in Southwest Virginia. In addition, the researchers will document how teachers and students describe and comprehend the ways in which participating in a technology-mediated narrative in outdoor AR simulations aid or hinder learning and teaching math and science. AR builds upon the emerging informal and collaborative learning styles that middle and high school students use as they communicate and share resources with their cell phones, portable gaming platforms, and handheld computers. Furthermore, the physical activity inherent within AR implementations affords the students physiological exercise embedded within cognitive tasks such as scientific problem solving, which in theory will enhance student engagement, learning, and retention. In the principal investigator's prior research, teachers and students reported that the technology-mediated narrative and the interactive, situated, collaborative problem-solving affordances of AR simulations were highly engaging, especially among students who had previously presented behavioral and academic challenges for the teachers. However, while the AR simulations provided potentially transformative added value, it simultaneously presented unique technological, managerial, and cognitive challenges to teaching and learning, which need to be explored further.

Ramps and Pathways: A Constructivist Approach to Teaching Physical Science

Grant #	0628082
NSF Program	IMD
PI	Betty Zan
Co-PI(s)	
Institution	University of Northern Iowa
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Professional Development guides and DVD

The purpose of the Ramps and Pathways project is to develop an approach to physical science curriculum for young children (grades preK-2) that will result in improved science achievement. The project brings together an interdisciplinary team of early childhood educators, developmental psychologists, and science educators to address the problem of a need for better physical science curriculum specifically designed to be both intellectually rigorous and developmentally appropriate for young children. The project's approach to physical science supports young children's inquiry through exploration and error-informed experimentation.

Specific goals of the project are (1) to develop age-appropriate physical science curriculum concerning the movement of objects on inclines; and (2) to develop professional development materials that will support early childhood educators in understanding how to support young children's learning about physical science and scientific inquiry in the context of inclines.
Anticipated learning outcomes for children include increased achievement in (1) practical understanding of the laws of force and motion as they pertain to inclines; (2) practical understanding of relationships among variables involved in moving objects on inclines; (3) exploring, observing, and describing physical phenomena; (4) asking questions about physical phenomena; (5) planning and conducting simple investigations; (6) communicating results of investigations to others; and (7) identifying and solving problems in the engineering of ramp structures.

Affective outcomes for children include the development of (1) positive attitudes toward science and engineering, and (2) positive images of themselves as science learners. Anticipated learning outcomes for teachers include (1) increased understanding of concepts of force and motion; (2) demonstrated ability to implement the curriculum and choose appropriate accommodations for children of diverse ability levels and learning needs; and (3) increased ability to observe children's experimentation and assess learning.

Year 3 activities consisted of a field test of the project with 23 teachers in grades preK-2 classrooms and 6 site facilitators in three sites geographically distant from the developers (Alabama, Texas, and Idaho). A one-week summer workshop and monthly meetings throughout the school year provided teachers with a support for implementing the curriculum. Project developers provided the summer workshop for the teachers at one site and the facilitators from all three sites. The facilitators from the other 2 sites provided the summer workshops for their teachers. Facilitators from all three sites provided the professional development at the monthly meetings throughout the year.

Evaluation results showed that implementation was good, and that children made progress in their understanding of the movement of objects on inclines. Further analyses in Year 4 will focus on questions concerning differences in implementation and child outcomes, and determining if a learning progression can be identified.

RAPID: The Science of Atoms and Molecules Project

Grant #	DRL-0946582
NSF Program	NSF
PI	Frieda Reichsman
Co-PI(s)	
Institution	The Concord Consortium
NSF Program Manager	Salinger, Gerhard L.
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	See http://sam.concord.org

This Rapid Supplement For The Science Of Atoms And Molecules Project undertakes a longitudinal study of student retention and application in subsequent years of concepts related to atoms and molecules. This work supplements the Science of Atoms and Molecules (SAM) project at the Concord Con-sortium using the Molecular Workbench software. The RAPID funding will enable researchers at the Concord Consortium to exploit a fleeting opportunity to undertake important longitudinal studies over this academic year (2009-2010). These studies will provide important data concerning the transfer of core molecular science concepts across years. Time is of the essence because two groups of schools can be used to conduct research on student retention, schools that have used SAM chemistry activities last year (academic year 2008-2009) and will use the biology activities this year, exposing students to at least two years of SAM activities in a chemistry-biology sequence.

Intellectual Merit. The SAM materials have a number of features that are designed to maximize learning across years. All the activities are based on guided inquiry. The same computational engine and Jmol molecular visualizations are used throughout. The activities are structured into four general themes that span the three years: motion and energy, charge, structure, and light. There is a common format and design for all activities.

The research will address the following questions:
1. Does student exposure to SAM activities in one year influence performance in SAM activities in a subsequent year?
2. Can students recall or apply concepts from SAM activities from prior years?
3. Is the available teacher professional development with SAM activities adequate?

To address these questions, we will assess the impact of previously completed SAM chemistry activities (used during the 2008-2009 academic year) on performance on SAM biology activities during the 2009-2010 academic year, in a capstone biology course. The study will include 300 biology students split approximately equally between classes taught by SAM pilot teachers and by cohort one RI-ITEST (Rhode Island Information Technology Experiences for Students and Teachers) teachers, who receive additional professional development in using these activities. All teachers in the study will be required to use at least five SAM biology activities during the year.

Broader Impacts:
It is important to know whether the SAM design and amount of content accomplishes the overall goal of improving the secondary science sequence by teaching important concepts that can be built on in subsequent courses. This is an extremely important question, since positive results could transform secondary science education by justifying a broader implementation of these materials and providing empirical evidence for additional research and curriculum initiatives of this kind. In particular, such evidence would provide justification for a more radical and comprehensive series of courses that systematically focused on basic atomic -scale concepts.

Reform Math Students' Transition from High School to College

Grant #	0732161
NSF Program	NSF
PI	Steven Kramer
Co-PI(s)	Ned Wolff
Institution	Arcadia University
NSF Program Manager	Karen Marrongelle
Grade Level Band	High School, Post Secondary
Target Audience	Other
STEM Content Area	Mathematics
Deliverables	Methodological and Scholarly Reports

This project has two major goals. The first is to explore how students who studied Contemporary Mathematics in Context (Core Plus) or the Integrated Mathematics Program (IMP) fare in two and four years post secondary institutions. The second is to discover methods that can efficiently obtain information about the effects of high school programs on eventual college success.
Specific research questions are:

1) How do students who studied Core Plus or IMP differ from Control group students in post-high-school academic success, including (a) the likelihood that they will attend any college? (b) the likelihood that they will attend a four-year college? (c) achievement in college-level mathematics? (d) the likelihood that they will receive a bachelor's degree within six years of high school graduation? (e) the likelihood that they will pursue a STEM major?

2) How do four different data collection approaches differ regarding addressing question #1? (a) obtaining, with student permission, transcripts from post-secondary institutions; (b)surveys of students; (c) working with school counseling staff to identify what percent of graduates attended college and to identify the smallest set of Institutions of Higher Education that account for 50 percent or more of the graduates from the school, followed by contacting for further information the registrars of those Institutions; (d) obtaining information from the National Student Clearinghouse about college experiences of targeted high school graduates.

Researching Mathematics Leader Learning

Grant #	0554186
NSF Program	TPC
PI	Judith Mumme
Co-PI(s)	Cathy Carroll, Rebekah Elliott, Elham Kazemi
Institution	WestEd
NSF Program Manager	Ferdinand Rivera
Grade Level Band	PreK, Middle School, High School
Target Audience	Other
STEM Content Area	Mathematics
Deliverables	Research Articles

Currently in its fourth year, Researching Mathematics Leader Learning (RMLL) is a five-year research project intended to study mathematics professional development leaders' understandings and practices associated with developing mathematically rich learning environments. In its effort to create leadership materials, the Leadership Curriculum for Mathematics Professional Development Project (NSF #0096672) identified difficulties leaders face in cultivating mathematics-rich environments in professional development. Using quantitative and qualitative research methods, RMLL investigates this issue by considering: How can leaders cultivate professional development environments where teachers have a greater opportunity to grapple with and understand mathematics deeply?

The original scope of the RMLL project entails how leaders made sense of and appropriated the construct of sociomathematical norms to guide their work when they facilitated mathematical tasks for teachers. Specifically, this project considers the following research questions: (1) What impact does a focus on sociomathematical norms as a construct and its enactment in leadership professional development practice have on leader-participants' thinking about promoting mathematical sense-making in professional development? (2) How and what sociomathematical norms are developed in mathematics professional development that leader-participants facilitate? (3) How do teacher-participants think about promoting mathematical sense-making in their teaching?

Findings from the first phase of research suggest that although leaders found the construct of sociomathematical norms useful to inform the kinds of mathematical conversations they pursued with teachers, ideas related to fostering sociomathematical norms were not sufficient to support them in constructing and attending to teachers' mathematical learning. With supplemental funding the project is expanding its previous framework to explore how leaders' mathematical knowledge for teaching (MKT) can mediate their own sense making and to help leaders develop facilitation practices that can actually support the development of the mathematical knowledge needed for teaching. The project aims to articulate the relationship between sociomathematical norms and a particular aspect of MKT, which Ball and colleagues call specialized content knowledge for mathematics teaching. An additional research question has been added: 4) What is the relationship between sociomathematical norms and specialized mathematical knowledge for teaching that might co-frame mathematical activity in PD? This frame will be tested in the phase two RMLL seminars and with the research on leaders' facilitation of PD with this additional research question:
In two phases data will be gathered from 75-100 participants in leadership seminars. Teacher leaders' understanding of sociomathematical norms will be assessed prior to and following the leadership seminars to capture how their understanding and dispositions change. For a subset of leaders, these data will be correlated with measures of their mathematical knowledge for teaching. Eight to ten leader-participants will be selected as case studies from leadership institutes. They will be followed as they go on to facilitate mathematics PD. Data will also be collected on the teacher participants in case-leaders' PD sessions to determine the conceptions about norms they develop while engaged in PD.

The project will document the factors that shape the sociomathematical norms that get established in mathematics PD and the role of specialized content knowledge plays in shaping these norms, contributing to the extremely limited research base on leader learning.

Researching Science and Mathematics Teacher Learning in Alternative Certification Models

Grant #	0553929
NSF Program	TPC
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Institution	University of Missouri
NSF Program Manager	Keith Sverdrup
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Research Articles, Conference, Book, Web

Situated in the context of an alternative certification program, the principal investigators study knowledge development of beginning mathematics and science teachers over a two to four year time span, seeking to understand what knowledge these non-traditional teacher education students bring into a program and how that knowledge develops over the course of the program and into their first years of teaching. An important aspect of our work has been developing a dialectical process between current theoretical frameworks for knowledge for teaching and the empirical evidence of knowledge that we have gathered as part of our study. Building on the work of Magnusson, Krajcik and Borko's (1999) model of pedagogical content knowledge (PCK), we view PCK as resulting from the integration of knowledge about learners, curriculum, instructional strategies, and assessment that are related to the content. This knowledge is filtered through an individual's orientation for teaching, meaning the knowledge of the purposes and goals for teaching a particular subject and the general way of conceptualizing teaching, learning, and the nature of mathematics. Our framework is based on two assumptions: (1) PCK is knowledge that is transformed and more powerful than its constituent parts (Southerland & Gess-Newsome, 1999) and (2) teacher knowledge influences classroom performance and student learning.

This research project targets science and mathematics teacher learning in the context of an alternative certification program (designed for individuals with baccalaureate degrees in science or mathematics) employing two different models of field-based preparation. In one model, pre-service teachers participate in an eight-week summer session and then become independent full-time teachers with complete responsibility for instruction. In the second model, pre-service teachers participate in the same eight-week summer session followed by a year-long internship guided by a veteran teacher. In both models, participants continue to enroll in university courses. To examine teacher learning in these two models the researchers collect longitudinal data from 72 participants at five transition points. The researchers collect qualitative data via project-designed instruments (authentic instructional planning tasks with accompanying interviews, video analysis tasks, and classroom observations with accompanying stimulated recall interviews) to investigate the overarching research question, "How does science and mathematics teacher knowledge develop within two models of alternative certification, and what facilitates and constrains teacher learning?"

Researching the Expansion of K-5 Mathematics Specialist Program into Rural School Systems

Grant #	DRL 0918223
NSF Program	NSF
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Co-PI(s)	Patricia Campbell
Institution	Virginia Commonwealth University
NSF Program Manager	Sharon Lynch
Grade Level Band	PreK
Target Audience	Inservice, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Training - rural Math Specialists

The project is a research and development proposal which will address the challenge: “How can promising innovations be successfully implemented, sustained, and scaled in schools and districts in a cost effective manner?” We will research the expansion of an established preparation and induction support program for K-5 Mathematics Specialists into rural school systems. The proposed project is based on a developed and refined program that has successfully prepared and inducted Mathematics Specialists into K-5 urban and suburban regions in Virginia. These Specialists are enhancing the ability of K-5 classroom teachers to provide high quality mathematics education. The exciting results from the prior research, which used control groups in the experimental design, indicate the positive impact of Specialists on teachers’ attitudes and beliefs and on student learning as measured on the high stakes Virginia Standards of Learning tests. The preparation program will need to be scaled to incorporate distance learning to reach participants in remote areas who are not within commuting distance of a university. Also a new professional support structure will be needed to transition Specialists into their role in small school systems which do not have mathematics supervisors or other administrators who can nurture their impending mathematics coaching roles. The research of the implementation and impact of these adaptations and refinements of currently developed programs is necessary to validate implementation of Mathematics Specialists across diverse settings and to model their work on the national level.

Researching the Wireless High School: Effects on Science Teaching and Implications for Professional Development

Grant #	0455795
NSF Program	TPC
PI	Brian Drayton
Co-PI(s)	Joni Falk
Institution	TERC, Inc.
NSF Program Manager	Michael Haney
Grade Level Band	High School
Target Audience	Preservice, Inservice, Administrators, Policy Makers
STEM Content Area	Science, Technology
Deliverables	

TERC is conducting a 3-year study in 6 high schools that have recently invested in the installation of wireless technology and 1-to-1 computing, with high speed Internet connectivity.

Research questions
Our study addresses the following three questions in each case study school. In reference to all three of these questions we will explore: [a] Similarities and differences between schools ---carefully documenting possible contributing factors such as student demographics, staff science and technology background, amount and nature of professional development programs, technology support in place, physical set up, school technology plans, and administrative vision and support. [b] Similarities and differences among teachers of different science disciplines across schools (including biology, chemistry and physics).

I. Level of Infusion: In schools that have installed wireless, 1-to-1 ubiquitous computing environments with high speed Internet access, are science teachers making regular use of the tools this environment makes available? What technologies are being used (e.g. software, Web-ware, communications tools, intranets)? Are teachers more likely to infuse technology when teaching particular subjects or themes? What is the range of use (e.g. early adopters and resisters) across science faculties and what are the factors that promote the sharing of resources and exploratory use within schools?

II. Science Value Added: Do the classrooms have characteristics of added value for science education such as: enriched science content, introduced through the use of software, Web-ware, probe-ware, and communication tools; access to scientific data sets, enhanced data analysis, sharing, and knowledge representation; labs enriched or supplemented by simulations, remote instrumentation, models, or 3D visualization tools; altered participant structures in the classroom; and connection to the wider science community.

III. Curricular, Pedagogy and Assessment Practices: How do teachers assess and critique the new resources or tools that they introduce? What content is added, from what sources? Is other content displaced, or is "standard" content reconceptualized? How if at all has the ubiquitous computing environment affected teachers' pedagogical and assessment practices? Is there any evidence of increased sharing of content or assessments (e.g. teachers sharing resources with other teachers or students commenting on each others' work)?

Methodology: The project takes a "collective case study approach," developing both school and teacher case studies, as well as cross-case comparisons. Sites were chosen to provide as much information as possible bearing on the research questions. We gathered quantitative and qualitative data from multiple sources, including principals, technology and science coordinators, teachers, and (in phase III) students. Interviews and documents were triangulated with teachers' logs and with observations. We iteratively analyzed fieldwork data, and were incorporated into analytic summaries, allowing us to test emerging hypotheses as they develop from our interpretive work. Data and summaries were circulated to the whole research team for discussion. As hypotheses arose, we took the opportunity to "member check," with informants.

Scaffolding Teacher Learning in Support of Student Inquiry

Grant #	0733143
NSF Program	NSF
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Co-PI(s)	Richard E. Bonney
Institution	Cornell University
NSF Program Manager	Joseph Reed
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Asynchronous Distance Learning Course

This three-year project is developing, piloting, and evaluating online professional development for middle school teachers interested in enhancing their ability to engage students in scientific research. Our goal is to determine what types of Web-based experiences and resources can most effectively support teachers in overcoming the hurdles inherent in enabling students to design and conduct their own investigations.

In summer 2008, we piloted a 7-week asynchronous course designed to scaffold middle school teachers' use of BirdSleuth curriculum resources developed by the Cornell Lab of Ornithology. Using the same readings and activity sheets designed for student use, teachers designed and conducted investigations. After writing simple research reports, they exchanged peer reviews, revised their writing, and submitted final reports summarizing their investigations. These were published in a special Teacher Edition of BirdSleuth Reports, which normally is published twice annually to highlight selected reports by middle school students. Online discussions woven throughout the course provided a forum in which teachers exchanged advice and reflected on challenges and rewards of implementing student research in their classrooms. For example, teachers selected and applied a rubric to grade example research reports, and they reflected on their approach to inquiry teaching as viewed on a continuum from guided to open inquiry.

We considered creating a school-year course in which a new cohort of teachers would facilitate and reflect on student research rather than carrying out their own investigations. However, feedback from Year 1 teachers led us to conclude that few teachers would be willing to take on this multi-week commitment during the school year. In response to this feedback, we instead explored less formal ways of scaffolding teachers' work, including interacting through the Tapped In teacher online community (http://tappedin.org).

In Year 2, we revised the summer course and shortened it from seven to five weeks to lower the attrition rate and enhance learners' experiences. Although the course remained asynchronous, we added several optional synchronous chats to bolster group cohesion and to introduce participants to Tapped In, which they will be able to continue to use throughout the school year. In Year 2 we also introduced use of a wiki-based system in place of our previous reliance on email for exchange of peer critiques. We currently are creating several new tools and curriculum resources to scaffold student investigations. These include an interactive tutorial about graphing, a searchable database of BirdSleuth student research reports, and a peer review tutorial.

Teachers who have enrolled in the summer courses have rated themselves from novice to expert in ability to facilitate student investigations. Some were experienced users of the BirdSleuth curriculum, and others were 1st or 2nd year teachers with little prior experience in inquiry-based teaching. Ongoing research is focusing on teachers' satisfaction with the online professional development and web-based learning tools provided, and on the impact of these experiences and resources on teachers' confidence and ability to facilitate student research.

Scaffolding Understanding by Redesigning Games for Education (SURGE)

Grant #	0822370
NSF Program	NSF
PI	Douglas Clark
Co-PI(s)	Brian Nelson
Institution	Vanderbilt University
NSF Program Manager	Michael Haney
Grade Level Band	Middle School, High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Research and Game

The proposed SURGE Exploratory Project addresses Frontier Challenge Topic "A" in terms of broadening access to science and Contextual Challenge Topic "B" in terms of teaching advanced physics concepts earlier and in greater depth. Students struggle with misconceptions grounded in tacit intuitive understandings based on students' perceptions of everyday events. School science, with its focus on explicit formalized knowledge structures, does not address these tacit intuitive understandings, and thus does not support students in revising intuitive misconceptions. As a result, students often develop low self-efficacy and interest in school science, which compounds into a widening gap between high- and low-achieving students over time, disproportionately marginalizing female students and English language learners (ELL). Many commercial video games focus on physics, ecology, and engineering. Furthermore, commercial video games are exceptionally successful at helping learners build accurate intuitive understandings of the concepts and processes embedded in the games due to the situated and enacted nature of good game design. As James Gee explains, good game design is inherently about problem solving. According to Gee, however, these games fall short because they do not help students articulate and connect their evolving tacit intuitive understandings into larger explicit formalized structures allowing knowledge transfer and application across broader contexts. SURGE will develop and assess design principles and learning environments instantiating these principles, that integrate research on conceptual change, cognitive processing-based design, and socio-cognitive scripting into the design of popular commercial video games to support students' understanding of Newtonian mechanics. The goals of SURGE will focus (1) on increasing eighth grade students' understanding of Newtonian mechanics including core elements from high school curricula (2) while retaining the strong motivational components of current commercial game design, and (3) and helping close achievement, motivation, and self-efficacy gaps among female students, ELL students, and students with low prior success in science.

Intellectual Merit Criterion. SURGE leverages a well-conceived theoretical foundation employing game design principles and scaffolding approaches developed through prior NSF-funded studies. SURGE extends this previous work through the development and assessment of design principles and exemplar environments integrating research on conceptual change, cognitive processing-based design, and socio-cognitive scripting into the powerful and largely untapped potential of commercial video games with the support of a potent team of cognitive scientists, physics researchers, game-based learning and assessment experts, and learning/design theorists.

Broader Impacts Criterion. This study will contribute to the burgeoning field of immersive, game-based learning by providing a foundation for empirically-based design approaches for implementing technology-supported physics curricula that scaffold learners in making explicit the tacit intuitive knowledge gained through interactive problem-solving in situated physics games. Middle school is notorious as a turning point where female and ELL students are "turned off" from science and where gaps in achievement, self-efficacy, and motivation expand irrevocably. By focusing on eighth grade and physics (which many teachers and learners consider challenging and forbidding), SURGE will contribute to broadening access for all students to advanced physics concepts in terms of achievement, self-efficacy, and motivation. Furthermore, by helping students revise and integrate their experientially-based tacit intuitive understandings into overarching formalized explicit knowledge structures, SURGE will provide middle school students with a strong foundation for success in the upper level high school courses that are gate keepers to college and beyond in STEM fields.

Scale Up of Math and Science K-12 Education Reform in a Large Urban District

Grant #	0935816
NSF Program	NSF
PI	Stacy Wenzel
Co-PI(s)	Bret Feranchak, David Slavsky
Institution	Loyola University Chicago
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	PreK, Middle School, High School, Post Secondary, Other
Target Audience	Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Mathematics
Deliverables	Web-based resources, articles

The major goals of the project are to:
A. Produce new knowledge that addresses the overarching research question:
What are the critical mechanisms involved in reforming, scaling up and sustaining math and science education systemically in the context of a large urban district?
B. Share/communicate findings that have relevance and utility to those engaged with policy and practice such as educational planners, administrators and educational researchers and evaluators and others studying educational systems.
C. Leverage future collaborations and communications between those engaged in practice/policy and research on math and science education.

Toward these goals, during 2007 – 2008 we held a two-day working conference of Chicago stakeholders in the 2002 – 2008 math and science education reforms in the Chicago Public Schools. During 2008 – 2009, we drafted and have available on the web (http://www.luc.edu/cse/programs/White_Paper_MASTER_012609.pdf) a working white paper titled: Math and Science Education Reform in Chicago, 2002 – 2008. With a no-cost extension, work will continue through 2009-2010. Refinement of the web-based documents, articles and a book are under development by the project team. The project will be seeking to engage additional Chicago and national stakeholders in the research and discussion.

Scaling Up Mathematics Achievement (SUMA)

Grant #	0733690
NSF Program	NSF
PI	Cathy Kinzer
Co-PI(s)	
Institution	New Mexico State University
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	PreK, Middle School
Target Audience	Students, Inservice, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Model for Mathematics

Scaling Up Mathematics Achievement (SUMA) uses the Building Capacity Model (BCM) which has been proposed as a framework for learning about and promoting systemic change in an effort to improve mathematics achievement for K-8 students in a school district. The model evolved from (1) extensive research on the need for systems thinking to improve math achievement (National Science Foundation); (2) the successful results of an NSF-funded K-8 math initiative in a low-income border district; and (3) a decade of experience building university/school district partnerships for mathematics teaching and learning throughout New Mexico.

The Scaling Up Mathematics Achievement (SUMA) grant will use design-based research and quantitative findings to study a district as it implements a standards-based curriculum in grades K-8. The project will research, analyze and share data regarding district decisions, tools, and processes in relation to the Building Capacity Model. This data will enable the district to make informed decisions that guide the mathematics implementation process. The research will be valuable in studying how adaptations can be made to the model and to the district as a learning organization. The data sharing and learning between the district and the SUMA team is accomplished through feedback loops that provide for the collection of the data in relation to the model's three components: (1) quality aligned and learned curriculum, (2) teacher quality and intentional collaboration, and (3) administrative and parent/community support.

This type of research requires systems thinking which is the ability to understand interactions and relationships in complex systems (Senge, 2000). It provides ways of studying complex situations as a whole. Schools are nested within the cultural and political systems surrounding them. Changes must occur at the classroom, school, and district levels. Therefore, SUMA research is conducted in these nested layers within the context of system-wide change (Rozenholtz, 1989).

The SUMA research project focuses on the school district as the unit of study and analysis. It embraces what Wagner (1998) suggests is the "new practice of whole school change that is consistent with our understanding of how learning takes place and how organizations change." Fullan (1997) writes about how an entire system from top to bottom can engage in systematic deeper reform on a continuous basis "and doing it in a way that results in continuous improvement in actual practice." The goal of the SUMA research project is to collaborate with the district to study mathematics teaching and learning through the lens of the Building Capacity Model and to modify the model when appropriate in order to improve mathematics learning for all students.

Science and Mathematics Integration for Literacy Enhancement (Project SMILE)

Grant #	DRL-0918505
NSF Program	NSF
PI	Pradeep M. Dass
Co-PI(s)	Tracy Goodson-Espy
Institution	Appalachian State University
NSF Program Manager	Gerhard L. Salinger
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Science, Technology, Mathematics
Deliverables	Instructional Modules

Project SMILE is designed to study the effectiveness of integrated science and mathematics instruction for improving middle school teachers' ability to teach scientific inquiry and mathematical problem solving using InspireData (a data visualization software) as the tool for integration. The overarching goal of the project is two -fold: To investigate the extent to which use of InspireData aids in integrating scientific inquiry with mathematical problem solving in instruction; and how effective are such tools in enhancing teachers' ability to teach these components of STEM "literacy". To that end, the project will investigate and address the following research questions:

1. To what extent can InspireData improve the integration of scientific inquiry with mathematical problem solving in exploring real world situations, issues and questions in grades 6 – 8 math and science classes?
2. To what extent can professional development focused on integration of science and mathematics instruction, mediated by InspireData, enhance middle school teachers' ability to teach scientific inquiry and mathematical problem solving?

Our hypotheses are that InspireData will allow for easy integration and more thorough instruction of scientific inquiry and mathematical problem solving at middle grades level. We will recruit a cohort of 20 middle school science and mathematics teachers to engage in activities designed to develop and use integrated instructional modules. These modules will integrate scientific inquiry and mathematical problem solving using InspireData as the tool for gathering, organizing, analyzing, and visualizing data and presenting conclusions about questions, issues and concerns, derived from real life situations relevant to middle school students (pedagogy based on Science-Technology-Society [STS] approaches). The Iowa Chautauqua Model of professional development (ICP) will be used to organize all professional development activities, which include a three-week summer institute, academic year on-line courses through MOODLE (an on-line course management software), and classroom implementation projects during the school year. Both the ICP model and STS-based pedagogy have been studied thoroughly and found highly effective in reforming professional development and science instruction. Using these proven approaches, we will investigate the effectiveness of InspireData as a tool to enhance scientific literacy and mathematical problem solving in an integrated manner. We will use Teacher Surveys and SCOOP Notebooks as pre-post data sources and modified Reformed Teaching Observation Protocol (RTOP) to analyze classroom instruction, in order to test our hypotheses and answer the research questions. SCOOP Notebook (funded by the US Department of Education) and RTOP (funded by NSF) are both reliable and valid instruments for collecting the type of data required for testing our hypotheses.

Teachers will be recruited from several school districts in the Appalachian State University's Public School Partnership Program, which collectively serve diverse student populations. The project design is based on collaborations among College of Education, College of Arts & Sciences, and ASU Mathematics & Science Education Center. Results of our research will be disseminated through a variety of state, national and international conferences and publications. The instructional modules developed and tested by teachers will be compiled as both print and web-based collections (on Project SMILE web site) for access and use by other teachers.

Science in Global Issues: An Integrated High School Science Course

Grant #	0352453
NSF Program	IMD
PI	Barbara Nagle
Co-PI(s)	
Institution	University of California
NSF Program Manager	Gerhard Salinger
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science
Deliverables	Instructional Materials

The Lawrence Hall of Science's Science Education for Public Understanding Program (SEPUP) is developing a two-year integrated science course, titled Science and Global Issues (SGI), for Grades 9–10. The Science in Global Issues project has used a backward design approach. The two-year program includes a complete year of new material, along with a major revision of the previously developed Science and Sustainability high school course, initially published in 2000. This two-year sequence will complete the SEPUP sequence for Grades 6–10. When these courses are published in 2010, they will provide the equivalent of a yearlong biology course and a semester each of chemistry and physics.

Issue-oriented science forms the core of SEPUP curriculum materials and is integral to the SEPUP learning cycle and goal of developing science materials for all students. Every unit and course uses personal and societal issues to provide thematic continuity for students' investigations and observations. The materials focus on the use of scientific concepts and evidence when making personal and societal decisions. The high school courses integrate and coordinate science content around issues of sustainability.

Like all SEPUP courses, SGI includes an embedded authentic assessment system, based on the SEPUP/BEAR Assessment System developed as part of a research and development project conducted in collaboration with the Berkeley Evaluation and Research (BEAR) Center at the University of California at Berkeley's Graduate School of Education. This assessment system assesses students' understanding of science content and process, as well as their ability to use this understanding to provide evidence for and analyze trade-offs of societal and personal issues. The courses also use embedded approaches to literacy in science that are based on the published work of literacy experts and field-tested in the context of the SEPUP program.

Field-testing of the nine units in the SGI sequence is now complete, and the materials are currently being revised based on classroom feedback, scientific review, and student learning results on matched pre-tests/post-tests and embedded assessments. Evaluation of the SGI program focuses on student learning that results from using the issue-oriented and inquiry approaches in these materials.

Science Learning: Integrating Design, Engineering and Robotics (SLIDER)

Grant #	0918618
NSF Program	NSF
PI	Richard Millman
Co-PI(s)	Marion Usselman. Juan-Carlos Aguilar,Donna Llewellyn,
Institution	Georgia Institute of Technology
NSF Program Manager	Daniel Householder
Grade Level Band	Middle School
Target Audience	Students, Inservice, Administrators
STEM Content Area	Science, Engineering, Mathematics
Deliverables	research & instructional materials

The Science Learning: Integrating Design, Engineering and Robotics (SLIDER) project is a collaborative effort involving the Center for Education Integrating Science, Mathematics and Computing (CEISMC), the Center for the Enhancement of Teaching and Learning (CETL), the School of Psychology, the School of Biomedical Engineering, and the College of Computing at Georgia Tech; the State of Georgia Department of Education; and three Georgia school systems: one urban, one rural, and one suburban. The project is developing and implementing a rigorous eighth grade physical science program that utilizes engineering design, LEGO™ robotics and mechanics, and a problem-based learning approach to teach mechanics, waves, and energy. The project seeks answers to these research questions: Can research-based physical science instructional materials that use problem-based inquiry learning in the context of engineering design scenarios empower a broad range of middle school learners to learn physical science content and reasoning skills? Can these educational materials lead to increased engagement, motivation, aptitudes, creativity, and interest in STEM fields; if so, does this effect persist as students move into high school? Do students engage with the materials differently depending upon their gender, race, socioeconomic status, prior academic achievement level, or location (urban, suburban, or rural)?

In the process of answering these primary questions, additional questions being addressed include: How should the learning be assessed in the classroom and how does this assessment impact student performance? What instructional materials and professional development are necessary to prepare teachers to deliver this type of instruction effectively in their classrooms?
Three geographically disparate schools with strong school leadership and an existing track record of robotics use are participating in the project. In each school, two teachers will utilize LEGO™ kits and storage units to fully support instruction in their physical science classes. The SLIDER instructional materials will consist of contextualized, problem-based challenges that require students to design, program, investigate, reflect, and revise their products or solutions.

Intellectual Merit: SLIDER contributes to the knowledge base on the effectiveness of using engineering design and robotics in K-12 education.

Broader Impacts: SLIDER impacts K-12 physical science education by providing a research-based and thoroughly tested set of instructional materials for use by teachers. These materials will be designed to help attract more students, particularly those previously underrepresented in STEM, into technical fields and careers. The project also impacts the educational research workforce by training graduate students, undergraduate students, and postdoctoral researchers in the theory and methods of educational research and evaluation.

Science Literacy through Science Journalism

Grant #	0822354
NSF Program	NSF
PI	Joseph Polman
Co-PI(s)	E. Wendy Saul, Alan Newman, Cathy Farrar
Institution	University of Missouri-St. Louis
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	High School
Target Audience	Students, Inservice, Other
STEM Content Area	Science, Technology
Deliverables	Book, Articles, Standards & Rubrics

The Science Literacy through Science Journalism project is designed to answer the following question: Does the teaching of science journalism using an apprenticeship model, reliable data sources, and science-specific writing standards improve high school students' understanding of science-related public literacy? Sub-questions include (1) Is the teaching of science journalism an efficacious, replicable, and sustainable model for improving science literacy? (2) How useful are science-related standards and rubrics for scaffolding and evaluating students' science writing? (3) What is the nature of the engagement in science this apprenticeship model invites? To investigate these questions, a local science news service will be created in selected schools, supported by a working newsroom at the St. Louis Science Center.

Anticipated products include a book on the teaching of science journalism, in-print and online science articles produced by students, a well-researched set of science writing standards and rubrics that can be used for instruction and evaluation nationwide, research articles on the affordances and challenges involved in using an apprenticeship model within schools, and research on student achievement relative to science literacy. This project should be viewed as part of a national effort to better understand how the teaching of science literacy can be scaffolded and how engagement in the production and interpretation of science text can be fostered. As students learn to assess information critically and write journalistically, their understanding of public science will be transformed and their ability to function as science-literate citizens—in the workplace and at home—will increase.

Intellectual Merit: Top-ranked science journalists and well-published senior faculty will use various methodological strategies to examine questions that are recognized by the American Association for the Advancement of Science and the National Research Council as central to the development of a scientifically literate public. Their claim is that the very survival of the nation depends on the development of individuals who are able to seek out reliable science information, critically assess the information they encounter, learn from publicly available sources, and collect the data needed to make informed decisions. Science journalists routinely engage in all the behaviors listed above, but, to date, there are no model programs that teach science journalism in high schools as a way of learning these skills and no research to evaluate science journalism as a model for instruction.

Broader Impact: This project is sustainable within the St. Louis region and can be used as a model for other groups seeking to build science literacy within their communities. The project begins in, and will continue to support, poorly performing, low SES schools. It also includes the participation of urban, suburban, and rural teachers. As result of this project, a new science journalism network involving the St. Louis Science Center and the local schools will be developed, and science writing from students will be shared with the public through local newspapers and online sources. This project will result in publications for the research community, the teaching public, and for local citizens.

Science Teachers Learning from Lesson Analysis (STeLLA) Professional Development Program: Scaling for Effectiveness

Grant #	DRL-0918277
NSF Program	NSF
PI	Kathleen Roth
Co-PI(s)	Joe Taylor
Institution	Biological Sciences Curriculum Study (BSCS)
NSF Program Manager	Sharon Lynch
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Research reports, PD program guide

This is a full research and development proposal addressing challenge question 4: How can promising innovations be successfully implemented, sustained, and scaled in schools and districts? The promising innovation is the Science Teachers Learning from Lesson Analysis (STeLLA) professional development (PD) program which supports 4th and 5th-grade teachers in teaching concepts in biology (food webs), physical science (phase changes), and earth science (earth's changing surface, weather).

The STeLLA program is promising for scale up because of its demonstrated impact on both teacher and student learning and its innovative form and substance. A quasi-experimental study of the program demonstrated significant improvements in 32 teachers' science content knowledge and pedagogical content knowledge compared with 16 comparison group teachers. Experimental teachers also showed significant improvements in their science teaching practice and increased student achievement. The STeLLA program's one-year, analysis-of-practice form uses videocases and analytic tasks to engage teachers in content-specific analyses of science teaching. In facilitated learning teams, teachers examine both program-provided videocases and video from their own classrooms. The videocases provide rich contexts for deepening teachers' knowledge by providing a shared context for evidence-based analysis.

The program's substance focuses on two key, research-based ideas for teacher learning that are examined in depth. The first is that teachers can improve their science teaching effectiveness by developing two lenses for analyzing teaching: the student thinking lens and the science content storyline lens. The second key idea is that teachers will deepen their science content knowledge through the use of these two lenses in analyzing videocases of science teaching.

This project is designed to test the effectiveness of the STeLLA PD program when it is scaled to: (a) reach larger numbers of teachers and students in a wider array of settings, (b) include random assignment to two treatment groups, and (c) be delivered by facilitators who were not program developers. The scaled version of STeLLA (100 teachers) will be compared to a science content deepening professional development program of the same duration (100 teachers). Measures of teachers' science content knowledge, pedagogical content knowledge, and teaching practice will document impact on teachers. Student pre-post unit tests will provide evidence of student learning. The goal is to understand the impact of the STeLLA program on teacher and student outcomes compared to a content-deepening PD program, and to identify factors that explain variance in student achievement.

Intellectual Merit. Few studies of professional development look at program effectiveness in terms of its impact on student learning. Even fewer use rigorous experimental designs that can identify causal links to account for program effectiveness. Such information is important in strengthening the knowledge base about the particular features of PD programs that are most important in enriching teacher knowledge and practice and in improving student learning. Policy decisions about how to spend scarce PD dollars should be informed by high quality research. The proposed study fills a critical need for such research.

Broader Impacts. This project will produce both research results about the effectiveness of the STeLLA program and professional development curriculum materials that will enable future widespread implementations of the program. These materials include a video-assisted manual for training program facilitators, and a facilitator's guide with accompanying online videocase materials and tasks. Dissemination will pair the study findings with these PD materials to support policymakers in using evidence to guide decisions about program selection. Careful selection of schools in districts that include high percentages of students from underrepresented groups and a range of urban, suburban, and rural settings will ensure diverse participation and produce results that

can be used in a wide variety of settings.

Seeds of Science / Roots of Reading: Developing a New Generation of Research-based Elementary Science Instructional Materials

Grant #	0628272
NSF Program	IMD
PI	Jacqueline Barber
Co-PI(s)	P. David Pearson
Institution	University of California, Berkeley
NSF Program Manager	Julio Lopez Ferrao
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Instructional Materials

The Seeds of Science/Roots of Reading project addresses the urgent need for materials that help students make sense of the physical world while addressing foundational dimensions of literacy. Seeds/Roots employs a multi-modal "Do it, talk it, read it, write it" learning model, with literacy used in the service of science inquiry. The learning model capitalizes on natural synergies between science and literacy to the benefit of both domains and emphasizes support for English Language Learners.

During an initial three-year proof of concept grant, the Seeds/Roots staff built a model of science-literacy integration, applied that model to the development of three units for second and third grade students, and developed and produced 27 innovative student science books for use as part of those units, Each prototype Seeds/Roots unit consisted of 40 hour-long sessions, about half of which addressed key reading/language arts standards, while at the same time engaging students in thinking, talking, reading, and writing about science. We conducted a nation-wide field test of these first three units involving nearly 90 classrooms in 21 states. One -third of these classrooms had a high percentage of English learners. Both quantitative and qualitative results from this first phase of work are exceptionally promising. Early results of a quasi-experimental evaluation of two of the three prototype units showed that students who participated in these units made significantly greater gains on an assessment of science understanding as compared to students in a comparable inquiry-science-only condition. Similarly positive findings were demonstrated on literacy measures, with Seeds/Roots students outperforming the control students on gain scores on reading of conceptually related and unrelated science text and on conceptually-related vocabulary items and unrelated science vocabulary items, demonstrating an ability to transfer reading gains in these units to the ability to read science texts in general.

Now in a continuation phase, project staff are capitalizing on these promising results by applying, modifying, and adapting, as appropriate, the Seeds/Roots model for upper elementary students, and completing the development and testing of the program so it extends from second through fifth grades. In addition to an extensive field test of the materials, we are also conducting a separate efficacy study on one of the units for third and fourth grade students—Light Energy, and on one of the units for fourth and fifth grade students—Planets and Moons, to examine student outcomes related to science understanding, inquiry, nature of science, science attitudes, reading comprehension, writing, and vocabulary development, as compared to students engaged in content-comparable treatments. To further explore the promise of a combined science-literacy approach, we are also collecting evidence related to the total amount of time spent on science instruction, teachers' perception of curricular economy, and on teachers' sense of self-efficacy in Seeds/Roots classrooms over comparison classrooms.

Semiotic Pivots and Activity Spaces for Elementary Science

Grant #	0733218
NSF Program	NSF
PI	Noel Enyedy
Co-PI(s)	
Institution	University of California-Los Angeles
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK
Target Audience	Students
STEM Content Area	Science, Technology
Deliverables	Physics Learning Environment

The target audience for the Semiotic Pivots and Activity Spaces for Elementary Science (SPASES) project is 5-8 year old students. SPASES is a proof of concept project that aims to build and test a computer environment that teaches force and motion to young students by transforming symbolic play into scientific modeling. It is hypothesized that using new, but commercially available, computer vision (augmented reality) and tactile interface technologies we can engage young students with force and motion concepts at an early age. Outcomes and findings include a prototype and activities and the qualitative and quantitative findings from the SPASES classroom implementation last year.

Shifting Mindsets: A Study of a First-Year Implementation of "New Technology High School"

Grant #	0738247
NSF Program	NSF
PI	Melissa Gresalfi
Co-PI(s)	Gayle Buck, Dionne Cross, Meredith Park Rogers, Cathy Brown
Institution	Indiana University
NSF Program Manager	Janice Earle
Grade Level Band	Middle School, High School
Target Audience	Students, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Supports for Project-based Instruction

The purpose of this study is to provide baseline knowledge about the changes teachers and students go through in their first year of implementing a project-based curriculum. Using new project-based units and associated instructional practices requires a shift from traditional teaching practices, to create classroom cultures that focus on flexible and robust understandings of math and science. This departure from conventional modes of teaching involves more than just a change in teachers' knowledge, but also a reconceptualization what it means to teach and learn (Cobb, McClain, Lamberg & Dean, 2003;Goldsmith & Shifter, 1997; Franke, Carpenter, Levi & Fennema, 2001). This suggests that investigations of change in practice need to focus beyond the content with which teachers engage, and incorporate the ways that teachers make sense of new information and new ways of teaching as it relates to their conceptions of themselves as teachers. At the same time, reform initiatives also challenge students' notions of learning developed through their own educational experiences.

These initiatives often require students to redefine their role in the classroom and become more active participants in their own learning, a process which can be difficult for students to embrace.
In this study, we use a case-study design (Creswell, 2002) at two levels. First, to gain insight into teachers' experience, data will be gathered from all math and science teachers, and each will constitute a case for analysis. Second, case analyses of a group in each classroom will be conducted and contrasted. Both levels of analysis will be guided by three main research questions: What sort of adjustments are required of 9th grade teachers and students in implementing a new project-based curriculum; what barriers do teachers and the students face in their first year and how did they work through them; and at the end of the school year, what were the successes of the implementation, and what contributed to these successes? What barriers remain and what supports are needed to help work through them for the following year?

Results of this study will lead to new understandings of how to support the enactment of project-based learning environments that claim to promote "dramatic shifts" in the development of learning skills (Rockman et al., 2006) similar to those identified as 21st century workforce skills (NCREL, 2003; NSF, 2005). By examining the first year of implementation, we will be able to establish a baseline of knowledge critical for supporting the reform efforts in these and other schools across the state and country. We are seeking to support this initiative by designing and implementing professional development that will prepare teachers to engage students in 21st century skills. This is an innovative approach to professional development, as we seek to build models of teacher professional development based on the challenges that teachers experience, rather than based on a vision of implementation conceived by curriculum developers. To do so, we must actively engage teachers and students in the creation of teacher development programs that provide workable solutions to real-school problems.

Silicon Prairie Initiative for Robotics in Information Technology 2.0 (SPIRIT 2.0)

Grant #	0733228
NSF Program	NSF
PI	Bing Chen
Co-PI(s)	Neal Grandgenett, Elliot Ostler
Institution	University of Nebraska-Lincoln
NSF Program Manager	Karen Zuga
Grade Level Band	Middle School, High School
Target Audience	Students, Inservice
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	CEENBoT Developed and Curriculum Lessons

This DR-K12 project is developing an educational robotics curriculum for grades 5-8 that comprises a set of instructional modules organized into a flexible, Internet-accessible curriculum. This curriculum will be focused on the instruction of specific robotics related topics in science, technology, engineering, and mathematics (STEM). The curriculum is building upon the previous work of a NSF professional development ITEST project (Information Technology Experiences for Students and Teachers) called SPIRIT (Silicon Prairie Initiative for Robotics in Information Technology), where foundational work in lesson development has already taken place by a core group of teachers along with university educators, district specialists, and engineers.

The objectives of the project are to (1) develop a grades 5-8 educational robotics curriculum that will enhance the student learning of STEM concepts using the flexible TekBot® robotics platform; (2) refine the instructional effectiveness of the curriculum in an extended development process, using peer editing, expert review, pilot testing, and field testing; (3) integrate a series of interactive and focused assessments into the curriculum to help teachers determine what STEM concepts students are learning; (4) extend the TekBot® learning platform for use with the curriculum, including detailed technical enhancements, hardware tutorials, software guidelines, and a GUI interface, (5) create a cyberinfrastructure support environment, including a flexible sequencing of lessons, materials, assessments, technical information, and online diagnostics, and (6) begin to scale the project, by the use of two summer workshops with national educators (in person and via distance learning), to help teachers learn to use the curriculum.

Simulation and Modeling in Technology Education (SMTE)

Grant #	0821965
NSF Program	NSF
PI	Michael Hacker
Co-PI(s)	David Burghardt, Deborah Hecht, Karl Kapp, Gordon Snyder,
Institution	Hofstra University
NSF Program Manager	Michael Haney
Grade Level Band	Middle School
Target Audience	Students, Inservice, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	3D Web-based Game Teaching STEM Concepts

Simulation and Modeling in Technology Education (SMTE) is a five-year project that develops and researches the academic potential of a hybrid instructional model that infuses computer simulations, modeling, and educational gaming into middle school technology education programs. These prototypical materials use 3-D simulations and educational gaming to support students learning STEM content and skills through developing solutions to design challenges. The virtual environment allows students to analyze and improve their designs by changing variables and observing how their changes affect design performance. Once the designs are optimized on-screen, students will construct physical models and compare their functionality and effectiveness to the simulated virtual models.

A uniqueness of the project is the development of an innovative Web-based instructor design interface and a library of objects to enable instructors to modify the context of the design problems to fit different instructional and geographic settings. The research investigates the transferability of the model and its potential to improve STEM teaching and learning.

The project incorporates a cyber-enabled engineering design approach that integrates science and mathematics and uses contemporary technological tools and pedagogical strategies. The content is driven by the concepts and skills identified in the K-12 Standards for Technological Literacy (STL). The partners are Hofstra University's Center for Technological Literacy, the State University of New York at Buffalo, the NSF National Center for Telecommunications Technologies, Bloomsburg University in Pennsylvania, and the City University of New York.

The research design includes a test of three conditions: the experimental (hybrid) condition; the gaming and simulation-only condition that involves students in the virtual tasks only; and students doing physical modeling task. Testing will involve 12 teachers and 240 students with data collected in six assessment domains. Data will be analyzed using a variety of multivariate statistical analyses.

Situated Assessment using Virtual Environments for Science Content and Inquiry (SAVE Science)

Grant #	0822308
NSF Program	NSF
PI	Diane Jass Ketelhut
Co-PI(s)	Brian C. Nelson, Catherine Schifter
Institution	Temple University
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science, Technology
Deliverables	Assessment Modules for 7th and 8th Science

SAVE Science proposes to create an innovative system for evaluating learning in science, consistent with research- and policy-based recommendations for science learning that are focused around the “big ideas” of science content and inquiry for middle school years. The motivation for this comes not only from best practices as outlined in the National Science Education Standards and AAAS’ Project 2061, but also from the declining interest and confidence of today’s students in science. One source of data for students on whether they can succeed in science comes from tests, but do current tests accurately measure students’ knowledge of both content and processes in science? According to the National Research Council, science processes are more often assessed by asking students to define words such as “hypothesis” and “scientific method.” However, knowing the definitions of these words is not synonymous with understanding how to do the processes that underlie scientific inquiry. What are needed are classroom assessments that not only assess inquiry and content but also do so authentically.

SAVE Science will design and implement a series of virtual environment situated assessment modules for evaluating both science content and inquiry in grades 7 and 8 in the School District of Philadelphia (SDP) and surrounding school districts. These will generate knowledge to inform teachers and learners about student understanding, while increasing interest and confidence. The modules will make use of a novel assessment rubric based on student interactions within an authentic context-based science curriculum, embedded in game-like quests conducted in a virtual environment. This project will also investigate how best to help students make sense of the complex virtual environments, and how to help teachers integrate technology into their pedagogy.

Broader impacts from this study will be in helping students better understand their own knowledge and learning processes, thus promoting increased efficacy in science and interest in science careers and in directing teacher practices by providing them with more detailed data to inform meaningful differentiated instruction. It is hoped that this project will help close the achievement gap. The intellectual merit of this research lies in its contribution to the burgeoning field of collaborative, game-based STEM education by using virtual environments to standardize performance assessments leading to the development of innovative assessments of student understanding of science content and inquiry, and by producing recommendations for how researchers can design virtual environments with rich immersion in authentic inquiry practices without overwhelming students.

Strategic Integration of Mathematics and Science

Grant #	0455866
NSF Program	NSF
PI	Juliet Baxter
Co-PI(s)	David Moursund, Dean Livelybrooks
Institution	University of Oregon Eugene
NSF Program Manager	Joseph Reed
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	AERA presentation April 2009

This project studies the effects of professional development that focuses on the strategic integration of science and mathematics. With strategic integration, elementary grade science teachers learn to develop the mathematical ideas in science lessons by providing meaningful contexts for understanding concepts (e.g., functions) and processes (e.g., graphing). Working with standards-based science and mathematics curricula that support inquiry learning and making sense of mathematics, elementary teachers are learning to integrate math and science. It is important to note that this is not a curriculum development project, but rather a research study of how a particular approach (i.e., strategic integration) to the enactment of science and math curricula affects (a) teachers' knowledge, beliefs, attitudes, (b) teachers' classroom practice, and (c) students' understanding, attitudes, and beliefs. In this approach not every math lesson and science lesson is integrated, only those that promote learning of both disciplines in a robust way. Mathematics offers powerful intellectual tools to analyze and study phenomena in the sciences. In turn, the sciences provide engaging contexts for using mathematics. Research on learning suggests that strategic integration will help teachers and their students better understand content and develop more positive beliefs and attitudes about science and math. To test these assertions, we have conducted two controlled experiments using random assignment of schools to two different treatments: professional development focusing on strategic integration and professional development that addresses math and science separately. Data sources include surveys of beliefs and attitudes, performance tasks, individual interviews, and classroom observations. Our results have documented the impact of strategic integration on: teachers' knowledge, beliefs and attitudes; teachers' classroom practice; and student understanding and beliefs. During the fifth year of our project, we are studying critical factors in scaling up our model of professional development. By working with the entire staff of three elementary schools, we are studying the specific features of school settings that support both teachers' and students' learning when mathematics and science are strategically integrated.

Intellectual merit: Our studies are based on current research on learning mathematics and science and professional development of science teachers. In addition, national standards for the teaching of mathematics and science are integrated throughout the project. Our research design includes rigorous quantitative analyses that compliment theoretically-based qualitative analyses based on the TIMSS videotape analyses.

Broader impacts: Our research findings on strategic integration of math and science will enable others to develop professional development programs that best suit their local conditions. Our analyses of how various subgroups of students respond to teachers who incorporate strategic integration into their teaching will inform diversity efforts across the nation. The project's dissemination plan includes two-day workshops to reach rural educators, participation in state-level meetings of the superintendent, development of a high-quality website, and annual presentations at national research conferences to reach a broad and diverse audience.

Student Polar Research with IPY National (and International) Teacher Training (SPRINTT)

Grant #	0732793
NSF Program	NSF
PI	Glen Schuster
Co-PI(s)	
Institution	The U.S. Satellite Laboratory, Inc.
NSF Program Manager	David Campbell
Grade Level Band	Middle School, High School
Target Audience	Students, Students - Special Population, Inservice, Administrators
STEM Content Area	Science, Technology
Deliverables	Classroom Materials and Training

SPRINTT (Student Polar Research with IPY National [and International] Teacher Training) brings cutting-edge thematic classroom activities and investigative research into grades 5-12 classrooms, bridging the science and society divide as it inspires the next generation of polar explorers. SPRINTT uses an innovative, live, online training format to train teachers in how to teach science content in a polar context. This ensures that the lessons of IPY and specific SPRINTT curriculum activities, including western science content and perspectives of Alaska Natives, become a part of teachers' regular curriculum for years to come. Polar scientists directly inform the content of, and participate in teacher training, bringing current research into the classroom to enhance science content. SPRINTT provides teachers with existing and adapted high-quality standards and culturally-based curriculum materials to promote understanding of polar science. SPRINTT collaborates with science professionals and educator partners to simplify research data and create a user-friendly interface from which students can begin their own authentic polar investigation and/or research projects. Students from around the world can share their findings within the SPRINTT Web site. Students create a 'build-your-own' Research Paper that becomes its own 'web page'. SPRINTT has (1) prepared hundreds of teachers onsite in Alaska and online from across the Nation and in other countries to teach about the significance of the polar regions within the Earth system; (2) provided scientific and cultural education materials and tools for teachers and students to investigate the polar regions; and (3) brought scientists, teachers, and students together both online and in person to bridge the gap between science and society.

Intellectual Merit: SPRINTT's instructional design is soundly built on research in K-12 education and teacher professional development. During the teacher training, educators learn both content and pedagogy, and embark on their own inquiry-based research using authentic polar data. Through synchronous (live) and asynchronous collaboration, teachers share best practices as they infuse and adopt polar science into their curriculum and learn to effectively facilitate student research and/or investigations.

Broader Impacts: This project has now impacted more than 25,000 upper elementary, middle and high school students around the world, engaging and inspiring them to learn about Earth's polar regions and their importance in the Earth system. The majority of U.S. students are from underrepresented groups, including urban, minority, rural and Alaska Native populations. SPRINTT is spreading the work of many other polar and IPY-related partners, including SCAR, the Inuit Circumpolar Council, the International Polar Foundation, Alaska Native Science Commission, Alaska Native Knowledge Network, Teachers Domain, Exploratorium, NSIDC, ANDRILL, NOAA, BEST, Summit Station in Greenland, and others.

Relevance to IPY: SPRINTT addresses several broad goals of IPY. The project promotes international collaboration between formal educators, students and scientists, both virtually and in person, encouraging diverse groups to engage in an ongoing discussion and examination of the Polar Regions as it engages the public in polar discovery through guided student investigation and research projects. Innovative teacher training brings Earth's polar systems into the classroom, as students examine the critical role of the Polar Regions in global processes and the changes to the Arctic as viewed by indigenous peoples.

Supporting Grade 5-8 Students in Writing Scientific Explanations

Grant #	0836099
NSF Program	NSF
PI	Katherine McNeill
Co-PI(s)	
Institution	Boston College
NSF Program Manager	Gerhard Salinger
Grade Level Band	
Target Audience	
STEM Content Area	
Deliverables	Book

The recent National Research Council publication Taking Science to School: Learning and Teaching Science in Grades K-8 (Duschl, Schweingruber & Shouse, 2006) offers a new vision for proficiency in science, which includes a focus that students be able to "generate and evaluate scientific evidence and explanation" (p. 2). Although this focus on evidence based scientific explanations is prevalent in the current research literature, there are few concrete examples of what this scientific inquiry practice looks like when it is successfully supported in classrooms. Our project focuses on the development of a book and a research study to investigate the impact of that book and accompanying professional development on teachers' beliefs and classroom practices to support grades 5-8 students in writing scientific explanations. The book will provide concrete examples in both student written work and video of the current theoretical ideas being advocated in the science education field. We use an instructional framework that breaks down the complex practice of scientific explanation into four components: claim, evidence, reasoning, and rebuttal. We have found that incorporating this framework for scientific explanation into curriculum materials (Krajcik, McNeill & Reiser, 2008; McNeill, Lizotte, Krajcik & Marx, 2006), teacher instructional strategies (McNeill, in press; McNeill & Krajcik, 2008), and assessments (McNeill & Krajcik, 2007) results in students writing stronger explanations and it makes student thinking visible to teachers so they are better able to adapt their instruction to meet the needs of their students.

Through student writing, excerpts from classroom transcripts, and video, the book will transform a theoretical idea and illustrate what it looks like in actual classroom practice that can be used by teachers as well as in teacher preparation and professional development. The examples will include a variety of different contexts in terms of different content areas, grades 5-8, and students with a variety of backgrounds including diverse students from urban schools. During the 2009-2010 academic year we will research the impact of the book and accompanying professional development with grade 5-8 science teachers in terms of both their beliefs and classroom practice around scientific explanation. The study will include twenty-five grades 5-8 science teachers in the Boston metro area. Teachers will be asked to read the book and attend a three professional development workshops developed from the facilitator materials. Data sources will include pre and post surveys, videotape and artifacts created during the workshop for all twenty-five teachers. Furthermore, five focal teachers will be selected from the 25 that attended the professional development based on their pre and post surveys in order to include teachers with a range of different beliefs. The five focal teachers will be interviewed about their beliefs around explanation and argumentation and will be observed for three lessons that incorporate scientific explanations into their science lessons. The results from this study will inform the field about teachers' beliefs around scientific explanation, how professional development can change those beliefs, and the subsequent impact on teachers' classroom practices.

Supporting Staff Developers in the Implementation of Professional Development Programs to Improve Mathematics Education for Students with Disabilities

Grant #	0822313
NSF Program	NSF
PI	Babette Moeller
Co-PI(s)	Amy Brodesky, Lynn Goldsmith
Institution	Education Development Center, Inc.
NSF Program Manager	John Bradley
Grade Level Band	Other
Target Audience	Administrators
STEM Content Area	Mathematics
Deliverables	Materials for Staff Developers

School districts across the country face a pressing need to increase access to significant mathematics content for students with disabilities. To help address this issue, two NSF-funded projects, Math for All (MFA, elementary grades) and Addressing Accessibility in Mathematics (AAM, middle grades) have created intensive curriculum-based professional development (PD) programs to help prepare both general and special educators for improving the mathematics education for students with disabilities. Prior research shows that the MFA and AAM programs (when implemented by the developers) have a positive impact on teachers' content knowledge and their instructional practices. However, more research is needed to investigate how these programs are being put into practice by district-based teacher leaders and what kinds of training, support, and resources they need to implement them effectively.

The overall goal of this project is to investigate the kinds of supports that are needed to develop the capacity of teacher leaders to effectively implement the MFA and AAM programs in their districts. The proposed project will be carried out in two phases. In the first phase, we will conduct a small-scale qualitative study to collect and analyze in-depth data on the implementation practices and support needs of district-based facilitators. Results of the qualitative study will inform the development of facilitator-support resources, including print materials, facilitator institutes, and an online support environment. In the second phase, we will conduct a larger experimental study to investigate how different levels of support (curriculum materials only; materials and facilitator institute; materials, institute, and ongoing online support) contribute to teacher leaders' learning, implementation of one of the PD programs and teacher learning outcomes. We will use a variety of data sources, including pre- and post-assessments, implementation logs and observations, to assess impact on facilitators' knowledge and implementation practices, as well as the participating teachers' learning outcomes.

Supporting the Development of Model-based Reasoning

Grant #	0628253
NSF Program	IMD
PI	Leona Schauble
Co-PI(s)	Richard Lehrer
Institution	Peabody College, Vanderbilt University
NSF Program Manager	Janice Earle
Grade Level Band	PreK, Middle School
Target Audience	Students, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Web Site, Assessments, Inst'l Materials

This proposal is to develop and test a learning progression for modeling that spans the elementary and middle school grades (grades 1-6). Modeling instruction will be organized around concepts in life sciences that cumulate to a strong conceptual understanding of micro- and macroevolution. PIs and the National Science Research Center will work directly with participating teachers to support their content knowledge and their appropriation of modeling approaches to science instruction. Research will focus on both the development of students' biological concepts and their modeling practices.

Intellectual Merit: Modeling is central to the epistemology of science, but modeling perspectives are rare in school science and have not been cultivated as a specialized form of thinking with developmental roots that need to be deliberately supported and extended from early grades onward. The PIs seek to build on a twelve-year program of research on the development of model-based reasoning to construct frameworks, student curriculum, professional development, and assessments that support a modeling approach to teaching and learning in the life sciences, oriented toward the end point of a deep conceptual understanding of micro- and macroevolution. Unlike mathematics, science education in the early grades is not taught in ways likely to foster accumulation of scientific knowledge, skills, and reasoning. The broad, shallow, and modular nature of the early science curriculum mitigates against student conceptual understanding, teacher mastery of the content, and well-aligned assessment. If teaching and learning were instead organized around research-based understanding of the development of student knowledge, teaching, research, and assessment could build more systematically toward the forms of learning and performance valued later in schooling.

Broader Impacts: Outcomes of the project include both products and findings. Products will be (a) four related conceptual papers that detail the conceptual framework of the learning progression, (b) well-piloted versions of modeling activities for students in grades 1-6 (published on a website), (c) modeling extensions for existing Science and Technology for Children units, and (d) an assessment system to track the development of students' science concepts and modeling. Findings will report student learning over two years across grades 1-2, 3-4, and 5-6, providing preliminary test of the modeling progression. This research will be conducted in two districts with underserved children, one urban and primarily African American, one rural and primarily Hispanic. Therefore, the work will demonstrate how even students in struggling schools can master difficult science concepts and engage in complex forms of scientific reasoning.

Supports for Learning to Manage Classroom Discussions: Exploring the Role of Practical Rationality and Mathematical Knowledge for Teaching

Grant #	DRL- 0918425
NSF Program	NSF
PI	Patricio Herbst
Co-PI(s)	Daniel Chazan
Institution	University of Michigan
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice, Higher Education
STEM Content Area	Mathematics
Deliverables	Web objects, articles, presentations

The project focuses on practicing and preservice secondary mathematics teachers and mathematics teacher educators. The project will research, design, and develop materials for preservice secondary mathematics teachers that enable them to acquire the mathematical knowledge and situated rationality central to teaching, in particular as it regards the leading of mathematical discussions in classrooms. The project connects the dispositions that practicing teachers exhibit in instructional actions in algebra and geometry to the knowledge and skills aimed at by current approaches to teacher education. Thus the project contributes to three of the five components of NSF's cycle of innovation: synthesizing and theorizing notions of teacher knowledge and practical rationality; hypothesizing and clarifying how those participate in decision-making in specific situations in algebra and geometry instruction; and designing, developing, and testing a "virtual setting" for practice-based teacher education, organized around animations created with prior NSF funding.

System-wide Change: An Experimental Study of Teacher Development and Student Achievement in Elementary Science

Grant #	0554566
NSF Program	TPC
PI	Adam Gamoran
Co-PI(s)	Geoffrey Borman
Institution	University of Wisconsin-Madison
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	PreK
Target Audience	Students, Inservice, Administrators, Policy Makers
STEM Content Area	Science
Deliverables	Research and Practitioner Articles

The purpose of this study is to test the impact on student achievement of a content-rich, systemic approach to teacher development for elementary school science. Low levels of science proficiency and extensive inequality are already evident in results from the National Assessment of Educational Progress, and as science assessments enter the accountability systems required by No Child Left Behind, addressing these challenges will become more pressing than ever.

System-Wide Change is a broad-based approach to science teaching and learning that involves a partnership among scientists, science educators, and K–12 practitioners; includes preservice, inservice, and curricular development; and is supported by a comprehensive NSF Math and Science partnership in four urban school districts. The research project will test the achievement benefits of the System-Wide Change elementary science component, which provides teachers with professional development activities in summer institutes and ongoing coaching and mentoring in the use of detailed instructional guides for elementary science. The guides contain conceptual lessons coupled with science immersion units that bring teachers and students through a full cycle of inquiry in core problems of scientific investigation, leading to deeper understanding of science, higher scores on science achievement tests, and reduced inequality of science achievement. Preliminary research suggests the development activities are associated with increased teacher knowledge, more effective pedagogy, and greater student learning. The full-scale field trial will be carried out in a large sample drawn from the 420 K–5 elementary schools of the Los Angeles Unified School District. The main study will be a randomized field trial producing rigorous impact estimates of the System-Wide Change strategy on the science achievement of students in grades 4–5. A total of 80 schools will participate in the study, with half randomly assigned to the intervention and half to the control group. One supplementary study will gather observational data on the classroom practices of teachers in the experimental condition to assess the quality of implementation of the conceptual lessons and immersion units and to aid understanding of the mechanisms through which the achievement effects operate. A second supplementary study will identify key elements of school capacity associated with successful implementation, and will monitor the effects of the intervention on teacher retention. A third supplementary study will focus on System-Wide Change as a case of the translation of centralized policy into teachers' classroom practice, examining district and school capacity to bring about change.

The study will simultaneously promote teacher development and student learning in a major urban school district and advance knowledge about new approaches to science education. By improving science teaching and learning in Los Angeles, this project will promote achievement of groups that traditionally underperform in science. The student population of the district is diverse, with 73 percent of students from Latino backgrounds, 11.7 percent African American, 6.4 percent other minorities, and 8.8 percent White. By disseminating implementation strategies and tools as well as research findings, the study promises to have a broad impact on science teacher development and student learning across the nation.

Talk Science: Scalable, Web-based Professional Learning to Improve Science Achievement

Grant #	DRL-0918435
NSF Program	NSF
PI	Susan J. Doubler
Co-PI(s)	Harold McWilliams, Sarah Michaels
Institution	TERC
NSF Program Manager	Joe Reed
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Curriculum-aligned web-based PD

TERC, in close collaboration with the Mason School in Roxbury, MA, the Benjamin A. Banneker School in Cambridge, MA, Newton Massachusetts Schools, and self-selected schools in Vermont, along with scientists and linguists from Tufts University, Clark University, and Boston University is conducting a four-year project to enhance and study the development of elementary science teachers' skills in managing productive classroom talk in inquiry-based physical science studies of matter.

The project hypothesizes that aligning professional learning with conceptually-driven curriculum and emphasizing the development of scientific discourse changes classroom culture and increases student learning. The project is developing new web-based resources, Talk Science PD, to help elementary teachers facilitate scientific discourse. These resources are comprised of two nine-week professional development "courses" for 4th and 5th grade teachers. The resources are being designed in collaboration with scientists, linguists, and cognitive psychologists to develop media-rich video case-based learning experiences that enhance teachers' understanding of the science and classroom discourse. The resources are closely aligned with the newly-developed, NSF-funded Inquiry Curriculum, a curriculum for elementary grades about the nature of matter and the conceptual development of material, mass, volume, and density. Four research questions are central to the study:

1. How do teachers' awareness, understanding, and skills for supporting science talk change as they use Talk Science?
2. How do teachers' understanding of science concepts and processes change as they use Talk Science?
3. How does student talk change as a result of changes in teachers' language-related actions?
4. How do classroom discourse patterns change as a result of changes in the teacher's action?

The Talk Science resources will be evaluated through a comprehensive pre/post evaluation plan. The project will document teachers' learning and closely study the changes in discussion patterns in 18 science classrooms from urban, suburban and rural schools in Massachusetts and Vermont.

Target Inquiry: Investigating the Teacher and Student Effects of a New Model in Chemistry Teacher Professional Development

Grant #	0553215
NSF Program	TPC
PI	Ellen Yezierski
Co-PI(s)	Deborah Herrington
Institution	Grand Valley State University
NSF Program Manager	Reed
Grade Level Band	High School
Target Audience	Students, Inservice, Higher Education
STEM Content Area	Science
Deliverables	Research articles, Web site, curriculum, conference presentations

Funding from Grand Valley State University, the Camille and Henry Dreyfus Foundation Special Grant Program in the Chemical Sciences and the NSF TPC program has supported the development, implementation, and study of an innovative new professional development program for high school chemistry teachers called Target Inquiry (TI). TI uses a chemistry research experience as the foundation for adapting teaching materials and studying their effects through action research. The study of TI seeks to understand how the three core experiences (chemistry research experience for teachers (RET), materials adaptation (MA), and action research (AR)) impact in-service high school chemistry teachers' (a) content knowledge in chemistry; (b) attitudes and beliefs about scientific inquiry and self-efficacy; and (c) classroom instructional methods in addition to how teacher participation in TI affects student achievement.

Currently, the first cohort of TI teachers (N = 8) has completed all three core experiences and the second TI teacher cohort (N = 8) has completed their materials adaptation experience and will be implementing and studying their new activities this upcoming academic year. Findings from the mixed-methods, longitudinal study of the TI program indicate that the research experience improves teachers' knowledge of higher-level applied topics in chemistry as well shifts their understanding of the process of science towards that of practicing scientists (Kennedy, Yezierski, & Herrington, 2008). Furthermore, as teachers progress through the TI program, we see improvements in classroom instructional practices with respect to reformed teaching approaches. A statistically significant gain on teacher RTOP scores after the inquiry materials adaptation experience indicate that both the RET and the materials adaptation are key. Furthermore, RTOP scores after their action research experience stayed constant showing that teachers maintained their gains in instructional quality one year after completing the program. Teacher interviews support classroom observational data, as all of the teachers indicated that what they thought about inquiry instruction at the beginning of the program was not correct or complete and that now they have a much better understanding of what inquiry instruction is. Finally, gains in student achievement were found as teachers progressed through the program. For the 9 TI teachers studied who taught Chemistry 1 for 3 or more years, 6 had significant student achievement improvement over 1 year (3 teachers post-RET and 3 teachers post-MA), and 7 had significant student achievement improvement over 2 years (5 post-MA only, 1 post-AR only, and 1 post-MA and post-AR). For the 4 TI teachers studied who taught Advance Placement Chemistry for 3 or more years, 3 had significant improvement over 2 years and 2 of the 3 had significant improvement over 3 years.

Two noteworthy recognitions of the TI project occurred recently. First, PIs Herrington and Yezierski gave an invited talk at the Gordon Research Conference on Chemical Education Research and Practice in June 2009. Second, PIs Yezierski and Herrington have been invited to speak at the National Academies of Science Chemical Sciences Roundtable.

Future work includes: Complete one more year of data collection for first teacher cohort; complete data collection for second teacher cohort (in the same cycle as the first cohort); address research questions with data from two teacher cohorts and disseminate findings; explore expanding TI into biology, physics and geology; and plan the multi-site dissemination and study of TI. We currently have 3 colleges and universities in

other states working with us to implement the Target Inquiry model for high school teacher professional development.

Teacher Helping Teachers Teach Science Inquiry: The "Just ASK" Project

Grant #	0733195
NSF Program	NSF
PI	James Shymansky
Co-PI(s)	
Institution	University of Missouri-St. Louis
NSF Program Manager	Dr. Joe Reed
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	www.umsl.edu/~ask/Home.html;

The “Just ASK” project builds on 15 years of NSF-funded work by the “Just ASK” team on “adapting science kits” (ASK) as a K-6 professional development strategy and using distance technologies to reach small, rural school districts. The project is designed to produce: (1) a validated set of ASK lessons and accompanying classroom videos specific to STC K-6 science kits, (2) a web-based community of practice where ASK activities and classroom videos can be accessed and posted and where teachers can interact in real-time with other teachers nation-wide, and (3) research evidence on the impact of ASK communities of practice on school districts programs, teachers and students in a group of pilot schools.

The ASK approach focuses primarily on having teachers “adapt” science inquiry activities to “teach more than science when you teach inquiry science.” This ASK approach utilizes and respects the teacher’s prior knowledge and recognizes that “much of what a teacher needs to know (and know how to do) is learned in the context of practice [from other teachers]” (Schlager & Fusco, 2004). The ASK approach builds “communities of practice” with colleagues within school buildings and districts and with colleagues and experts outside—both of which are critical to continued professional development (Darling-Hammond & Ball, 1998).

Teachers are in the third year (2009-10) of helping each other to develop and study a new generation of ASK lessons and to use the “Just ASK” website for building 14 topic-based communities of practice across the six small, rural and small-town pilot schools. Both lesson plans and video footage (with teacher commentary) are being developed by pilot teachers and posted on the Just ASK website. In the final years (2010-12) of the project, the Just ASK website will be opened to teachers nationally via links with kit publishers. The website with its 14 communities of practice will be maintained for at least three years after NSF funding has ended. The research plan calls for expert observers to rate baseline and post-treatment teaching by pilot teachers.

Teacher Learning Communities: Centering the Teaching of Mathematics on Urban Youth

Grant #	0742614
NSF Program	NSF
PI	Laurie Rubel
Co-PI(s)	
Institution	Brooklyn College of the City University of New York
NSF Program Manager	Jim Fey
Grade Level Band	High School
Target Audience	Students, Preservice, Inservice, Higher Education
STEM Content Area	Mathematics
Deliverables	Professional development

This is a five year CAREER project that integrates research and educational activities designed to enhance our knowledge base about the teaching and learning of mathematics in urban high schools. The project is designed around the creation, support and study of mathematics teacher learning communities in four high schools in low income, urban neighborhoods. These teacher learning communities are organized around learning to implement culturally relevant mathematics pedagogy (CuReMaP), defined as 1) advances students toward understanding of and proficiency with mathematical concepts and skills by teaching for understanding, 2) includes aspects of the lived experiences of students and their communities as contexts for mathematization; and 3) uses mathematics to analyze societal inequities to develop students' awareness, critical literacy and sense of agency so that they can fully participate in our nation's democracy. The project consists of two phases of 2-year cycles, each phase focused on a pair of schools, with the following fundamental objectives:

1) To improve our understanding of how to better prepare and support teachers to teach mathematics effectively in urban high schools, using a framework of CuReMaP.

2) To gain an understanding of the learning outcomes of CuReMaP for students at urban high schools.

The 2009-2010 academic year marks the opening year of the first 2-year cycle. A 5-day project summer institute was held in August 2009, for 17 high school teachers.

Teachers' Use of Standards-Based Instructional Materials

Grant #	0732184
NSF Program	NSF
PI	Karen King
Co-PI(s)	Monica Mitchell; Carole Mulligan; May Samuels
Institution	New York University
NSF Program Manager	Elizabeth VanderPutten
Grade Level Band	Middle School
Target Audience	Inservice, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Research Reports

The objective of this project is to study the ways in which middle grades teachers adapt standards-based instructional materials in mathematics. To conduct this study, the project team will conduct a mixed-methods research design. The sample of teachers comes from 30 K-8 or 6-8 schools in the Newark Public Schools. The project team will survey all middle school mathematics teachers in these schools building on the Survey of Enacted Curriculum (SEC) about the ways in which they adapt and supplement the Connected Mathematics Project instructional materials and why.

Additionally, two schools will be chosen as case study schools to provide a richer sense of how and why teachers adapt and supplement instructional materials. Each teacher responsible for teaching middle grades mathematics will be observed over at least two consecutive days, including pre- and post-observation interviews, to examine how the teacher uses the CMP instructional materials in his or her planning and enactment of a lesson. The project will also collect student achievement data in the form of scale scores on the state test for all students and benchmark assessments in case study classes to provide further information on the impact of instruction on students' learning. Analysis will focus on describing the ways in which teachers use the CMP instructional materials and also on the relationships between different types of adaptations and students' achievement.

Teaching Ecosystem Complexity through Field Science Inquiry

Grant #	0554379
NSF Program	TPC
PI	Marion Dresner
Co-PI(s)	Andy Moldenke, Stephanie Bestelmeyer, John Moore, Ariel Lugo
Institution	Portland State University
NSF Program Manager	David Campbell
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Technology-based resource (including Web

Teaching Ecosystem Complexity helps high school science teachers build their knowledge of ecosystem complexity and understanding of consequences of human activities on ecosystems. Participating scientists and educators from Long Term Ecological Research sites in Oregon, Colorado, New Mexico, Arizona, and Puerto Rico have created web-based teaching tools and use them during a two-week summer courses about patterns in ecosystems. Central to the program are field experimentation, cross-site comparisons, and the use of modeling and simulations. New teams of Professional development providers from nature center sites will use the materials with their own groups of teachers in their own teacher training. Spanish translations of student material, combined with outreach to organizations that will help provide classes with locally relevant ecological work to increase Hispanic student involvement in science. During summer courses held at five different sites, teachers work as novice ecologists in partnership with scientists at the five different Long Term Ecological Research sites. We are measuring how effectively the materials promote teacher confidence, knowledge, science inquiry skills, and understanding of ecological complexity. Qualitative conceptual modeling is used as a means for participants to express what they understand at key points during their participation in a research project. Teachers model the variables in the ecosystem under study and the relationships between variables. We document their use of ecological models to both portray ecological knowledge and to assess changes in teachers' understanding about ecological diversity and experimentation. Teacher understanding about ecological complexity, diversity, and experimentation are documented by their models, their essays, through interviews with program staff, content tests, using a pre-post-test design. We have developed a heightened understanding about teacher professional development.

High school science teachers need direct instruction in scientific research. This needs to be conducted with minimal lecture and with a high degree of interaction and "hands-on" instruction. But, since even the best immersion experience in following the steps of science inquiry does not necessarily lead to greater understanding, we use their qualitative conceptual models to engage metacognitive processes and thus help strengthen their scientific understanding. By providing opportunities to reflect on what they comprehend at points in time, through use of qualitative conceptual modeling, teachers are helped in understanding more accurate or new concepts, and even learn how to monitor their own learning process. One goal of our collaboration is to also develop a greater understanding about how biota is shaped by climate. Litter decomposition, arthropod diversity, and vegetation diversity data is being gathered by teachers at five distinct sites. Teachers and scientists at the H.J. Andrews LTER, Luquillo LTER, Shortgrass Steppe, Central Arizona-Phoenix LTER, and Chihuahuan Desert Nature Park will analyze this data and draw inferences about the role of climate on ecosystem functioning. The website (ecoplexity.org) provides practical resources to the teachers for immediate use with their students when they are back at school. The Web site is used during the summer courses for all online material used in teacher training.

Temple University Science Math Assessment Research for Teachers (TU-SMART)

Grant #	0455786
NSF Program	TPC
PI	Susan Jansen Varnum
Co-PI(s)	Judith Stull
Institution	Temple University
NSF Program Manager	Robert Gibbs
Grade Level Band	PreK, Middle School, High School, Post Secondary
Target Audience	Students, Students - Special Population, Preservice, Inservice, Higher Education, Administrators
STEM Content Area	Science, Mathematics
Deliverables	Web site (resources and collaboration area), course materials; research reports, conference presentations, summer institutes, culminating national conference, conference proceedings

Recruitment and retention of participants is an issue that all projects must confront to varying degrees. On any one occasion enough participants must be recruited to meet statistical minimum needs. In longitudinal projects losing participants compromises the ability to generalize the results. Among the strategies that researchers have used are incentives, mandates, social networking, and testimonials from satisfied participants. While “success stories” are too often perceived as being based only on unique situations, they are often the end product of some very interesting and informative discussions and decisions. It is these discussions which can provide the stimulus for creative solutions. The goals of the SIG meeting will be broaden and deepen the participants' understanding of recruitment and retention issues and to forge new collaborative relationships. The SIG facilitators will share their successes and failures. Input from participants and free discussions will be welcomed.

The Advanced Mathematics for All Project

Grant #	0455572
NSF Program	TPC
PI	Philip Uri Treisman
Co-PI(s)	Susan Hudson Hull
Institution	University of Texas at Austin, Charles A. Dana Center
NSF Program Manager	John S. Bradley
Grade Level Band	High School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Tools to support Alg II teachers

The Charles A. Dana Center, its school district partners, and commercial e-publisher Agile Mind, Inc., propose to create an integrated system of online and face-to-face support services that will strengthen the teaching and learning of advanced mathematics. The support system will be responsive to individual teachers' needs at key phases of their careers — as inductees, novices, master teachers, and instructional leaders — and will help sustain communities of teachers focused on broadening and diversifying the pool of students who succeed in contemporary and rigorous high school mathematics courses. A-MAP will focus on four dimensions of educational work: instructional planning, instructional delivery, instructional outcomes assessment, and professional capacity development. Novel uses of technology will support communities of practice by providing rich resources for teachers, data for intelligent instructional decision making, and infrastructure for aggregating, testing, and refining hard-earned practice knowledge.

The proposed work builds on the Dana Center's mathematics education leadership work both in Texas and nationally. With education publisher Agile Mind, the Dana Center has over the past five years developed online and face-to-face resources for teachers and students in Algebra I, Geometry, Algebra II, Precalculus, and middle school mathematics (as well as in Calculus and Statistics). These resources have now been used for four full years by over 5,000 teachers and teacher-leaders and over 300,000 of their students. The great majority of these teachers teach in high-poverty schools in Texas and in large urban districts including Chicago, New York, Dallas, and Houston.

Unlike many technology-mediated approaches to strengthening mathematics teaching and learning, A-MAP will be organized primarily as a support system for teachers and teacher-leaders rather than as a stand-alone support for students. A-MAP will provide its users with multi-dimensional student performance data to drive intelligent instructional planning. It also will provide its educator users with rich instructional resources, including animations and simulations that can be used in the classroom to help students investigate challenging mathematical content.

The project is focusing on advanced mathematics as a critical component of mathematics programs. While increasing numbers of students are prepared for and required to take advanced mathematics (Algebra II and beyond), few school districts have the capacity to responsibly offer this course to all their students, as national and state-level data show. But especially relevant to the equity focus of this project is that these reports reveal alarmingly high percentages of unqualified teachers — including teachers teaching out of field — in schools serving high-poverty and minority communities (Darling-Hammond, 2000; Ingersoll, 2001). A-MAP will provide supports to build teacher knowledge and capacity. A-MAP will integrate interactive online classroom resources and immediate technical assistance and intervention with face-to-face training to support teachers as they implement standards-based instruction and assessment in their classrooms. The Dana Center will ensure that this set of professional development tools and resources is coherent, comprehensive, and correlated to national and state-level standards.

The African Diaspora: Developing Black Scholars in Science Education for the 21st Century in the United States

Grant #	0840039
NSF Program	NSF
PI	Mary Atwater
Co-PI(s)	Malcolm B. Butler, Eileen Carlton Parsons
Institution	the University of Georgia
NSF Program Manager	Dr. Julia Clark
Grade Level Band	Other
Target Audience	Higher Education
STEM Content Area	Science
Deliverables	symposium evaluation, research studies

The overall goal of this project is to improve K-12 teaching and learning by further development of the research scholarship of Black science educators in the United States. To accomplish this goal, a symposium was funded. Hence, the major goals of the symposium are:
1. To develop a network of Black science education faculty members to research issues related to science teaching and learning.
2. To develop research teams in order for the team members to submit research proposals to such federal agencies as the National Science Foundation and private foundations.
3. To increase the number of Black science education faculty members at traditionally White and Historically Black Universities and Colleges who successfully publish scholarly writings about science education on science teaching and learning.
Focused studies on science teaching and learning, especially at elementary, middle school and high school grades will result due to coherent research

The Coaching Cycle: An Interactive Online Course for Mathematics Coaches

Grant #	0732495
NSF Program	NSF
PI	Loretta Heuer
Co-PI(s)	
Institution	Education Development Center, Inc.
NSF Program Manager	John Bradley
Grade Level Band	PreK, Middle School
Target Audience	Administrators
STEM Content Area	Mathematics
Deliverables	Online Course for K-8 Math Coaches

Mathematics coaches are charged with providing sustained, site-based professional development to teachers. Coaches, however, often have limited opportunities for their own initial and ongoing training. This can be especially true in districts that, because they are small, geographically isolated, or in difficult economic circumstances, do not have the capacity to provide comprehensive training for their coaches.

"The Coaching Cycle" addressed these constraints through an online course designed to meet the needs of coaches in these districts. Each session of the course engaged participants in activities related to both mathematics content problematic for K-8 students and a particular skill needed for effective coaching. Coaches, whose work helps break down the isolation of teachers, often become isolated themselves. Thus, the course created a professional learning community for coaches who, because of district size or location, lack structures for collegial support.

The pilot version of the course ran during the early part of 2009; the field test version will run during the 2009-2010 school year. We were heartened by the degree of interest in the course: over 80 potential participants vied for the pilot study's 20 available seats. We anticipate an equally robust response for the field test version.

A formative evaluation component, developed by the University of Massachusetts' Donahue Institute, solicited feedback from the pilot study participants to improve the course for the upcoming field test. The second evaluation component used an instrument developed in cooperation with the Education Alliance at Brown University to address the following questions:

- What is the relationship between instructional coaches' participation in The Coaching Cycle and changes in their coaching practice? To what extent is there:
  - A strengthening of coaches' content knowledge in relation to the course's selected mathematical topics?
  - An increased capacity for coaching as evidenced by use of the coaching cycle and/or the tools and strategies provided through the course?
- How effective were the course's tools, strategies, and training/consultation resources in conveying the intended knowledge of mathematics content and skills for instructional coaching?
- In what ways did the course stimulate a community for professional learning among program participants?

Because both online learning and instructional coaching are fairly recent models of staff development, a program that combines the two will add to the developing knowledge base about how these interventions support coaching as a mechanism to change instructional practice and increase student achievement.

Finally, an online course designed to provide both training and ongoing support for coaches in small and rural districts could be scaled up to meet the needs of larger districts that need to provide initial training for newly hired coaches, or that are seeking a coordinated staff development plan to build capacity in their existing coaching program. To this end, we are working with the Massachusetts Department of Elementary and Secondary Education to make the course available to coaches in high-needs districts, and have worked with a publisher during the course's formative stages so that the finished product will have marketing potential.

The Development of Student Cohorts for the Enhancement of Mathematical Literacy in Under Served Populations

Grant #	0822175
NSF Program	NSF
PI	Robert Moses
Co-PI(s)	Ed Dubinsky, David Henderson, Mary West
Institution	The Algebra Project Inc.
NSF Program Manager	John Bradley
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Mathematics
Deliverables	Instructional materials, teacher professional developlement,documentation of cohort implementation and student outcomes

This is a Full Research and Development proposal which addresses the Contextual Challenge: How can the learning of significant STEM content be achieved to ensure public literacy and workforce readiness? Our nation is failing to prepare millions of youth for meaningful and productive participation in an information-based society. The target population are those students performing in the bottom quartile on state and national tests, many of these are children of color living in under resourced communities, and most of these young people do not finish high school and end up diverted into an underground economy, gangs, and prisons.
This project addresses this failure by further developing and testing an approach that the Algebra Project is developing for high school mathematics, in which students form a cohort that stays together for all four years of high school, study mathematics every day using project-designed curricular materials with teachers who participate in project professional development, and are supported by local community groups.
The Algebra Project seeks to stimulate a demand for math literacy in those most affected by its absence -- the young people themselves. It stresses the importance of peer culture, using lessons learned from experiences in the 1960s Civil Rights Movement, as well as in the emergence of project graduates into a group with their own perspectives and initiatives.
In the 60s, project founders learned how to use the meeting place as a tool to engage and empower the people that the meeting was intended to serve. In the proposed project, there are two meeting places: the students' high school mathematics classroom and supplementary education activities; and the network of sites around the country that are communicating and learning how to develop and implement cohorts. Young peoples' roles in each of these settings are key to creating the motivation and commitment needed for student success as well as developing local interest. The combination of classroom and professional development work, innovative curriculum materials, and community involvement creates an intervention that can significantly transform the peer culture, even in the face of negative forces.
The Algebra Project has developed a cohort model that we predict will stimulate and enable students to pass the state and district mandated tests in mathematics, to pass the mathematics portions of any graduation test, and to score well enough on the SAT or ACT to enter college, and to place into mathematics courses for college credit (not remedial courses). Building on previous awards, the project will continue to research and develop the cohort model, and will create a small network of cohorts to establish that our model can be widely successful.

Intellectual merit: This project will demonstrate how students entering high school performing in the bottom quartile nationally and state-wide can be prepared for college-level mathematics, using lessons learned from many years of past experience working in such communities and in their middle schools, and more recently in their high schools and in collaboration with university mathematicians. The research results are critical to the nation's learning how to improve mathematics achievement for all children – to gaining a sense of what such a program "looks and feels like", and what resources and commitments are required, from which institutions.

Broader impact: The results of this discovery research project will advance understanding of how to improve mathematics learning and achievement in low performing districts, so students are prepared to take college mathematics without repeating high school mathematics in early college. It will also demonstrate the resources and commitments needed to reach this result.

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The GENomics Inquiry through Qualitative Trait Loci Exploration with SAIL Technology (GENIQUEST): Bringing STEM Data to High School Classrooms

Grant #	0733264
NSF Program	NSF
PI	Janice Mokros
Co-PI(s)	Stephen Bannasch, Jon R. Geiger
Institution	Maine Mathematics and Science Alliance
NSF Program Manager	David Hanych
Grade Level Band	High School
Target Audience	Students, Inservice
STEM Content Area	Science, Technology, Mathematics
Deliverables	Software, Teacher Guide/Curriculum

This exploratory project focuses on bringing genomics and computational biology to high school students. The platform for this work is an innovative software prototype based on work by Concord Consortium and further developed by Jackson Labs (JAX). The project introduces students to genetics, Quantitative Trait Loci (QTL) analysis, and the relationship between phenotypes and genotypes. It involves virtual breeding of dragons and drakes (small dragons, which serve as a model organism), allowing students to breed animals inside a virtual computer-generated world to answer genetic questions. Students learn to use Genome Browsers to explore target genomic regions for potential genes of interest. Ultimately, students are guided through a search for the genetic cause of a disease. The goal of the project is to understand how new work in genomics can be incorporated into the high school biology curriculum.

Helping students understand genomics also entails developing material for teachers that enable them to incorporate new content into their honors and AP Biology courses. The project developed a teacher guide and professional development sessions for teachers, and field tested these materials in several Maine classrooms. The classroom implementation work with teachers and students, led by the Maine Mathematics and Science Alliance, enabled us to understand the contexts in which the innovative materials produced by the project could be used in a variety of classrooms. Six teachers used the materials in a total of 13 classes, including 11 AP Biology Classes and two honors classes. Over 160 students participated in the field test, with a median of 7 hours of classroom time spent on GENIQUEST by these students.

Analysis of the field test, currently underway, reveals the following preliminary findings: 1) The program is not only very relevant to the AP curriculum, but is also a good match with honors Biology programs; 2) Students developed a solid understanding of connections between genotype and phenotype, and learned the manner in which an inbred strain is created. They also developed a better understanding of pedigree charts and how they are used in genomics research and applications; 3) The findings with respect to QTL analysis are mixed: Understanding QTL representations was difficult for students, particularly the notion of thresholds. Many students had a beginning but not yet a solid understanding of the meaning of these graphs.

We are exploring dissemination of the program through the Maine Laptop Initiative, which would provide free access to GENIQUEST for all schools participating in this program (which provides laptops and a standard set of instructional materials to all high schools that enroll). The GENIQUEST project has resulted in a new DR-K-12 project, led by Concord Consortium and involving an expanded group of collaborators.

The Inquiry Project

Grant #	0628245
NSF Program	IMD
PI	Susan Doubler
Co-PI(s)	Jodi Asbell-Clarke, David Carraher, Roger Tobin
Institution	TERC
NSF Program Manager	Janice Earle
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	See the website: inquiryproject.terc.edu

TERC and Tufts University are developing a learning progression in scientific inquiry about the nature of matter to prepare students in grades 3–5 for the ideas, concepts, representational forms, and habits of mind considered foundational for learning about the atomic-molecular theory of matter in middle school. The project has developed measures and is assessing students' understanding of volume (length and area), mass (and weight), density, matter and material kind, constancy and variation under transformations, and proportional reasoning (including intensive quantities).

On the basis of the current and prior research, the project is producing a coherent set of curricular, professional development materials, and formative assessment measures to support the adoption of the learning progression in classrooms from grades 3–5. The project's close collaboration with scientists and urban schools, and the intertwining of research and curriculum development play crucial roles in creating the inquiry-based learning environments that lie at the heart of the present approach.

The inquiry-based activities are designed to (a) build on children's existing ideas, (b) help children to first develop robust macroscopic understanding of matter, (c) support children's qualitative reasoning as well as reasoning with metrics, and their use of mathematical representations (number lines, tables, graphs, and linear notation) to enrich their science understanding, (d) engage children early on in devising, comparing, and assimilating models, and (e) promote meta-conceptual awareness and epistemologies of mediation as alternatives to naïve realism.

Three themes weave throughout the work: (1) Measurement and modeling: Students are encouraged to distinguish, order, and measure physical quantities (such as weight and volume) and relate these quantities to each other in consonance with their emerging models of matter; (2) Change and conservation: Students deepen their understanding of matter and materials through investigations of constancy and change when matter is reshaped, divided, mixed, and so forth. Through investigations students identity and differentiate key quantities, learn to measure them and conceive of them as variables bearing theoretical meaning in their emerging models of matter; (3) Scale: Students extend their intuitions about, and willingness to draw inferences regarding, phenomena occurring at various ranges along scales (and at various orders of magnitude)—including ranges for which direct perceptual judgment is not possible.

The Inquiry Project includes a range of activities, the most important of which are (1) the elaboration and refinement of the learning progressions model so as to include mathematical as well as scientific understanding; (2) the planning and execution of a 2.5-year longitudinal study of treatment and control subjects, using 10 key assessment tasks as repeated measures, classroom observations, and out-of-class interviews for clarifying student understanding and approaches to selected topics; (3) the creation of Instructional materials for grades 3-5 along with embedded formative assessments; and (4) teacher professional development that uses formative assessment as a window for helping practitioners to further their own understanding of science and promote that of their students. The project seeks to integrate the above aspects of its work components into a framework that will broadly serve the science education community.

The NextBio Project: A Student Collaboratory for Biology Cyberlearning

Grant #	0918642
NSF Program	NSF
PI	Frieda Reichsman
Co-PI(s)	Chad Dorsey
Institution	The Concord Consortium
NSF Program Manager	David Hanych
Grade Level Band	High School
Target Audience	Students
STEM Content Area	Science, Technology
Deliverables	Interactive online collaboration space for biology learning

The NextBio project aims to address diverse populations of biology teachers and students at the high school level. The NextBio project responds to the need for students to understand the experimental basis behind biology concepts, and to the exponential increases occurring in biology knowledge today. NextBio will study the feasibility of engaging students in an environment where they can learn firsthand how science knowledge develops in the rapidly changing biology fields of bioinformatics and DNA science by performing collaborative, simulated experiments to solve open-ended problems.

Through learning modules and extended scenarios involving populations of mythical dragons, students will manipulate models and simulations to learn about the core biological concepts behind key experimental methods of bioinformatics and DNA science, and to learn about the methods themselves. Students will apply these methods to study quandaries and maladies within the dragon population, collaborating to share knowledge and results as they combine the results from multiple experimental methods. By publishing short summaries of results and debating others' findings and methods, students will learn important biology knowledge by participating in scientific investigation. The NextBio project will research students' learning about biology concepts, their integration of biology knowledge, their skill at scientific argumentation and their knowledge of the process of science. The NextBio project will also study the conditions that enable teachers to implement this cyberlearning environment effectively into the classroom.

The Role of Educative Curriculum Materials in Supporting Science Teaching Practices with English Language Learners

Grant #	0822119
NSF Program	NSF
PI	Jacqueline Barber
Co-PI(s)	Marco A. Bravo, Jonna Kulikowich, Gina N. Cervetti
Institution	Lawrence Hall of Science; University of California, Berkeley
NSF Program Manager	Julio Lopez Ferrao
Grade Level Band	PreK
Target Audience	Students, Inservice
STEM Content Area	Science
Deliverables	Two Technical Reports

The Science Educative Materials Innovation for Language Learner Achievement (SEMILLA) project aims to (1) determine whether curriculum materials that are designed to support teacher learning, as well as student learning (known as educative curriculum materials) have positive impacts on teacher knowledge, attitudes, and instructional practices, and if so, which educative elements teachers value and use most; (2) determine to what degree educative curriculum materials help teachers who have more and less experience teaching English language learners and how the level of teaching experience relates to teacher knowledge, attitudes, and instructional practices; (3) determine the effects of the educative curriculum elements in high implementation settings on ELL students' knowledge and attitudes in science, and developing English proficiency; and (4) create and disseminate a technical report that characterizes the profile of educative features that were demonstrated to be most powerful in assisting teachers in meeting the needs of English language learners.

The instantiation of educative curriculum materials used will be a fifth grade curriculum unit from the NSF-funded Seeds of Science/Roots of Reading program for Grades 2-5, jointly developed by the University of California, Berkeley's Lawrence Hall of Science and Graduate School of Education. Built into the Seeds of Science/Roots of Reading teacher's guides are just-in-time educative features, designed to support teacher learning.

This study will proceed in two phases. The goal of Phase One is to provide an opportunity to strengthen student measures, to give 60 teachers an opportunity to gain experience in implementing the unit and using the educative curriculum elements, and to allow program researchers to identify the highest implementation settings for a more focused study. In Phase Two, we will focus the study on 20 teachers who were high implementers of the educative curriculum elements in order to answer our questions about whether and how educative curriculum materials can support teachers in meeting the instructional needs of English language learners. Data will be analyzed using quantitative and qualitative approaches, including growth curve analysis and grounded theory.

The Scientific Thinker Project: A Study of Teaching and Learning Concepts of Evidence and Nature of Scientific Evidence in Elementary School

Grant #	0918533
NSF Program	NSF
PI	Susan A. Kirch
Co-PI(s)	Catherine Milne, Anna Stetsenko
Institution	New York University
NSF Program Manager	Joseph Reed
Grade Level Band	PreK
Target Audience	Students
STEM Content Area	Science
Deliverables	experimental curricula, books, papers

Current curriculum materials for elementary science students and teachers fail to provoke the following essential questions during science instruction: What is evidence? Why do you need evidence? The goal of this study is to identify whether and how elementary school students formulate answers to these questions and develop concepts of evidence and understandings of the nature of scientific evidence. By studying the teaching and learning concepts of scientific evidence, we can also investigate this approach as a means to improve the school science education experience of students in grades 3-4. Using a design-based research approach, we will study the promise of curriculum modules that feature contemporary issues, methods and ways of thinking in science. The modules will be based on three principles of teaching and learning derived from Activity Theory: (1) the object of learning should be related to the everyday knowledge and interests of schoolchildren, (2) learning outcomes depend on providing the students with tools for theoretical (conceptually based) generalizations which allow students to orient in a systemic way in the studied subject, and (3) elementary school students can master theoretical concepts if these are provided within a context where their practical relevance is revealed – including the origins and the applications of concepts in meaningful human activities.

Two test modules are being developed to study strategies for teaching and learning about scientific evidence. The first proposed module, Debate of 2000-year-old Seed and the Challenge of Storing Seeds, is based on the efforts of international conservationists, farmers, and botanists working together to save and store seeds. Students will learn about experiments to study seed viability and longevity and develop plans for collecting and storing seeds in human-made seed banks. The second proposed module, Pollination crisis! The Missing Honeybee Mystery, is based on recent work related to Colony Collapse Disorder and focuses on studies of observations, evidence and arguments among apiarists, entomologists, citizens, and specialists. It builds on the concepts of development and ecological interactions introduced in the seed storage module and supports students as scientists enlisted in proposing explanations for the phenomena of commercial stock honeybee disappearance.

We are using a design-based research model – cycling between intentional intervention and analysis. The project team will work closely with teachers and participating students to analyze data throughout the development process in order to: revise the materials, improve the experiences for participants in the project, and further develop theories of evidence. To monitor whether the instructional intervention used for the research program is functioning at the level of operation, a series of observational, survey and qualitative assessments will be used to address the usability of the materials and ensure that the barriers to student learning are not a product of poorly designed tools for learning. To determine whether the intervention is meeting the intended learning outcomes for students we will examine: (a) understanding of evidence concepts (b) problem-solving performance, (c) understandings of scientific and personal worldviews, and (d) science content learning in the areas covered by the Scientific Thinker Modules.

ThEMaTe: Thought Experiments in Mathematics Teaching

Grant #	0353285
NSF Program	TPC
PI	Patricio Herbst
Co-PI(s)	David Chazan
Institution	University of Michigan, Ann Arbor
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Preservice, Inservice
STEM Content Area	Mathematics
Deliverables	Research articles, conference proceedings, IT resources

This five-year research project focuses on secondary mathematics teachers of algebra and geometry. We seek to understand the practical rationality that undergirds teachers' actions as they meet subject-specific goals of the teaching of algebra and geometry. A central aspect of the study is the development of a collection of representations of teaching that showcase possible classroom episodes and allows practitioners to ponder alternatives in teaching. The representations are built on computer animations and other forms of sequential art that permit to display action over time. The construction of those representations is informed by theoretical models that describe the customary ways in which algebra and geometry instruction is organized to fulfill specific curricular obligations such as engaging students in proving or in solving equations. Representations showcase both stories that follow those models and stories that depart from (or breach) those models. Hypotheses are developed that predict how practitioners may react to those breaches. The representations are used in study groups (four parallel study groups meeting over two years, each of size greater than five and fewer than ten participants and including expert teachers of algebra or of geometry) and summer academies for teachers (two cohorts of intensive 10-day workshops for 4 groups of 10 teachers each). The representations are meant to create an immersive context for conversations among practitioners and about practice. Discourse produced by practitioners looking at and reacting to those representations provides the data for the study. In particular, data is to respond to the questions of why practitioners perceive some classroom episodes less viable than others, which is expected to inform instructional improvement. Discourse and multimedia analysis methods are used to make sense of the conversations and of the interactions between practitioners and representations.

Thinking with Data: A Cross-Disciplinary Approach

Grant #	0628122
NSF Program	IMD
PI	Dale Cook
Co-PI(s)	Phil Vahey, Karen Swan
Institution	Kent State University
NSF Program Manager	Robert Gibbs
Grade Level Band	Middle School
Target Audience	Students, Inservice
STEM Content Area	Science, Mathematics
Deliverables	Instructional Materials

Thinking with Data: A Cross Disciplinary Approach (TWD) will create four two-week, integrated replacement modules for cross-disciplinary implementation in seventh-grade social studies, mathematics, science, and English Language arts classes designed to develop students' deep understanding of data literacy across the curriculum. Building on findings from a TWD pilot project (REC-0337384), the modules will similarly address issues of data representation, common measure, and proportional reasoning using real data in discipline specific problem-solving contexts aligned with relevant subject area standards.

The context for the Thinking with Data materials is a compelling one: world water issues. Specifically, materials will be designed around students' investigations of fair distribution of water in the Tigris/Euphrates basin. In Social Studies, students will use available data to explore water availability and usage in Turkey, Syria, and Iraq, and try to devise fair ways of sharing and conserving available water. In Mathematics, they will learn techniques of proportional reasoning and data analysis to expand on their Social Studies work and to develop data-based arguments for fair use. In Science, they will learn about the science behind water issues in the Tigris/Euphrates basin, beginning with how the water cycle manifests itself in the region, and how ditch irrigation contributes to soil salinity. Students will then explore water issues in six US watersheds. In English Language Arts, students will develop reports on these issues and present possible solutions to them as persuasive arguments, in multimedia formats and supported by data-based evidence, and present these to a larger audience.

The TWD unit will be grounded in a Preparation for Future Learning (PFL; Bransford & Schwartz, 1999) pedagogical approach. It investigates how preparing students to learn can occur in one curricular context (Social Studies) with the learning activity occurring in another (Mathematics). The project further explores extending the PFL approach to include applications and communications activities in still other curricular contexts (Science/English Language Arts). If PFL is found to be effective in these conditions, and if the processes of this effectiveness are uncovered, it will dramatically strengthen the plausibility of claims that PFL uncovers a general mechanism of transfer. Findings will also advance the field's understanding of how mathematics and science can be meaningfully integrated throughout the curriculum.

The TWD materials produced will make use of appropriate technology tools and include detailed lessons and activities, relevant data sets, embedded formative and summative assessments, and teacher professional development materials. They will be pilot- and field-tested with intact student and teacher 7th grade teams from middle schools in northeastern Ohio.

This project uses authentic school settings to promote the teaching and learning of data literacy, a critical skill in our data- and technology-rich society. This project will provide a scientific basis for conducting school-based data literacy activities that cut across disciplines. It will contribute to a future in which the importance of teaching data literacy is recognized as critically important, providing a model for cross-curricular data-literacy activities. By reevaluating the overall curriculum structure, policy makers can enhance STEM education and increase the range of students both interested in and capable of analyzing data as a basis for thinking about societal issues.

Tool Systems to Support Progress toward Expert-Like Teaching by Early Career Science Educators

Grant #	0822016
NSF Program	NSF
PI	Mark Windschitl
Co-PI(s)	Jessica Thompson
Institution	University of Washington
NSF Program Manager	Julio Lopez-Ferrao
Grade Level Band	Middle School, High School
Target Audience	Preservice, Inservice, Policy Makers
STEM Content Area	Science
Deliverables	Research Findings, System of Tools

The goals of this project are to develop and study a system of tools and tool-based practices for early career and pre-service secondary science teachers that support transitions from novice to expert-like pedagogical reasoning and practice. These expert-like capabilities are characterized by being able to (1) shape instruction around the most fundamentally important science ideas commonly found in curricula, (2) scaffold student thinking in ways that intentionally couple classroom activity with a deep understanding of content,(3) press students through classroom discourse and tasks to construct evidence-based explanations for important scientific phenomena, (4) facilitate evidence-based reasoning in students through rigorous forms of inquiry in which they engage in the development, testing, revision, and application of scientific models, and, (5) adapt instruction for English language learners and students of a range of abilities.

We have developed prototypes of three inter-related tools/tool sets which will be iteratively tested and refined with cohorts of beginning teachers over three years. The first is a learning progression for teachers specifying how they can support content-rich activity for students within the context of model-based inquiry (MBI). The second is a set of discourse tools that scaffold complex classroom conversations within the context of MBI. Because the discourses above depend upon teachers' awareness of students' current thinking, they are coupled with a supportive tool-based assessment strategy we refer to as Rapid Surveys of Student Thinking (RSST). The third part of this system of tools involves longer-term systematic analyses of students' work (SASW) around specific skills such as evidence-based explanation. This practice involves collecting samples of student work, from pupils of a range of abilities and from English language learners over a period of weeks, then identifying data-based trends in student understanding.

After analysis, the pupil artifacts are then used by participants in a Critical Friends Group (CFG) setting to consider with colleagues how their instructional decisions influenced these trends and how changes in teaching practices could impact achievement for all students. These three tools sets are mutually reinforcing. For example, preservice or early career teachers will be able to use the learning progression to identify at what level of effectiveness they are engaging their students in inquiry, and what might characterize the "next level" of sophistication in practice. To attempt this advance in practice, they would not only use the description of specific teaching practices in the learning progression to plan, but also would use one or more of the discourse tools to enact classrooms conversations that would push student thinking in accordance with the learning progression goals. The RSST practice would guide day-to-day decisions about which discourses and tasks to employ. To assess the long-term influence of instruction on different types of learners, participants would use the systemic assessment of student work. This would provide evidence-based feedback of student learning and help participants identify which groups of student are not being served well through current instruction.

Toward a Scalable Model of Mathematics Professional Development: A Field Study of Preparing Facilitators to Implement the Problem-Solving Cycle

Grant #	0732212
NSF Program	NSF
PI	Jennifer Jacobs
Co-PI(s)	Hilda Borko, Karen Koellner, Ed Wiley
Institution	University of Colorado at Boulder
NSF Program Manager	Karen Marrongelle
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Mathematics
Deliverables	Year 1 Annual Report

The proposed study is an effort to bring the Problem-Solving Cycle model of mathematics professional development to scale by fostering the facilitation skills of middle school mathematics instructional leaders (ILs). The study includes two and a half years of preparation and support for all the ILs within a large urban school district with a substantial minority student enrollment, who in turn will implement the PSC with the mathematics teachers in their schools. Researchers will analyze the preparation and support that ILs need, the quality of their implementation, and the impact of the professional development process on ILs, teachers, and students.

Transition to Algebra: A Habits of Mind Approach

Grant #	DRL-0917958
NSF Program	NSF
PI	E. Paul Goldenberg
Co-PI(s)	June Mark, Deborah Spencer
Institution	EDC
NSF Program Manager	Jim Fey
Grade Level Band	High School
Target Audience	Students, Students - Special Population
STEM Content Area	Mathematics
Deliverables	Curriculum materials

Transition to Algebra: A Habits-of-Mind Approach is a four-year research and development project that will provide resources for 9th grade mathematics students and teachers by developing, piloting, and field-testing intervention modules designed as supplementary materials for Algebra 1 classes (e.g., double-period algebra). Rather than developing isolated skills and reviewing particular topics, these materials aim to foster the development of mathematical habits of mind—in particular, the algebraic habit of abstracting from calculations, a key unifying idea in the transition from arithmetic to algebra. This algebraic habit of mind connects a disparate collection of algebraic topics: solving word problems, working with rational numbers, graphing equations, reasoning about proportions. The goal of the proposed project is to develop feasible instructional modules that make double-period Algebra 1 classes substantially more effective by enabling more students to make the transition from arithmetic to algebra and become increasingly competent and confident in their algebraic work. The Transition to Algebra materials will be designed in a modular format to allow some flexibility in their use; taken together, the modules would constitute a yearlong curriculum for a one-period class designed to supplement a regularly-scheduled Algebra 1 class. Each module will include student materials and a teacher guide.

Undergraduate Science Course Reform Serving Pre-service Teachers: Evaluation of a Faculty Professional Development Model

Grant #	0554594
NSF Program	TPC
PI	Dennis Sunal
Co-PI(s)	Cheryl Mason, Cynthia Sunal, Dean Zollman
Institution	University of Alabama
NSF Program Manager	Terry Woodin
Grade Level Band	Post Secondary
Target Audience	Higher Education
STEM Content Area	Science
Deliverables	http://nseus.org

This project focuses on critical needs in the preparation and long-term development of pre-service, undergraduate, K-6 teachers of science. The project focus is on 1) short-term impact of entry level undergraduate science courses on all students and 2) long-term impact on in-service K-6 teachers of science who graduated from these courses. The goal is to investigate the impact on students of undergraduate, standards-based, reform entry level science courses developed by faculty during participation in the NASA Opportunities for Visionary Academics (NOVA) professional development program.

Thirty reform and 30 comparison undergraduate science courses from a national population of 103 diverse institutions, stratified by institutional type, were being selected and compared in a professional development impact design model. Data is being collected using multiple quantitative and qualitative instruments and analyzed using comparative and relational studies at multiple points. Research questions to be explored include: 1) determination of short-term course learning outcomes on all undergraduate students and long-term effects on graduated in-service K-6 teachers in their own classroom science teaching, 2) identification of characteristics of undergraduate science courses that produce significantly greater than expected learning outcomes, and 3) identification of characteristics of effective faculty as related to significant short and long term learning outcomes in undergraduate students and in effective in-service K-6 teachers of science..

The intellectual merit of the project evolves from the large sample of reformed courses available for study, all based on the same extensive longitudinal professional development model. The study advances understanding of effective faculty professional development and of the characteristics of entry undergraduate science courses that can impact undergraduate student learning outcomes and the subject matter and pedagogical content knowledge of in-service K-6 teachers of science. The broader impacts of the project stem from the diversity of the student populations and variety of the institutions involved in the study. The population from which the study sample is drawn consists of over 30% minority institutions, is geographically diverse, and is representative of the variety of teacher preparation institutions. The study is advancing the teaching, training and learning of undergraduate science faculty and their students at the 30 institutions directly involved and, more broadly, at a national network of institutions.

Understanding Science -- Improving Achievement of Middle School Students Through Content-Rich Professional Development Grounded in Classroom Practice

Grant #	0455856
NSF Program	TPC
PI	Steven Schneider
Co-PI(s)	
Institution	WestEd
NSF Program Manager	Lopez-Ferrao
Grade Level Band	Middle School
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Books

The fundamental goal of this three-year project is to improve the science achievement of middle school students, especially English learners and students with poor literacy skills, by building the content knowledge and pedagogical content knowledge (PCK) of their teachers. This work helps teachers, beginning to veteran, help their students make sense of science in ways that lead to a deeper, more connected, conceptual understanding of science. Two Understanding Science courses for grade 6-8 teachers will be nationally field-tested, published by Heinemann, and address challenging physical science topics and important pedagogical themes:
• Force and motion, focusing on teaching English Learners
• Energy and chemical change, focusing on literacy

This work builds on our existing elementary courses designed to help teachers learn major concepts of science, examine how children make sense of those concepts, and analyze and improve their teaching. Based on comparative studies, the elementary courses have a “track record” showing greater student achievement gains and measurable teacher outcomes such as increased science content knowledge and more sophisticated PCK (Heller & Kaskowitz, 2004).

Intellectual merit: Innovation lies in developing PD resources that knit together science, student thinking and instruction in a coherent, connected way that builds teachers’ PCK. Research will generate new knowledge about materials and methods fostering the development of teachers’ PCK in science.

Broader impact: Greater potential for nation-wide gains in middle school students’ science achievement, resulting from widely available, low-cost PD resources that enhance middle school teachers’ science content knowledge and improve their teaching practices.

Universal BioMusic Education Achievement Tier in Science (Universal BEATS)

Grant #	0733180
NSF Program	NSF
PI	Patricia Gray
Co-PI(s)	David Teachout, Eric Wiebe, Sarah Carrier
Institution	University of North Carolina Greensboro
NSF Program Manager	David Hanych
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Curricula, Support Materials, Dissemination

Universal BioMusic Education Achievement Tier in Science (Universal BEATS aka UBEATS) is a two-and-a-half-year project to develop, pilot, and refine four BioMusic instructional modules that enable students in grades two through five to explore the emerging interdisciplinary field of BioMusic. In this project, the Kenan Fellows Program (KFP) model is being utilized so four Kenan Fellows—two BioMusic teams each with a music specialist teacher and a science specialist teacher—are mentored by the four PIs—two music education faculty and two science education faculty—and five internationally known BioMusic scientists, to develop, pilot, and refine the curricular materials. Many “big ideas” in science are most often outgrowths of cross-disciplinary, creative thinking that draw on multimodality in learning and action. Consequently, tapping awareness of the sonic world and its impact on all life holds great promise as an approach to educating elementary-aged students.

The central aims of this project are to develop materials that (1) engage children’s instinctive musical abilities and their curiosities about the natural world; (2) reflect solid linkages between standards-based science and music content and align those with process and content standards; and (3) enable teachers to break through traditional divides between the teaching of science and discipline-based music through blended content and pedagogical activities.

In January of 2008, the PIs engaged in a rigorous recruitment process to identify two BioMusic teams, each with a music specialist teacher and a science specialist teacher. In summer of 2008, the BioMusic teams attended a six-week intensive professional development workshop, including a two-week residential workshop at NC State University in which participants joined a new class of other selected Kenan Fellows. The remaining four summer weeks were devoted to working virtually and face to face with the PIs and Virtual Science Mentors to develop modules using standards-based strategies through which classroom teachers would be able to integrate BioMusic concepts and methods into their teaching.

Beginning fall of 2008, preliminary materials have been incorporated into the classrooms of the BioMusic teachers. Data are being collected on the team members’ attitudes regarding the challenges and benefits associated with module development as well as on needed adjustments to the modules as they are being implemented initially.

Module materials continued to be field tested and refined throughout the fall of 2008 and spring of 2009. In summer 2009 the BioMusic teams were joined by 22 invited classroom teachers and 25 elementary grade students to participate in a week-long institute during which the new UBEATS Teacher Cohort was introduced to the modules with the participating children. The UBEATS Teacher Cohort will use the UBEATS modules in their classrooms during AY09/10 to extend the ideas and methodologies developed in the first year. The materials will be implemented in an expanded number of classrooms and data will be collected from all teachers to further refine knowledge about barriers to and incentives for the use of BioMusic modules, and from students to document attitude and achievement trends.

By the end of the 2009-2010 academic year, it is anticipated that the BioMusic modules will be ready for wide-range distribution.

Universal Design of Inquiry-Based Middle and High School Science Curricula (Collaborative Research - Miller)

Grant #	0730603
NSF Program	NSF
PI	Jacqueline Miller
Co-PI(s)	June Foster
Institution	Education Development Center, Inc.
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Students - Special Population
STEM Content Area	Science
Deliverables	Prototype of UDL Curriculum

Education Development Center, Inc. (EDC), the University of Michigan (UM), and the Center for Applied Special Technology (CAST) are in the second year of a four-year collaboration to improve science education through the application of Universal Design for Learning (UDL) to the Foundation Science and IQWEST curricula. Through the UDL framework and the flexibility afforded by digital technology, the curricula will accommodate a wide range of student needs, broadening the participation of diverse learners (including those with and without learning disabilities) in science and supporting them as they learn science content, engage in scientific practices, and develop scientific literacy. The Collaborative Team is developing

- a Web-based Universal Design for Learning Inquiry Science System (ISS), a software system that curriculum developers can use to digitally customize inquiry-based science curricula to incorporate UDL features
- UDL Design Heuristics for Universal Design for Science
- UDL Exemplar Units in physical and life sciences that illustrate the application of the UDL ISS to inquiry-based curricula and the benefits of the resulting curricula to middle and high school students with and without learning disabilities.

The collaborative is iteratively designing, developing, and formatively evaluating the design and technologies necessary to create UDL versions of curricula. The project is applying the design and technologies to the biology and chemistry curricula for sixth grade and high school students and conducting user and pilot tests followed by a summative evaluation to determine impact on student learning.

The project will expand and improve the achievement of underserved and often marginalized students, and will provide information about what contributes to their success in learning science. Design heuristics, curriculum exemplars, and the ISS will enable curriculum developers to apply what is learned in this project to other materials in an efficient and cost-effective manner, and will open many research opportunities from this foundational work. In addition, the project will provide early examples of National Instructional Materials Accessibility Standards-aligned materials.

Universal Design of Inquiry-Based Middle and High School Science Curricula (Collaborative Research - Rose)

Grant #	0730260
NSF Program	NSF
PI	David Rose
Co-PI(s)	Boris Goldowsky
Institution	Center for Applied Special Technology
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School
Target Audience	Students, Other
STEM Content Area	Science
Deliverables	exemplars, authoring system, guidelines

Federal Legislation has raised the expectations for students with disabilities within the general curriculum and assessment systems. Science education faces increased accountability for raising science achievement for a much more diverse population, while increasing the emphasis on learning that integrates higher-order thinking skills with content knowledge. Active science learning requires students to develop and use a number of complex skills including reading, observing, collecting and analyzing information, drawing conclusions and presenting findings. The principles of Universal Design for Learning (UDL) provide the flexibility of representation and the support of multiple means of expression and engagement to address this need. The Center for Applied Special Technologies (CAST) has pioneered the development of technology to differentiate instruction, mainly in literacy, for students with a wide range of abilities and disabilities. The University of Michigan and Education Development Centers are developing and testing comprehensive science curricula for the middle school and high school, respectively. They bring their joint expertise together to create heuristics for universally designed science materials for middle and high school instructional materials; to build an open source UDL Inquiry Science System (ISS) that enables science curricula to be transformed into digitally supported versions that incorporate UDL features; and to use the ISS to produce four UDL exemplars of chemistry and biology units from tested instructional materials and to evaluate the benefits of these exemplars for middle and high school students with and without learning disabilities. These materials support the development of the National Instructional Materials Accessibility Standards (NIMAS).

Universal Design of Inquiry-Based Middle and High School Science Curriculum (Collaborative Research - Sutherland)

Grant #	0730348
NSF Program	NSF
PI	LeeAnn M. Sutherland
Co-PI(s)	Joseph S. Krajcik
Institution	University of Michigan (Collaborative Research with EDC and CAST)
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School
Target Audience	Students, Students - Special Population
STEM Content Area	Science
Deliverables	Digital UDL curriculum materials

The University of Michigan (UM), Education Development Center, Inc. (EDC), and the Center for Applied Special Technology (CAST) are beginning the third year of a four-year collaboration to improve science education through the application of Universal Design for Learning (UDL) principles to inquiry- and project-based science curricula. The project aims to expand and improve the achievement of underserved and often marginalized students, including those with learning disabilities (LD) and struggling readers, and to optimize their opportunities to learn science. Beginning with NSF-supported materials from the middle school IQWST project (Investigating and Questioning our World through Science and Technology, UM) and the high school Foundation Science project (EDC), the collaborative is enhancing existing materials, in physical and life sciences, to accommodate a broad range of student needs and preferences. The project leverages the affordances of technology (e.g., immediate access to multiple representations such as interactive diagrams and simulations) to support students as they learn science content, engage in scientific practices, and improve their scientific literacy.

Using a framework based on each institution's own design principles, as well as new principles that result from the collaborative effort, the project will produce digital exemplars as well as tools and supports others can use to enhance existing materials or to develop new materials. In the latter instance, UDL can more readily become part of the fabric of materials design rather than a retroactive application. Deliverables include:

• a Web-based Inquiry Science System (ISS), a software system for digitally customizing inquiry-based curricula to incorporate UDL features
• design guidelines for applying UDL in science materials
• exemplar units that instantiate the guidelines and illustrate the application of UDL to inquiry-based curricula
• evaluation and research data that illustrate the impact of UDL features on student interest, engagement, motivation, and learning of science content

The collaborative is iteratively designing, developing, and evaluating the design and technologies necessary to create UDL versions of curricula. User-testing with teachers and students, pilot testing in classrooms, and summative evaluation of the impact on learning will inform the field as to which features and practices most contribute to students' success in learning science. User-testing with students has informed the first phases of materials revision; subsequent pilot-testing in classrooms will occur in the fall of 2009. Dissemination of project deliverables will enable others to apply what is learned in this project to new or existing materials in an efficient and cost-effective manner. Although the focus of this project is on students with learning disabilities, once deliverables are disseminated, research on other subpopulations will be far more cost efficient. In addition, the project will provide early examples of National Instructional Materials Accessibility Standards-aligned (NIMAS) materials.

Untangling Mathematical KnoTSS (Knowledge for Teaching Secondary School): An Investigation of Collaborations Between Mathematicians and Mathematics Educators

Grant #	0821996
NSF Program	NSF
PI	Rebecca McGraw
Co-PI(s)	Gladis Kersaint, Anderson Norton, Saad El-Zanati, William McCallum, Denise Mewborn
Institution	University of Arizona
NSF Program Manager	Karen Marongelle
Grade Level Band	Post Secondary
Target Audience	Higher Education
STEM Content Area	Mathematics
Deliverables	knowledge about teacher preparation

The KnoTSS project examine the nature and process of collaborations between mathematicians and mathematics teacher educators engaged in the preparation of secondary mathematics teachers. KnoTSS addresses a critical problem facing teacher education today – the persistent separation of subject matter knowledge development from the development of pedagogical knowledge. This problem is exacerbated by a lack of knowledge about how disciplinary specialists (e.g., mathematicians) and teacher educators can work together effectively to improve teacher education. Today, collaborative work is proceeding idiosyncratically in pockets across the U.S. When success is achieved, it is not reproducible and therefore cannot lead to systemic change. KnoTSS examines the work of teams of mathematicians and educators who co-teach two courses (one mathematics course and one methods of teaching mathematics course) aimed at building integrated knowledge of content and pedagogy. KnoTSS research questions include questions:

1)How do collaborations develop and evolve? How can they be fostered within institutions?
2)What is the intellectual terrain co-created and traversed by collaborators? How do they negotiate its boundaries? How do they position themselves with respect to it and to each other?

Underlying the proposed study is a sociocultural perspective on learning (Vygotsky, 1981; Wertsch, 1985; 1998) whereby an academic discipline is viewed as a set of theories, texts, and methods, and also as a community of individuals with particular social practices and styles of discourse (Lattuca, 2002). Thus, the proposed research investigates how participants are situated within their respective disciplines, how the disciplines are situated within institutions, and how the disciplines are situated with respect to one another. The research considers the historical contexts of these interrelationships. Data collection and analysis focuses on the interactions among team members, the development of shared discourses and practices, the appropriation and transformation of tools drawn from the disciplines of mathematics and education, and the influence of these factors on the education of future mathematics teachers. Each team in KnoTSS forms a case and qualitative case-study methodologies are used to investigate the research questions.

Using Practice as a Site to Learning Mathematics for Teaching: Developing Materials, Approaches and Professional Community

Grant #	0455828
NSF Program	TPC
PI	Hyman Bass
Co-PI(s)	Kara Suzuka, Deborah Ball
Institution	University of Michigan
NSF Program Manager	Royster
Grade Level Band	PreK
Target Audience	Preservice, Inservice, Higher Education, Other
STEM Content Area	Mathematics
Deliverables	Mathematics teacher development curriculum packages, featuring multimedia classroom records of practice

This project will build two mathematics teacher development curriculum packages for use in the professional education of K-8 teachers of mathematics that focus on the mathematics needed for teaching.

Instead of positing what teachers should know based on the inspection of topics of the school curriculum, viewed from the perspective of disciplinary mathematics, our work over almost the past decade has, instead, examined the actual practice of teaching – a kind of "job analysis" – to understand its mathematical demands and to develop a theory of "mathematical knowledge for teaching." This project builds upon this past theoretical work to provide teacher developers with resources and professional learning opportunities to help them support teachers in developing the mathematical knowledge and skills needed for the work of teaching.

Each package will consist of core materials for use with teachers and prospective teachers and a set of guidance materials that provide teacher developers with resources for adapting and using the materials in their own contexts. The packages will be designed for educational settings such as mathematics content courses for prospective teachers, pre-service teacher education methods courses, and professional workshops or study groups involving practicing teachers. Because we focus on the use of knowledge in practice, the core materials of each package will comprise selections of records of practice (e.g., video segments from classroom lessons, samples of student work, K-8 curriculum materials) and resources for their use (e.g., tasks, assessments, alternative definitions and solutions) that help create opportunities for teachers to work closely on the mathematical ideas and their use in practice, or on specific problems of teaching. Also, each package will contain resources for supporting teacher developers' own learning (e.g., detailed unpacking of special mathematics problems and tasks, "lesson plans" that include notes on likely issues that may arise, difficulties commonly faced for teacher-learners, suggestions for probing learners' thinking and steering discussions).

The packages resulting from this project will be disseminated through several channels. There will be "online," "always on" components of the packages that can be viewed on or downloaded from the internet. We will also explore various options for delivering high quality video and still images for use in professional education contexts – including "physical media" options such as VHS, CDs and DVDs. We are committed to finding and using some combination of delivery options that provides low-cost, high-quality, simple and easy access to teacher developers who work in diverse contexts with access to different levels of technology.

Video Analysis of Science Teaching: Developing a Shared Words-to-images Analytical Tool

Grant #	0957996
NSF Program	NSF
PI	Kathleen Roth
Co-PI(s)	Karen Givvin
Institution	Biological Sciences Curriculum Study (BSCS)
NSF Program Manager	Sharon Lynch
Grade Level Band	PreK
Target Audience	Preservice, Higher Education
STEM Content Area	Science
Deliverables	5 online K-8 science videocase modules

The ViSTA project developed and studied the impact of five online, videocase modules designed to support preservice teacher learning about science content, pedagogical content knowledge, and the skills necessary to learn how to learn from analysis of K-8 science teaching. The modules are intended for use in preservice teacher education program courses and experiences (most commonly, courses about methods of teaching science), and they are used in a combination of face-to-face (delivered by the instructor) and online sessions (homework). Each module targets a key science concept and its supporting ideas, and these concepts are examined in the process of analyzing K-8 videocases of teaching and learning. The concepts fall within the topic areas of electricity, force and motion, photosynthesis, water cycle, and inquiry. Each module presents videos of at least two different teachers so that preservice teachers have the opportunity to analyze different approaches to teaching the same content or to compare teaching of the same content at different grade levels.

The conceptual framework of the modules supports preservice teachers in learning how to learn from analysis of science teaching using two different lenses: the Student Thinking Lens and the Science Content Storyline Lens. Looking at teaching through these lenses challenges preservice teachers to shift their typical focus on classroom activities and student behavior to issues more at the core of effective science teaching. To scaffold preservice teachers' efforts at analyzing teaching through these two lenses, the core of each module is a set of analytical tasks that are embedded in the online software platform. These tasks structure and guide preservice teachers' analysis of the videos and supplementary materials. Through these tasks, preservice teachers learn about and look for different strategies that teachers use to make student thinking visible and to create a coherent science content storyline. The tasks and the instructor's manual encourage interactions among preservice teachers and between them and their instructors. The tasks support preservice teachers in deepening their understanding of science content, developing their knowledge about content-specific teaching strategies (pedagogical content knowledge, or PCK), and assessing student thinking and learning about this content.

In addition to the videocase modules, the project produced knowledge about the effectiveness of this videocase analysis approach in science teacher education. After multiple rounds of pilots and revisions, two of the modules (electricity and plants) were tested in a research study examining pre-post course changes in a ViSTA users group and in a control group. The results showed significantly higher gain scores on science content tests for ViSTA participants (in both electricity and plants modules) compared to the control ($p<.001$). In addition, ViSTA participants showed more growth than control group participants in their analyses of lesson video clips. For example, users of the electricity module focused more attention on science content ($p<.05$), student thinking ($p<01$), and science content storyline ($p<.01$) in their analyses compared to control group participants. For the plants module participants, there were significant group effects for science content ($p<.01$) and student thinking ($p<.05$). In all cases, experimental participants scored higher than control. Further analyses, including HLM, are underway.

The ViSTA project developed and studied the effectiveness of video-based science teacher education curriculum materials. Findings suggest that the materials are effective in producing significant preservice teacher learning gains, both in terms of science content knowledge as well as in the ability to analyze classroom lessons in terms of student thinking.

Videocases for Science Teaching Analysis (ViSTA)

Grant #	ESI-0353474
NSF Program	NSF
PI	Kathleen Roth
Co-PI(s)	Karen Givvin
Institution	Biological Sciences Curriculum Study (BSCS)
NSF Program Manager	Sharon Lynch
Grade Level Band	PreK, Middle School
Target Audience	Preservice
STEM Content Area	Science
Deliverables	5 online K-8 science videocase modules

The ViSTA project developed and studied the impact of five online, videocase modules designed to support preservice teacher learning about science content, pedagogical content knowledge, and the skills necessary to learn how to learn from analysis of K-8 science teaching. The modules are intended for use in preservice teacher education program courses and experiences (most commonly, courses about methods of teaching science), and they are used in a combination of face-to-face (delivered by the instructor) and online sessions (homework). Each module targets a key science concept and its supporting ideas, and these concepts are examined in the context of analyzing K-8 videocases of teaching and learning. The concepts fall within the topic areas of electricity, force and motion, photosynthesis, water cycle, and inquiry. Each module presents videos of at least two different teachers so that preservice teachers have the opportunity to analyze different approaches to teaching the same content or to compare teaching of the same content at different grade levels.

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The ViSTA project developed and studied the effectiveness of video-based science teacher education curriculum materials. Findings suggest that the materials are effective in producing significant preservice teacher learning gains, both in terms of science content knowledge as well as in the ability to analyze classroom lessons in terms of student thinking.

Visualizing to Integrate Science Understanding for All Learners (VISUAL)

Grant #	DRL-0918743
NSF Program	NSF
PI	Marcia C. Linn
Co-PI(s)	
Institution	University of California, Berkeley
NSF Program Manager	Gerhard Salinger
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Students, Inservice, Higher Education
STEM Content Area	Science
Deliverables	activities, assessments, research

VISUAL: VISUALIZING TO INTEGRATE SCIENCE UNDERSTANDING FOR ALL LEARNERS
Marcia C. Linn and Robert Tinker (Concord Consortium)
With Kathy Benemann, Jennie Chiu, Matt Fishbach, Libby Gerard, Lydia Liu (ETS), Kevin McElhaney, Beat Schwendimann, Hiroki Terashima, and Helen Zhang
VISUAL: Visualizing to Integrate Science Understanding for All Learners is a research and development project submitted to DR K-12 that addresses Challenge 1 and 3 by exploring how curriculum and assessment using dynamic, interactive scientific visualizations of complex phenomena can ensure that all students learn significant science content. Dynamic visualizations provide an alternative pathway for students to understand science concepts. This pathway can be exploited to increase the accessibility of a range of important science concepts, particularly ones that involve cause-and-effect and emergent phenomena. Computer technologies offer unprecedented opportunities to design curriculum and assessments using visual technologies and to explore them in research, teaching, and learning.
Intellectual Merit. Visualizations make unseen processes such as chemical reactions visible. They support virtual experiments about complex processes such as global climate change, airbag safety, or home insulation. They can provide multiple perspectives on three-dimensional phenomena such as molecular processes or planetary motion. Research concerning the educational value of dynamic visualizations is contradictory and inconclusive, leaving developers and practitioners in disagreement about whether to use visualizations, how to combine them with hands-on experiments, and how best to design them to exploit their apparent value. A thorough and thoughtful set of experiments is needed to elucidate this area of research. Work in this area needs to be based on evidence of how students process dynamic visual data in order to integrate what they see with what they know. We will create new technologies to assess student interactions with visualizations that are embedded in curriculum materials. These include tools to annotate visualizations and create flipbooks to illustrate ideas. Automatic scoring tools will allow VISUAL to study the impact of varied feedback to teachers and students. VISUAL will conduct research to clarify when, and how to use visualizations and create authoring tools to ensure that designers can add new visualizations and benefit from the findings.
Broader Impacts. VISUAL will strengthen the ability of all students to benefit from science instruction by focusing on physical science topics that often deter students due to their abstraction and complexity. VISUAL research has the potential to make high school Chemistry and Physics courses more accessible and effective. Visualizations can help learners connect symbolic, everyday, and abstract ideas to form a coherent view of science. We will develop criteria, instructional patterns, a teacher visualization dashboard, and specific interventions for using visualizations in online curriculum materials. VISUAL will identify conditions that make visualizations effective for all learners, including those who initially have low spatial skills or limited beliefs about the nature of visualizations. Our research will take place in schools that serve students at risk for failure and identify ways to increase participation and success in physical science courses. We will continue our practice of widely disseminating findings, materials, and open source software through reviewed papers, popular articles, talks, workshops, its website, and newsletters.

Work Contexts, Teacher Learning Opportunities, and Mathematics Achievement of Middle School Students

Grant #	0746936
NSF Program	NSF
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Co-PI(s)	
Institution	University of Missouri
NSF Program Manager	James T. Fey
Grade Level Band	Middle School
Target Audience	Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Mathematics
Deliverables	Not available yet.

Effective learning among mathematics teachers is crucial for making a transition from traditional, teacher-centered instruction to constructivist instruction. However, many mathematics teachers are unable to make this transition due to a lack of learning opportunities provided to them. It is essential to understand how teachers' work contexts hinder or foster learning of mathematics teachers in order to promote instructional improvement among mathematics teachers.

While several case studies have identified teachers' work contexts conducive to effective teacher learning, little is known about how various work contexts influence the quality of teacher learning opportunities, and how these opportunities lead to improvement in student achievement. This project will conduct a statewide survey of 1,047 mathematics teachers and 35,304 students in 6th through 8th grades in 201 middle schools, and case studies of eight middle schools in Missouri to address the following research and educational objectives: 1) examine the nature of mathematics teachers' opportunity to learn for instructional improvement, 2) examine how work contexts influence the quality of teacher learning opportunities, 3) examine the impact of teacher learning opportunities on changes in student mathematics achievement over four years, and 4) work with district and school administrators to promote instructional improvement and student achievement by effectively providing learning opportunities to mathematics teachers.

Intellectual merits of this project are: 1) advancement of our understanding of the relationships among work contexts, teacher learning opportunities, and student mathematic achievement; this will provide critical information for the success of school mathematics reforms, 2) application of multi-level, longitudinal, multivariate analyses of statewide teacher survey data to identify causal relationships among these three factors, and 3) use of a mixed methods approach of statewide survey and case studies; this will produce both generalizable findings and in-depth understanding of the processes in which work contexts create teacher learning opportunities and lead to improved student achievement.

Broader impacts of this project are: 1) dissemination of evidence-based recommendations and facilitation of dialogues on what district and school administrators and professional developers can do to promote learning opportunities for mathematics teachers through partnerships with the state department of education, various centers, and international collaborations, and 2) its impacts on state and district policies and reforms on mathematics teacher learning and quality by providing empirical data on the causal relationships among work contexts, teacher learning opportunities, and student achievement.

The PI proposes integrated research and education activities through working with school leaders to promote evidence-based practices for improving student achievement, and through educating future researchers and K-12 school leaders on how to use rigorous research methods to produce recommendations for effective policy and practices for improving teacher and student learning. This project involves participation of diverse citizens including ethnic minorities and low-income individuals in its research and education activities, which will enhance our knowledgebase on effective practices for all teachers and students.

Worldviews of Exemplary African-American Science Teachers (WEAST)

Grant #	0732173
NSF Program	NSF
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Co-PI(s)	Jianzhong Xu
Institution	Mississippi State University
NSF Program Manager	Julia Clark
Grade Level Band	PreK
Target Audience	Inservice
STEM Content Area	Science
Deliverables	Mentoring Guidelines

The project Worldviews of Exemplary African-American Science Teachers (WEAST) is a three-year study of exemplary African-American elementary science teachers that includes two phases: Phase 1 —identify characteristics of exemplary science teachers about how to better articulate students' cultural knowledge with science disciplines; and Phase 2 — assign beginning elementary science teachers to work with exemplary teachers and to examine the role of mentoring on beginning teachers.

By identifying characteristics of exemplary African-American elementary science teachers and by incorporating them into mentoring beginning science teachers opens a new avenue of theoretical investigation (i.e., linking the identification of characteristics of exemplary science teachers to mentoring beginning science teachers and to addressing the science achievement gap). The framework for this project relates to the important role of sociocultural context of learning in schooling. Although research on exemplary African-American teachers has received considerable attention (Delpit, 1986; Stanford, 1997), it focuses on African-American pedagogy in general, with reading and writing in particular (e.g., Ladson-Billings, 1995). Meanwhile, research on exemplary science teachers did not explicitly tap into science-related "funds of knowledge" extant in African-American communities (e.g., Barnett & Hodson, 2001).

Phase 1 includes 10 exemplary African-American elementary science teachers (e.g., award winning teachers). Multiple data sources (e.g., interviews, observations, and artifacts) will be used to identify characteristics of these teachers and conditions for promoting exemplary science teaching. Based on these findings, in Phase 2, beginning science teachers will be assigned to work with exemplary teachers and each exemplary teacher will work with two beginning teachers for one school year. This project is currently in its second year of funding.

This project will provide valuable insights about how to articulate science disciplines and students' cultural diversity early in the schooling. It will promote theory and research about how to address the science gap in high stakes science achievement tests, as well as how to mentor, support, and retain beginning teachers in critical shortage areas such as science. Dissemination will include presentations, publications, and a DVD that contains mentoring modules for beginning elementary science teachers.

Youth-based Program Impact on Education and Career Choices: An Exploration of Issues in Planning and Implementing Longitudinal Research (SGER)

Grant #	0748041
NSF Program	NSF
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Co-PI(s)	Xitao Fan
Institution	University of Virginia
NSF Program Manager	Janice Earle
Grade Level Band	Middle School, High School, Post Secondary
Target Audience	Inservice, Higher Education, Administrators, Policy Makers
STEM Content Area	Science, Technology, Engineering, Mathematics
Deliverables	Design longitudinal study

Project Summary

Are youths who participate in after-school information technology-oriented science-engagement programs more likely to eventually choose a STEM-related career? Are some programs more strongly associated with higher rates of science and technology-related career pursuit? The rationale for some programs makes workforce enhancement an explicit connection, e.g. ITEST. However, whether explicit or implicit, enhancement of the US information technology workforce catalyzed by these programs is important to understand, especially in light of the "American Competitiveness Initiative" highlighted in the President's most recent State of the Union address.

The benefit of youth-based information technology programs on US workforce development has long been presumed, but few data have been collected to offer generalizable findings on this linkage. The major challenge for this type of analysis is the time between programmatic participation and entrance into the workforce, which could span the better part of a decade. Current efforts to track programmatic effectiveness are not designed to carry out this type of long-term study. The purpose of this SGER is to explore the issues associated with organizing a large-scale longitudinal study on the effects of youth-based programs offering science-related information technology experiences upon students' post-secondary education and career choices.

A fairly recent longitudinal analysis (Tai, Liu, Maltese, & Fan, 2006) offered some evidence that science-related career aspirations early in adolescence are associated with a greater likelihood of actually earning baccalaureates in science-related fields. Surprisingly, this study was the first of its kind to offer a large-scale longitudinal analysis exploring this connection. Existing databases of this sort are designed to be used for a vast array of purposes by many different stake-holders and, as a result, do not contain information with the sufficient detail needed to answer more specific programmatic questions. The intellectual merit of this proposal stems from its potential to make some progress into filling this void in our understanding of the long-range workforce development impacts of youth-based programs. The value of large-scale, longitudinal databases is that they allow us to understand the trajectories of a representative sampling of adolescent population from their participation in youth-based career-enhancement programs to their later educational and career choices. These characteristics offer the potential for finding generalizable trends with potentially causal implications, a powerful outcome.

With accountability a more prominent part of US education, the broader impacts of this proposed SGER study stems from its potential to fulfill the urgent need to develop a more adequate understanding of the long-term impact of federally-funded youth-based programs, especially impacts that have a direct bearing on youths' career choices in fields closely aligned with information technology. The research we are proposing is an entirely new and innovative application of a robust research methodology.