Center for STEM Learning

UNIVERSITY OF COLORADO **BOULDER**

I^3: Towards a Center for STEM Education
Award Number: DRL 0833364

Final Report

1. Project objectives and summary

The NSF I³ project at the University of Colorado Boulder established the CU-Boulder Center for STEM Learning (CSL). This center fosters the incubation and mainstreaming of educational transformations that support student learning in STEM fields (and beyond) in the context of a sustainable model of institutional practice. This work includes promoting and legitimizing STEM education, educational transformation, and scholarship within the university; building and sustaining a STEM Education community on campus; identifying and helping mainstream successful transformative educational practice at CU; and providing a national platform for effective, transformational STEM Education practices. The official purpose (mission) of the CU-Boulder Center for STEM Learning (CSL) is:

1.A. Mission

To improve science, technology, engineering, and mathematics (STEM) education at the University of Colorado Boulder, and to serve as a state, national, and international resource for such efforts.

1.B. Vision

Our vision for achieving this mission is:

1. To maintain an infrastructure of institutional support in order to transform STEM education, support education research within and across STEM fields and departments, and promote K20 faculty recruitment, preparation, and professional development.
2. To facilitate change in STEM education by integrating an interdisciplinary community of scholars, promoting, sustaining, and evaluating existing reform efforts, sponsoring new programs, advocating for diversity and access, influencing relevant policy, fundraising, and communicating with the public.

1.C. Intellectual Merit

The NSF I³ has explicitly supported 54 research projects, resulting in at least 13 publications on STEM education research and reform in the past year, and 11 new NSF awards, totaling more than $4,500,000. As a result of NSF I³ efforts, the CSL supports a community of scholars in STEM education at CU-Boulder that spans more than 85 programs and 20 departments, and the center serves as a home for interdisciplinary grants and projects, currently totaling approximately $4M in new funding.

1.D. Broader Impacts

The 85+ different STEM education programs on campus impact roughly 10,000 undergraduates per year and thousands of pre-college children through community partnerships. While quite impactful, transforming these successful innovations into true normative practice is difficult for any one individual, program or department to do alone. To achieve lasting campus-wide impact – and to translate CU success to the overall field of STEM education – requires a shared platform for knowledge capture

and transfer. Funding from the NSF I³ has built the Center for STEM Learning, which serves as this platform.

For STEM educators who seek to transform educational practice, CSL will offer a toolbox of resources to help navigate the arc from innovation to practice. This arc is the process through which all successful transformative practices must go to move from innovation to widespread acceptance as normative educational practice. Like any new innovation, transformative STEM educational practices must also be designed, tested, evaluated, refined, shared and taken to scale. CSL's tools are intended to support innovators at all three stages of this arc:

- Stage One includes innovation development, early testing and refinement;
- Stage Two includes broader testing and evaluation, knowledge capture, and application on a larger scale.
- Stage Three includes knowledge transfer on a large scale.

CSL has and will continue develop shared tools to support STEM education innovators through the three stages of innovation. These tools will include resources and support structures for:

- Programmatic Development and Faculty Development: professionalizing education practice.
- Research and Development: fostering development in STEM education, incubating new STEM education activities.
- Communication and Community: building the STEM education community, sharing resources among programs, promoting affiliated efforts and CU, and connecting beyond CU.
- Assessment: supporting formative development for faculty, courses, programs, departments, and the institution itself.
- Policy and fundraising: translating evidence-based best practice into standard practice, through policy, communication, and development channels.

2. Summary of key successes this year (2013-2014)

2.A. Center Infrastructure

Over the past six years, CU-Boulder has established basic infrastructure for the Center for STEM Learning. This work has included identifying and reaching out to roughly 85 STEM education programs on campus, conducing a preliminary needs-analysis, and bringing in key stakeholders to shape the structure of the CSL. These stakeholders, though regular meetings, established vision and mission statements, drafted preliminary strategic and communications plans, implemented a functioning organizational structure, and developed a budget. The venture was officially launched in December of 2012. Since then, work to grow and enhance operations has been ongoing. Successes of particular note this year have been updating the organizational chart and making associated hires, as well as launching the CSL fellows program.

2.A.i. CSL Organizational Chart and Staff Hires

The CSL organizational chart (see **Appendix A. Organizational Chart**) was revised in order to streamline and more accurately reflect operational practices. Three key staff hires will greatly enhance the center's capacity to improve STEM education at CU-Bolder and beyond.

The new "spider" position serves as a communications integrator - liaising with relevant STEM education programs and with faculty members interested in educational transformation and discipline-based educational research. This position also works with CSL staff to develop educational transformation and research programs for faculty. Dr. Gabrielle Katz has been hired into this position. Gabrielle Katz is an environmental scientist and educator with over ten years of university teaching experience. She came to CU-Boulder from Appalachian State University, where she was Associate Professor and Graduate Program Director in the Department of Geography and Planning.

The new CSL Business Manager position provides budgetary & payroll oversight, ensures financial compliance, performs administrative management and planning duties, and provides support for key CSL programs. William Tarantino has been hired into this position. He brings a Bachelor of Science in Business Administration from Metropolitan State College of Denver, as well as a strong background in federal grant management.

The new CSL Program Manager/Interim Director will oversee day-to-day operations and take on leadership of the center. Duties will include: coordinating center programs, projects and events, building and maintaining both internal and extramural relations, supervising CSL staff, managing center public relations, developing and implementing strategic and development plans, and data collection. A search for this position is currently nearing completion.

2.A.ii. Fellows Program

A new fellows program has been established, linking campus leaders representing 13 departments from across four colleges. The fellows serve as CSL ambassadors, communicating about the center and about STEM education throughout campus and beyond CU-Boulder. Fellows also affiliate their research and programmatic efforts with the center, shape center activities, run appropriate grants through the center, and advise center staff. A slate of 30 fellows was elected in the past year (see **B.4. CSL Fellows**).

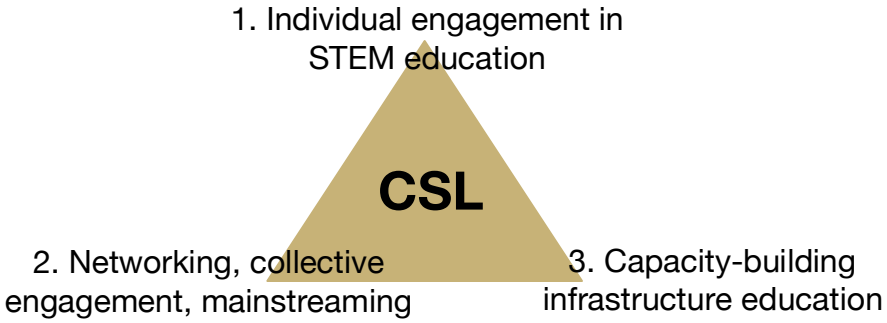
The fellows met twice during the academic year. At the inaugural meeting in the fall, the fellows were introduced to each other, oriented to the fellows program, engaged in visioning for the future of the center, and formed sub-committees for upcoming programs and projects. At the spring meeting, the fellows, further engaged in visioning for the fellows program and the center, more broadly.

2.A.iii. Draft Strategy Documents

The CSL directors began a strategic planning and goal setting process this year. This exercise led to a draft framework and three major goals. This work is ongoing. These pieces will be further discussed and refined until consensus is reached.

As they currently stand, CSLs three major goals are (1) Support individual engagement in STEM education, (2) Promote networking, collective engagement, and mainstreaming, and (3) Create a capacity-building infrastructure for CU-Boulder and the STEM education community more broadly. Sub-goals and priories related to these three goals are described in **Appendix C. Draft CSL Strategy Documents**. The Center for STEM Learning will serve to support and stitch together these three goals.

Center stitching together and supporting 3 major goals



2.B. Programmatic and Faculty Development

The Center for STEM Learning is professionalizing educational practice by supporting programmatic and faculty development. The NSF I[3] enables CU-Boulder to identify and reach out to roughly 85 campus-based STEM education programs. By working towards linking these efforts, CSL strengthens individual programs, leverages resources, gains broader attention, and nucleates new programs. One such new program is explicitly addressing faculty development.

2.B.i. AAU STEM Education Initiative Demonstration Site

CU-Boulder was chosen as one of eight project sites for Association of American Universities' Undergraduate STEM Education Initiative. The project was pitched by and is housed in the Center for STEM Learning. It aims to improve undergraduate STEM education by professionalizing educational practice through measurement, assessment, and cultural change. The focus is on department-wide change to achieve more coherent, long lasting reforms. The project uses a three-layer approach: (1) Work with individual faculty and groups of faculty to support transformation of high-impact and high-need courses within individual STEM departments (bottom up); (2) Apply targeted approaches to individual departments to stimulate cultural change (middle out); and (3) Work with the administration and faculty senate to promote and incentivize the use of evidence-based teaching practices (top down). These three layers are supported with infrastructure provided by the AAU and by collaborations with the CU-Boulder Office of Informational Technology (OIT) to develop and import technology for better utilizing already existing institutional student data. Read more about the project at http://www.colorado.edu/csl/aau/index.html.

2.B.ii. National Connections and Resources for Improving CU-Boulder

The NSF I³ project and resulting Center for STEM Learning have connected CU-Boulder to a variety of other national programs, outlined below, and are also bringing resources to CU-Boulder to help transform faculty practice and programmatic activity. For example, the Bay View Alliance is furthering CU's engagement by advancing the science teaching fellow model of the Science Education Initiative (one of hallmark efforts of the 85 active CU-Boulder STEM education programs), incorporating broader skills (problem solving, critical thinking, etc.) across the curriculum, and collecting and making accessible relevant data for making education decisions. See **2.D.iii.a. Bay View Alliance (BVA)** for more information about this connection. Another example is the Association of Public and Land-grant's effort to create a national network of STEM education centers. CU-Boulder's connection with his effort is providing a model of effective programmatic (and administrative) practice around STEM education. See **2**.D.iii.b. Association of Public and Land-grant Universities (APLU) National Network of University-based STEM Education Centers for more information about this connection.

2.B.iii Supproting Campus Infrastructure for STEM Education

In parallel with extramural drivers, the Center for STEM Learning is supporting campus infrastructure for advancing capacity and effectiveness in STEM education. For example, the Office of Information Technology (OIT) has STEM education as a strategic priority. CSL staff also advise OIT staff on areas of focus, including the development of analytic tools (those from the Bay View Alliance) for making evidence based decisions, and importing new tools for faculty practice (e.g., *nota bene*, a web-based collaborative annotation tool from the Massachusetts Institute of Technology, and *Calibrated Peer Review*, a web-based writing and peer review tool from the University of California, Los Angeles). CSL staff are also advising and supporting campus commissions to advance the institution. Key committees include the provost's Taskforce on Persistence (increasing retention) and the campus and system wide taskforces in technology use (e.g., online, distance education, and MOOCs).

2.C. Research and Development

CSL promotes STEM education research as a central tool in improving the quality, efficacy, and inclusiveness of STEM education. The center fosters collaboration between researchers across campus, and conducts research that creates new materials, resources, and models for STEM education, directed at improving student learning and access to STEM.

2.C.i. Chancellor's Awards for Excellence in STEM Education

A key and innovative component of the NSF I³ has been the Chancellor's Awards for Excellence in STEM Education program. These mini-awards provide funding to support engagement in innovative research on student learning and implementation of research-based STEM education programs and initiatives.

For faculty, staff, and researchers, funding can support course release, summer salary, or research costs associated with projects. Applicants may request support for STEM education projects in the early stages, for the coordination of existing projects,

and to seed efforts that can continue beyond the funding period. Grants of up to $10,000 are awarded for a period of up to one year.

The NSF I³ has funded 22 of these awards involving 29 faculty, staff members, and researchers from 13 departments and five schools and colleges (see **Appendix D.1. Faculty, Staff, and Research Scholars**). These projects have been followed with 11 new NSF awards in these research areas, totaling more than $4,500,000 (see **Appendix D.4. Resulting NSF Grants**), as well at least $15,000 in new awards from other sources. One of the inaugural awardees, Dr. Steve, Pollock, was named 2013 US Professor of the Year by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education.

Student Chancellor's Awards for Excellence in STEM Education promote the development of graduate students in STEM education, and provide resources to encourage their disciplinary departments to engage in course transformation and disciplinary-based education research.

The NSF I³ and matching funds supported 23 separate graduate student projects, aided by 21 faculty advisers. The funding supported work in nine departments (at least four of which now offer degree programs in STEM education) and four schools and colleges (see **Appendix D.2. Graduate Scholars**). These projects have resulted in more than $15,000 in new student awards and fellowships. At least 12 graduate awardees have now completed PhDs in STEM education.

A major goal for the Center for STEM Learning is to secure lasting, institutional funding to continue this very successful, capacity building program. Funding from the CU-Boulder provost has allowed CSL to fund four faculty awards for the 2014-15 academic year. CSL signed a five-year memorandum of understanding with the Graduate School this year promising funding for four student awards each year.

More information about the Chancellor's Award program and the full text of funded proposals is available at http://www.colorado.edu/csl/ChancellorAward.html.

2.C.ii. CSL-housed Grants

One of the key value-added components of CSL is that it can serve as the administrative unit for interdisciplinary grants and projects that would not otherwise have an obvious home. In the past year, the CSL became the home unit for four such projects, including Talking About Leaving (NSF/Sloan), the AAU STEM Education Initiative Demonstration site (AAU), XSci Experiential Science Education Research Collaborative (Merck Foundation), and the EFRI-ODISSEI: Photo-Origami (NSF). These projects have brought nearly four million dollars of external funding to CU-Boulder and are contributing groundbreaking work to the field of STEM education. CSL received nearly $30,000 in indirect cost returns from these projects last year, which will increase the center's capacity to support these and future research endeavors.

2.C.ii.a. Talking About Leaving Revisited

Anne-Barrie Hunter, CSL fellow from Ethnography & Evaluation Research in the Center to Advance Research and Teaching in the Social Sciences, serves as PI for Talking About Leaving Revisited: Exploring the Contribution of Teaching to Undergraduate Persistence in the Sciences. The departure of undergraduate students

from STEM majors has remained a persistent problem since researchers and policymakers first took note three decades ago. Moreover, women and students of color majoring in STEM fields are more likely to switch to non-STEM majors, and continue to be underrepresented among those who persist to attainment in these fields. There is not only an apparent shortage of STEM majors to fill crucial jobs, but also a lack of critical diversity to spur scientific and technological innovation and expand opportunities for traditionally underrepresented groups.

The 1997 book Talking about Leaving: Why Undergraduates Leave the Sciences identified numerous factors that affect STEM persistence. Although there have been widespread efforts over the past 15 years to address these factors, it's not really known if these efforts have had any impact on students' experiences and whether these experiences, in turn, have influenced student persistence in STEM fields. Thus, the primary objective of Talking About Leaving Revisited, co-funded by the Alfred P. Sloan Foundation ($666,959) and the National Science Foundation ($1,615,849), is to understand how student experiences shape national and institutional patterns of STEM persistence. More information about the program is available at http://talr.wceruw.org/.

2.C.ii.b. AAU STEM Education Initiative Demonstration Site

CU-Boulder serves as one of eight national demonstration sites for undergraduate STEM education transformation. In addition to this site work, the research team is feeding back their approaches and studies on institutional transformation to the national effort. This project is funded by a grant ($500,000) from the Association of American Universities. CSL co-director and fellow, Noah Finkelstein, is PI. For more information, see 2.B.i. AAU STEM Education Initiative Demonstration Site.

2.C.ii.c. XSci, Experiential Science Education Research Collaborative

Brad McLain, CSL fellow, is co-director of XSci. XSci's purpose is to uncover the ways educators construct extraordinary science learning experiences for themselves, their students, and their peers. To do this, they design, conduct, and research the impacts of several types of teacher experiences. The program emphasizes learning from direct first-person experience and a holistic perspective that includes the self-construction of knowledge as well as emotions, attitudes and beliefs that combine to form a learner's "science identity." They conduct research on Experiential Learning Theory and Science Identity Construction, and run experiential programs about geology, volcanology, botany, biology in Africa, about developing, designing, using, and distributing mobile apps for the classroom, about methods, techniques, and theories of modern paleontology at the Judith River Dinosaur Institute in Billings Montana, and several others. This program is funded in part by a gift ($900,000) from the Merck Foundation. More information about the XSci program is available at http://www.xsci.org/.

2.C.ii.d. EFRI-ODISSEI: Photo-Origami

Elisabeth Stade, CSL fellow from the Department of Mathematics in the College of Arts and Sciences, is conducting research as part of an engineering research team at the University of Colorado Boulder hat has won a $2 million grant from the National

Science Foundation to develop a light-controlled approach for "self-assembly" mechanisms in advanced devices based on the principles of origami - that amazing objects that can be created by folding a simple piece of paper. In addition to this research, the project staff works with CU Science Discovery and the local school district to provide research and educational opportunities for K-12 students and teachers. For example, they've developed an elementary Polymer Science class, "Bounce and Tangle," with CU Science Discovery, in which students used a variety of materials including plants, craft supplies to demonstrate polymer properties. They've also developed a middle school/teacher training unit, "Engineering is Everywhere," which equips and trains teachers to use 3-D printer technology. Additionally, they created opportunities for high school teachers and students to participate in research and mentoring activities with the Photo Origami team during the summer. This outreach component of the project ($306,464) is being run through CSL.

2.C.iii. Proposals submitted

In addition to the four projects mentioned above, several new projects were proposed in the last year. Nine CSL-affiliated PIs submitted proposals to five funding agencies (see **Appendix E. New Grant Proposals Submitted**). Five of the proposals, totaling more than $1.5 million, have already been accepted.

2.D. Communication and Community

Work to build an interdisciplinary community of STEM education scholars is ongoing. Focus has been on promoting and sustaining existing reform efforts, sharing resources among programs, and connecting beyond CU-Boulder.

2.D.i. CU-Boulder STEM Education Programs

CSL serves to link, coordinate, and integrate constituent programs. By creating a network of programs, CSL strengthens individual programs, leverages resources, gains broader attention, and nucleates new programs and collaborative efforts. Currently, CSL is reaching out to the more than 85 different programs on the University of Colorado Boulder campus to work towards linking these campus-based efforts with each other and with the CSL mission and activities (see **Appendix F. CU-Boulder STEM Education Programs**). CSL also directly supports individual programs that span a broad section of campus.

2.D.i.a. Boulder Area STEM Education Coalition (BASEC)

BASEC focuses on diversity, equity, and access for children in STEM. CSL has helped shape and create this 300-member program and links CU-Boulder efforts directly with the community. In partnership with BASEC, CSL has provided technical support and leadership, and supported career fairs for youth, campus visits, and networking among the dozens of community-based programs focusing on STEM. For more information about this program, see http://boulderareastem.org.

2.D.i.b. Catalyzing STEM Student Advocacy Workshop

The University of Colorado Assistant Vice President of Research and Federal Relations worked with a number of groups, including the American Association for the Advancement of Science, the American Chemical Society, the American Institute of Physics, the Association of American Universities, the Association of Public and Land-grant Universities, and Massachusetts Institute of Technology to design a pilot two-day workshop for first and second year graduate students (and talented undergraduates) to be held in DC on science policy and advocacy. The goal of the course was for students to learn about the structure and organization of Congress, the federal budget and appropriations process, and tools for effective science communication. Students worked with federal relations offices to schedule advocacy meetings on the Hill to discuss the important of federal investments in research and education. CSL, the Center for Science and Technology Policy Research, and the Gradate School developed a competitive application process, and sponsored two students to attend the event.

2.D.i.c. Colorado Learning Assistant (LA) Model

The LA program at the University of Colorado Boulder uses the transformation of large-enrollment science courses as a mechanism for achieving four goals: (1) To recruit and prepare talented science majors for careers in teaching, (2) To engage science faculty in the recruitment and preparation of future teachers, (3) To improve the quality of science education for all undergraduates, and (4) To transform departmental cultures to value research-based teaching. The transformation of large-enrollment courses involves creating environments in which students can interact with one another, engage in collaborative problem solving, and articulate and defend their ideas. To accomplish this, undergraduate LAs are hired to facilitate small-group interaction in our large-enrollment courses. CSL supported the LA program with administrative consulting and financial backing for program events this year. More on the LA program is at laprogram.colorado.edu.

2.D.i.d. Discipline Based Education Research (DBER)

CSL sponsors weekly DBER seminars. These meetings a forum for faculty, staff, researchers, and students interested in education research and course transformation to share their ideas and get feedback on their work. In addition to being intellectually rich, these meetings also serve to create community among the many STEM education researchers on campus. Twenty-five seminars were held in the past year. These seminars brought together faculty, staff, researchers, and graduate students from roughly 34 different programs and departments. Average attendance was roughly 20 people, and spanned more than 90 faculty, graduate students, and staff from the university. DBER is also serving as a vehicle to make connections with STEM education experts from other institutions and has already hosted visitors from 20 intuitions this year, including the American Association of Physics Teachers, Arizona State University, the Boulder Area STEM Education Coalition, DePauw University, Florida International University, Kennesaw State University, the Netherlands Institute for Curriculum Development, Purdue, Rochester Institute of Technology, Texas State

University, City University of New York, Universidad Católica de Temuco, University Corporation for Atmospheric Research, University of California, Berkeley, University of California, Davis, University of Wisconsin-Madison, Utrecht University, and West Virginia University. A complete calendar of DBER meetings, presenters, topics, and video recordings of many past seminars can be found at: http://colorado.edu/istem/DBER.html.

2.D.i.e. Discipline-based Education Research Groups

CSL provides serves as guest speaker and provides advertising for, the Chemistry Educational Research (CER) Discussion Group, the Engineering Education Research (EER) Group, and the Physics Education Research Group at Colorado (PER@C), which is one of the largest PER research programs in the nation. More information about CER can be found at https://sites.google.com/a/colorado.edu/cer2013/. More information about PER@C can be found at http://www.colorado.edu/physics/EducationIssues/.

2.D.i.f. Massive Open Online Course (MOOC) Project

In 2013, the University of Colorado signed a contract with Coursera to offer courses through their learning platform. CSL participated in launching a MOOC for introductory physics, along with a comparative study of the impact of this course on student learning versus an in-class 900-student lecture. The project included creating and recording a suite of lectures, including mini-assessments (concept tests), developing homework sets that could be put on line, assessments, exams, and measures of student learning, seeding discussion boards, and enacting protocols for the study. The center contributed administrative support, advising, and disciplinary expertise and understanding of physics education to this project.

2.D.i.g. Partnerships for Informal Science Education in the Community (PISEC)

PISEC is an out-of-school program that simultaneously supports the development of children and of undergraduate and graduate students at CU-Boulder. More information about this program is available at http://www.colorado.edu/physics/PISEC/index.html. CSL provided administrative and financial support for this program this year. This funding helped PISEC director, Dr. Katie Hinko, secure a $299,780 NSF grant to measure the impact of the program.

2.D.ii. STEM Education Events

CSL further builds community and supports STEM education scholars and programs by creating space for substantive intellectual discourse and resource sharing at sponsored events. Such events also serve to connect the CU-Boulder STEM education community with likeminded scholars across the nation and internationally. Several events were held in the past year.

2.D.ii.a. Annual Symposium on STEM Education

A cornerstone of CSL is an annual symposium celebrating STEM education at the University of Colorado Boulder. The fifth annual symposium was held September

23, 2013, and was attended by 220 participants, including Boulder County Commissioner Deb Gardner, Colorado State Representative Dickey Lee Hullinghorst, staffers from US Senator Mark Udall's office, and the Chancellor's Advisory Council (Norman Augustine, Retired Chairman and CEO of the Board of the Lockheed Martin Corporation; Pamela Drew, President, Information Systems, Exelis, Inc.; Bradley Feld, Managing Director, Foundry Group; Allison Keller, Executive Director and CFO of the W.M. Keck Foundation & President of Oakmont Corporation; Denise M. O'Leary, Private Investor; William N. Reinert, National Manager, Advanced Technology Group for Toyota Motor Sales, USA; Todd Rulon-Miller, Founding Partner, Apogee Venture Group; Sarah Schupp, CEO and Founder, University Parent; Mark Sirangelo, Corporate Vice President, Sierra Nevada Corporation (SNC) and Chairman of SNC Space Systems; Robert D. Strain, President of Ball Aerospace & Technologies Corporation; Philip A. Washington, General Manager, Regional Transportation District, Denver, Colorado; Earl L. Wright, Chair of the Board & Executive Committee, AMG National Trust Bank). Representatives from CU-Boulder, Boulder Valley School District, Jefferson County School District, St. Vrain Valley School District and Northglenn High School, Chicago State University, Texas State University, University of Maryland, Boston, University, University of Colorado-Colorado Springs and University of Amsterdam also took part in the celebration.

The program began with a poster session showcasing 60 programs and projects, which provided networking opportunities among our STEM education constituents. Harrie Eijkelhof, director of the Freudenthal Institute of Science and Math Education, Utrecht, gave a keynote address. US Representative Jared Polis and Colorado Lieutenant Governor Joseph Garcia also presented brief remarks. An award ceremony honored the recipients of the Chancellor's Award for Excellence in STEM Education.

Plans are under way for a sixth annual STEM education symposium to be held on September 29, 2014.

2.D.ii.b. Marco Molinaro

On October 8, CSL hosted Dr. Marco Molinaro, Assistant Vice Provost for Undergraduate Education at the University of California, Davis. He presented a DBER presentation about Interdisciplinary Agriculture Medicine Science Technology Engineering and Mathematics (iAMSTEM) Hub. This organization's mission is to maximize STEM student success through evidence-based actions. The Hub focuses on three primary strategies: 1) Facilitate faculty cultural change while building community, 2) Catalyze innovation in instruction, assessment, curriculum and student experimentation, and 3) Develop the analytics infrastructure to measure and inform improvement. Dr. Molinaro presented examples of progress thus far in each of the strategies, with a primary focus on efforts in biology, chemistry, engineering and academic analytics. The presentation ended with a discussion on experiences in utilizing data to elicit change, and potential barriers and pitfalls. This visit catalyzed a partnership with UCDavis to scale evidence-based measures for teaching, supported by the Helmsley Trust.

2.D.ii.c. Gabriela Weaver

CSL hosted Dr. Gabriela Weaver, Professor of Chemistry and Director of the Discovery Learning Research Center at Purdue University. While in Boulder, Dr. Weaver met individually with many campus scholars and presented about Purdue Academic Course Transformation (IMPACT) at the October 15, 2013 DBER. IMPACT was started in fall 2011 to better initiate student engagement. Through this program, faculty and staff members are redesigning key introductory classes, creating more student-centered environments for improved competency and confidence. The modified foundational courses facilitate interaction between students and the instructor with the aim of enhancing student-faculty bonds, especially during the critical period when students are integrating into the world of higher education. Specific goals for the IMPACT project include: focusing the campus culture on student-centered pedagogy and student success; enabling faculty-led course redesign based on best practice and sound research with campus-wide resources; creating a community of practice by connecting faculty through Faculty Learning Communities; assessing and disseminating the results. Assessment of the project focuses on three dimensions: faculty change, student perceptions and student learning and retention. Assessment of faculty change uses interviews and surveys with participating faculty to elucidate and document changes in teaching practices as a result of IMPACT, sustainability of these changes and transfer of new teaching practices to other courses. Student perceptions of the learning environment and their own academic confidence and competence are collected through online surveys and these data are used to investigate the process through which student-centered learning environments are achieved and their influence on student academic confidence and achievement. Finally, course and institutional assessment data including scores on learning outcome assessments, student final course grade and student retention are collected and monitored to determine the effects of IMPACT on student learning and retention. This visit led to a collaboration through the Association of Public and Land-grant Universities, focused on building a national network of STEM education centers. See **2**.D.iii.b. Association of Public and Land-grant Universities (APLU) National Network of University-based STEM Education Centers for more information.

2.D.ii.d. First annual K12 SUMMIT by Immersive Education Initiative (iED)

On October 24-26, 2013, CSL co-sponsored the First annual K12 SUMMIT by iED. iED Summits are organized specifically for educators, researchers, administrators and business leaders. They consist of presentations, panel discussions, break-out sessions, demos and workshops that provide attendees with an in-depth overview of immersive learning platforms, technologies and cutting-edge research from around the world. iED Summits feature new and emerging virtual worlds, learning games, educational simulations, mixed/augmented reality, and related teaching tools, techniques, technologies, standards and best practices. This Summit focused on STEM learning. More information about the event is available at http://summit.immersiveeducation.org/K12/.

2.D.ii.e. Berenice Michels

CSL hosted Dr. Berenice Michels of the Netherlands Institute for Curriculum Development. In 2007 a new elective course was introduced in the Netherlands: Nature, Life and Technology. The goal of the integrated STEM course is to increase the coherence between sciences and technology for high school students and to increase the number of students enrolling in STEM majors. This is done by offering the students a set of different STEM modules, each focusing on an authentic scientific or technological issue, corresponding with current activities of active, professional scientists. More than 70 modules have been developed, varying from intermediate to advanced levels. At the November 19, 2013 DBER session, Dr. Michels presented an overview of the characteristics of the course, the first results regarding the effect of the course, some examples of advanced (undergraduate) level modules, and about the development process of the modules, in which both high school teachers and university experts are involved.

2.D.ii.f. Matthew Hora

On February 27-28, 2014, CSL hosted Dr. Matthew Hora from the University of Wisconsin as part of the AAU STEM Education project. Dr. Hora is an expert on the analysis of curriculum planning and classroom instruction at the college level. While in town, he led a workshop on the use of the Teaching Dimensions Observation Protocol (TDOP) web-based classroom observation protocol, which is a tool designed to capture how five distinct aspects of teaching (i.e., teaching methods, pedagogical strategies, student-teacher interactions, cognitive demand, and use of instructional technology) unfold throughout a class period in descriptive rather than evaluative terms. The TDOP has been used extensively for research and faculty development purposes, and is publicly available as a web-based application (http://tdop.wceruw.org). In this training participants were introduced to the background of the TDOP, how to navigate the website, how to use it to code a video-taped lecture, and how to use its automated inter-rater reliability (IRR) and data export functions. The training also focused on how to customize the TDOP so that new codes can be used to fit local needs and interests. Through CSL and AAU, CU-Boulder is piloting multi-department uses of the TDOP for documenting faculty and student practices. More information about TDOP is available at http://tdop.wceruw.org/Document/Hora-Ferrare-2014-Jrnl-College-Science-Teaching.pdf.

2.D.ii.g. James Fairweather

CSL hosted Dr. James Fairweather April 21-22, 2014. Dr. Fairweather is a professor and the director of the Center for Higher and Adult Education at Michigan State University. He serves as co-Principal Investigator of the Association of American Universities (AAU) Undergraduate STEM Education Initiative. He is widely known for his work on faculty roles and rewards, higher education policy, and reforming STEM education (especially in engineering). In 2011, AAU (and association of the top 60 US research universities and two from Canada) launched a five-year initiative in collaboration with member institutions to improve undergraduate teaching and learning

in STEM fields. The overall objective of the initiative is to influence the culture of STEM departments at AAU institutions so that faculty are encouraged and supported to use teaching practices proven by research to be more effective in helping students learn and in better engaging students in STEM education. During his visit, Dr. Fairweather met individually with many campus scholars, and presented about the AAU initiative at DBER.

2.D.ii.h. Angie Hodge

Along with the Math Department and the School of Education, CSL co-hosted Dr. Angie Hodge, Special Projects Coordinator for the Academy of Inquiry-Based Learning (AIBL). CU-Boulder is one of five institutions nationally to receive a grant from the Helmlsey Foundation to implement Active Learning approaches in freshman mathematics. Dr. Hodge's institution, the University of Nebraska at Omaha, was one of the others. Dr. Hodge visited campus April 22-25, 2014, gave a talk about AIBL and observe calculus classes.

2.D.ii.i. Xperience STEM National Conference

Along with The Merck Foundation, REI, Lego, and CU-Denver School of Education and Human Development, CSL co-sponsored the Xperience STEM National Conference, hosted by XSci July 29 – August 1, 2014. The conference focused on the many incarnations and benefits of experiential methods in STEM education, showcased some of the best programs, and created a community of experiential STEM advocates. It began with a keynote address from Les Stroud (Survivorman), who discussed the necessity of risk taking, which allows for true learning. The conference also included 42 other speakers, including representatives from IBM, Lego, Discovery Education, National Geographic, STEMx, CSL, CU-Boulder, and the Smithsonian. Attendees participated in STEM “experiences”, such as the science of yoga, mobile apps development, indoor skydiving, geospatial wilderness orienteering, and modular robotics. 381 educators attended the conference. More information about the conference is available at http://www.xsci.org/xperience-stem-2014-conference-results/.

2.D.iii. Connections and Alliances with STEM Education Programs Beyond CU-Boulder

2.D.iii.a. Bay View Alliance (BVA)

Lead by the Center for STEM Learning, CU-Boulder was invited to become a member of the BVA effective January 1, 2014. The BVA is a consortium of universities carrying out applied research on the leadership of cultural change for increasing the adoption of improved teaching methods at universities. The BVA aims to identify and evaluate more effective ways for those of influence at all levels of a university to inspire and enable enhancements of teaching and learning, through adjustments to common educational methods and procedures. There are three focused Research Action Clusters (RACs): 1) improved resources for education, 2) including cross cutting ideas in content domains, and 3) evidence based practices. CU-BOULDER is activity participating in all three. Currently, the BVA has eight other member universities

(University of British Columbia, Indiana University Bloomington, University of Kansas, University of Saskatchewan, Queens University, University of California at Davis, University of Texas at Austin, and University of Massachusetts Amherst. More information about this consortium is available at http://bayviewalliance.org/.

2.D.iii.b. Association of Public and Land-grant Universities (APLU) National Network of University-based STEM Education Centers

With the support of the Alfred P. Sloan Foundation, the APLU launched a national discussion on university-based STEM education centers, with the goal of fostering communication and interaction among the center to enhance their capacity to support effective undergraduate STEM education. These centers are a critically important group to engage, since universities (with undergraduate education at their core) will potentially serve as the catalysts for broader national educational transformation in STEM, including research on teaching and learning STEM disciplines at all levels. A gathering of more than 40 institutions took place in September 2013, and a followup gathering will be held in October 2014. A larger-scale proposal is being assembled for the NSF, the Sloan Foundation, and the Helmsley trust. CSL co-director, Noah Finkelstein, co-chairs this effort, and CSL has served as a model and is a leading institution in this national discussion and network. More information about this effort is available at http://serc.carleton.edu/StemEdCenters/index.html.

2.D.iii.c. Informal Center Collaborations and Partnerships

Many universities across the country and internationally share a vision for supporting and shaping STEM education transformation on their respective campuses. We've collaborated with or formed explicit partnerships with several in order to communicate information about STEM Education-related activities and programs, including novel ideas for course and institutional transformation, share and coordinate STEM Education research studies, developing, when possible and of mutual interest, multi-institutional projects, seek opportunities for scholar-in-residence exchanges in which faculty and students of one institution spend time on the other's campus, coordinate public policy advocacy activities at the state and national level, sharing materials and strategies to advance the common goal of improved STEM education, and regularly evaluate the level of collaboration and synergy between the campuses. Such relationships have been established with Boston University, the Center for Advancing Science/Math Teaching, Learning, and Evaluation (CASTLE) at the Rochester Institute of Technology, the Center for the Advancement of Teaching and Learning of STEM (CATALyST) at Purdue, the Colorado State University STEM Center, the Freudenthal Institute for Science and Math Education, the STEM Gateway Program at UNM, the STEM Transformation Institute at Florida International University, the Tufts STEM Education Program, the University of Arizona STEM Learning Center, and the University of Maryland.

2.E. Assessment

CSL has and will continue develop resources and support structures for supporting the formative development of faculty, courses, programs, departments, and the center itself.

The Chancellor's Award program is one way CSL promotes course-level assessment. By supporting projects conducting assessments of educational practices, the center has been a catalyst for informed course transformation in departments across campus, and has aided the development of meaningful assessment tools for the broader STEM community. Dr. Ben Zwickl's project is an example of this. He conducted a comparative study of different forms of assessment in physics laboratory courses. Compared to lecture courses, labs typically involve more resources per student in terms of expense, equipment, space, contact hours with instructors, and low student/teacher ratios. They are learning environments that emphasize a broad range of learning goals, going beyond content learning goals to include a range of scientific practices, including written and oral communication, experimental design, data analysis, and others. Despite the abundance of resources and goals that often closely align with scientific practice, laboratory courses often produce unsatisfying or uncertain outcomes of student learning. In addition, national calls have been made for lab courses that engage students in more disciplinary-relevant activities as a means to improve recruitment and retention of students in STEM. For decades, efforts have been made to transform laboratory environments across the sciences, with "inquiry-based" being one of the more popular approaches. However, it is difficult to compare the efficacy of these innovations, and it is equally difficult for instructors to implement meaningful assessments in their laboratory courses. In spite of the need, the STEM education community has few assessment tools for laboratory teaching environments. Doing robust assessment in these environments has remained a long-standing challenge in laboratory instruction and physics education research. Dr. Zwickl's comparative study helped address this issue.

CSL continues to cultivate a community for supporting the development and dissemination of assessments of educational impacts. DBER is a prime example of this. The community decided to adopt an assessment theme for the Fall 2014 semester and invite participation from CU-Boulder scholars who specialize in various elements of the assessment process. A schedule of upcoming seminars is at http://www.colorado.edu/csl/DBER.html.

CSL is also engaged in studying larger-scale assessments of institutional change. The AAU STEM Education Initiative Demonstration Site project (see 2.B.i. AAU STEM Education Initiative Demonstration Site) is an example of this. As part of the AAU institutional transformation effort, both CU and the AAU central are seeking to create (and validate) metrics of institutional change. This project has been advancing models of institutional change and creating and adapting measurement instruments to align to these models. Another example is the partnership between CSL and the University of California, Davis (See **2.D.ii.b. Marco Molinaro**). The goal of this project is to make easily accessible visualizations that capture critical data for making educational decisions (e.g., What are critical courses or times in a career pathway to provide more support in order to reduce the attrition rate in STEM majors?).

2.F. Policy

CSL is actively engaged in translating evidence-based best practice into standard practice by influencing relevant policy.

In the past year, CSL staff have contributed to the development and release of the Colorado Education Initiative's (CEI) Colorado STEM Education Roadmap. CEI is a nonprofit focused on advancing K-12 public education through capacity building, innovation, and increased collaboration. The Roadmap is a plan to advance STEM education in ways that increase opportunities for all students, meet business needs, and attract new companies to the state. Goals include preparing students to be critical thinkers, to persevere through failure to achieve success, to communicate and collaborate across real and perceived barriers, and to solve complex and ever-changing problems. More information about this project is available at http://www.coloradoedinitiative.org/our-work/stem/.

Additionally, CSL staff have been invited to consult with key elected officials about STEM education issues. Meetings were held with Colorado Lieutenant Governor Joseph Garcia and with staff members from United States Senators Mark Udall and Michael Bennet.

Additionally, CSL coordinated a White House- and CU-Boulder-hosted College Opportunity Initiative STEM Education Workshop. The purpose of the event was to gather thought leaders and decision-makers focused on improving STEM learning and degree completion for more students. With this initiative, there is a strong focus on helping more low-income and disadvantaged youth succeed in critical STEM fields. This one of four such events held around the nation. More about this event is at http://www.colorado.edu/csl/WHCSL2014/index.html.

3. Summary of Project Successes

During this NSF I³ project, members of the CU-Boulder STEM education community worked towards establishing a national-scale center. Below is a summary of major accomplishments.

3.A. Year One

The first year of the NSF I³ project centered on building a foundation for the effort and fostering CU-Boulder's commitment to STEM education transformation and research. Key accomplishments included:

- Building out the Discipline Based Education Research seminar series
- Forming a Project Management Team and meeting weekly to discuss the design and implementation of the project
- Launching a website
- Visioning and launching the Chancellor's Awards for Excellence in STEM Education program
- Hiring a project administrator
- Identifying STEM education programs on campus and conducting a baseline survey of them to characterize their level of engagement and integration

- Engaging in state-level policy work

3.B. Year Two

The second year of the NSF I³ project centered on expanding programming and making initial preparations to launch a center. Key accomplishments included:

- Hosting the Inaugural Symposium on STEM Education
- Linking and developing a network of 25 CU-Boulder STEM education programs
- Continuing the success of the Chancellor's Awards for Excellence in STEM Education program
- Expanding DBER seminars to include a larger audience
- Founding the Boulder Area STEM Education Coalition
- Engaging in state- and national-level policy work
- Drafting mission and vision statements

3.C. Year Three

The third year of the NSF I³ project centered on further expanding programming, raising awareness and buy-in for the effort, and coordinating logistics in order to launch a center. Key accomplishments included:

- Expanding the network of CU-Boulder STEM education programs to include 45 separate efforts
- Hosting mini-symposia on CU-Boulder teacher professional development and the LA program, in addition to holding another successful Symposium on STEM Education
- Continuing the success of the Chancellor's Awards for Excellence in STEM Education
- Expanding DBER by recording sessions to make them available on the website and hosting faculty from the American Physical Society, Arizona State Polytechnic, Indiana University, Massachusetts Institute of Technology, Seattle Pacific University, the University of Copenhagen, the University of Nebraska, the University of New Hampshire, the University of North Dakota, the University of Texas at Austin, and the University of Wisconsin–Madison
- Creating brochures and one-page informational sheets about the I³ and affiliated efforts
- Engaging in local-, state-, and national-level policy work
- Establishing funding avenues for STEM education activities at CU-Boulder through work with the university-appointed half-time development officer from the CU Foundation
- Working with University Communications to develop a STEM education communications plan for campus
- Hosting Dr. Rachel Scherr, who conducted an external evaluation of the project
- Developing a database of STEM education people and programs on campus
- Drafting a center proposal

3.D. Year Four

The fourth year of the NSF I³ project centered on sustaining quality programming and taking final steps towards becoming an official center. Key accomplishments included:

- Holding another successful Symposium on STEM Education
- Continuing the success of the Chancellor's Awards for Excellence in STEM Education
- Supporting the network of CU-Boulder STEM education programs
- Continuing the success of DBER seminars
- Engaging in local-, state-, and national-level policy work
- Working with Dr. Barry Kluger-Bell to conduct a follow-up to the year 1 baseline survey and evaluation
- Submitting for review by the chancellor, provost, and legal council a center proposal including by-laws and an organizational chart
- Establishing a center Executive board

3.E. Year Five

The fifth year of the NSF I³ project centered on sustaining quality programming and launching the CU-Boulder Center for STEM Learning. Key accomplishments included:

- Holding another successful Symposium on STEM Education
- Continuing the success of the Chancellor's Awards for Excellence in STEM Education
- Expanding the network of CU-Boulder STEM education programs to include 75 separate efforts
- Continuing the success of DBER seminars
- Engaging in local-, state-, and national-level policy work
- Officially launching the Center for STEM Learning (CSL)
- Debuting a new CSL website
- Hiring a Program Manager and Administrative Assistant
- Naming Paul Chinowsky, Noah Finkelstein, and Valerie Otero as co-directors of the center

3.F. Year Six

The sixth year of the NSF I³ project centered on sustaining quality programming and fully operationalizing center structures. Key accomplishments included:

- Revising the organizational chart
- Hiring key center staff
- Launching the fellows program
- Drafting CSL strategy documents
- Being selected as one of eight project sites for AAU's Undergraduate STEM Education Initiative
- Institutionalizing funding for the graduate Chancellor’s Award program

- Serving as the administrative unit for four separate research projects and submitting nine new proposals
- Joining the Bay View Alliance
- Establishing partnerships and collaborations with other STEM education centers
- Engaging in local-, state-, and national-level policy work
- Holding another successful Symposium on STEM Education
- Identifying and reaching out to 85 separate CU-Boulder STEM education programs
- Continuing the success of DBER seminars

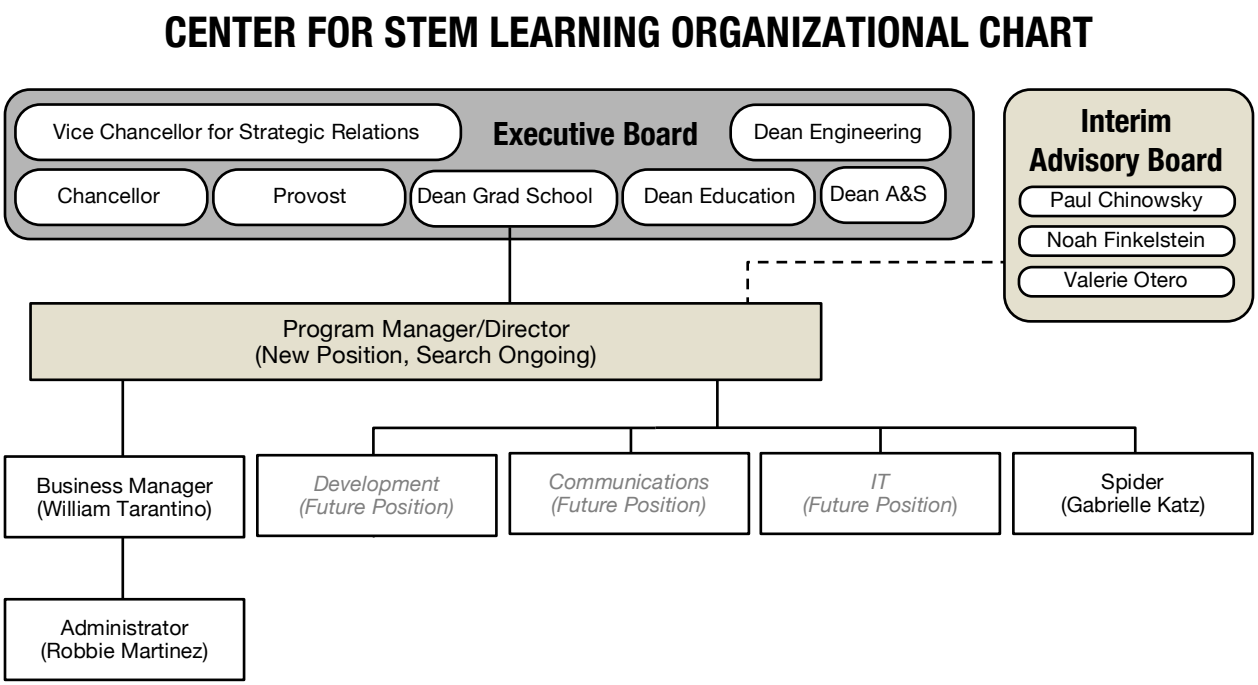
3.G. Overarching Successes

In addition to these concrete accomplishments, overarching successes during the six years of this project have included:

- Incubating and mainstreaming educational transformations that support student learning in STEM fields (e.g., the Chancellor's Awards, DBER, supporting and expanding the LA program, etc.)
- Promoting and legitimizing STEM education, educational transformation, and scholarship within the university (e.g., the annual symposia, recruiting upper-level university administration to serve on the CSL executive board, changing faculty reward systems through the AAU project, etc.)
- Developing a robust campus community and identity around STEM education (e.g., identifying and reaching out to 85+ programs, joining the BVA, connecting with other STEM education centers, etc.)
- Serving as a state, national, and international resource for transformational STEM education practices (e.g., policy work, hosting workshops and visiting scholars from around the world, the publications, presentations, and new funding resulting from this work, etc.)

Funding from the NSF I³ has enabled CU-Boulder to develop an infrastructure of institutional support to improve science, technology, engineering, and mathematics (STEM) education on campus and beyond.

Appendix A. Organizational Chart



Appendix B. Key Center Personnel

B.1. Executive Board

Phil DiStefano, Chancellor. Dr. DiStefano administers the academic policies and programs of the university and provides intellectual leadership for excellence in teaching, recruitment, development, and promotion of faculty, deans, and other academic leaders. He also works to implement diversity plans. Dr. DiStefano also served as CU-Boulder's interim chancellor from January 2005 to July 2006 and is former provost and former dean of the School of Education.

Russell Moore, Provost & Executive Vice Chancellor for Academic Affairs, Professor of Integrative Physiology, Adjunct Professor of Medicine at the University of Colorado Denver. Dr. Moore was appointed as Vice Chancellor for Research in 2006 and as Interim Vice Chancellor for Research in 2009. He began his appointment as Provost and Executive Vice Chancellor for Academic Affairs in October 2010. From 1994-2001, he co-chaired the Flagship 2030 Task Force on Research, Scholarship, and Creative Works. His research interests focus on adaptations of the heart to physiological and pathological stress, particularly when related to heart failure.

Frances Draper, Vice Chancellor for Strategic Relations. Ms. Draper manages communications with government, businesses, and the community for the University of Colorado Boulder. She provides the chancellor with leadership advice on communications and external relations. She also works to unite campus-wide efforts to implement CU-Boulder's Flagship 2030 plan. Prior to her appointment, Ms. Draper served as executive director of the Boulder Economic Council. She holds a BA in Political Science from Stanford University and an MBA with emphasis in marketing from the University of California Berkeley.

Steven Leigh, Dean of the College of Arts & Sciences. Dr. Leigh was appointed in July 2012. Before his appointment, he served as Dean of the College of Liberal Arts & Sciences at the University of Illinois Urbana-Champaign. He received his BA in Anthropology from Northwestern University, his MA in Anthropology from the University of Tennessee, and his PhD from Northwestern University. His research focuses on human and primate evolution and integrates data across numerous fields, including anatomy, genetics, and archaeology. He has previously held teaching and research appointments at the State University of New York, Stony Brook, and at Northwestern University.

Lorrie Shepard, Dean of the School of Education. Dr. Shepard is a professor of Education and chair of the Research and Evaluation Methodology Program at CU-Boulder. Her research focuses on

psychometrics and the use and misuse of tests in education settings. Dr. Shepard is a past president of the American Educational Research Association and the National Council in Measurement in Education. She was elected to the National Academy of Education in 1992 and served as Vice President of the NAS. She has been editor of the Journal of Educational Measurement and the American Educational Research Journal and interim editor of Educational Researcher. In 1999, she won NCME's Award for Career Contributions to educational Measurement. Dr. Shepard currently serves on the National Research Council's Board on Testing and Assessment.

Robert Davis, Dean of the College of Engineering & Applied Science. Dr. Davis has held his appointment since 2002. He received his BS in Chemical Engineering from the University of California, Davis, and his MS and PhD degrees in Chemical Engineering from Stanford University. His research and teaching interests include biotechnology, complex fluids, and membrane separations. He has received countless awards and recognitions, including the National Science Foundation's Presidential Young Investigator Award and a Guggenheim Fellowship. He also holds the Tisone Endowed Chair in Engineering.

John Stevenson, Dean of the Graduate School. Dr. Stevenson has also been a Professor of English since 1982. His emphasis is in British Literature of the eighteenth century, and many of his publications on the subject have garnered national and international recognition. His is the former chair of the English Department, and the former Interim Director of the Program for Writing and Rhetoric. Dr. Stevenson also served as chair of the Flagship 2030 Task Force on Graduate Education in 2008. He was appointed to his current position in March, 2011.

B.2. Interim Advisory Board

Paul Chinowsky is the Mortenson Professor of Sustainable Development in the Department of Civil, Environmental, and Architectural Engineering at the University of Colorado. He is Associate Chair of his department, and chairs the CU-Boulder Faculty Assembly. His research focuses on infrastructure adaptation to climate change and community response to extreme events. He is currently working on research for groups including the Environmental Protection Agency, the United Nations, and the World Bank. Dr. Chinowsky completed his undergraduate education and a Master's degree in Architecture at Cal Poly San Luis Obispo in 1987 and 1988 respectively. He received his PhD in Civil Engineering from Stanford University in 1991.

Noah Finkelstein is a Professor of Physics. Dr. Finkelstein conducts research on physics education, specifically studying the conditions that support students' interest and ability in physics, and developing models of context. He is a director of the Physics Education Research (PER). He is also

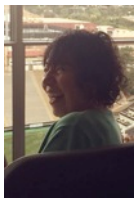
very involved in education policy and serves on many national boards (e.g., APS, AAPT, APLU, and AAU), is a Fellow of the American Physical Society, and a Presidential Teaching Scholar for the University of Colorado system.

Valerie Otero is a Professor of Education. She directs the NSF-DRL Colorado Learning Assistant program, the NSF-DUE Noyce Fellowship program, and co-directs the CU-Teach program. Dr. Otero serves on three national boards, including the American Institute of Physics and the National Task Force for the Professional Preparation of Teachers of Physics. Her research program investigates the recruitment and development of future science teachers and how these students' identities shift as science majors become science teachers and as non-science majors become elementary science teachers. She authored of two nationally recognized curricula in physical science.

B.3. Program Staff

William Tarantino
Business Manager

Gabrielle Katz
Communications Integrator



Robbie Martinez
Administrative Assistant

B.4. CSL Fellows

** Indicates Founding Fellow*

Brian Argrow
Aerospace Engineering Department
College of Engineering and Applied Science

Paul Chinwosky
Civil, Environmental and Architectural Engineering
College of Engineering and Applied Science

Melisa Dancy
Physics Department
College of Arts and Sciences

Stan Deetz*
Communication Department
Graduate School

Anne Dougherty
Applied Math Department
College of Engineering and Applied Science

Mike Dubson
Physics Department
College of Arts and Sciences

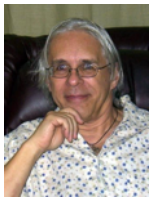
Doug Duncan
Astrophysical and Planetary Sciences Department
College of Arts and Sciences

Noah Finkelstein*
Physics Department
College of Arts and Sciences

Kris Gutierrez
School of Education

Seth Hornstein
Astrophysical and Planetary Sciences Department
College of Arts and Sciences

Anne-Barrie Hunter
Ethnography & Evaluation Research
Center to Advance Research and Teaching in the Social Sciences

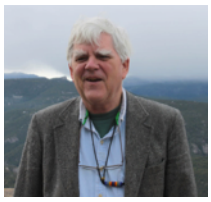


Mike Klymkowsky*
Molecular, Cellular, & Developmental Biology Department
College of Arts and Sciences

Jenny Knight
Molecular, Cellular, & Developmental Biology Department
College of Arts and Sciences

Daria Kotys-Schwartz*
Mechanical Engineering Department
College of Engineering and Applied Science

Laurie Langdon
Learning Assistant Program



Clayton Lewis
Computer Science Department
College of Engineering and Applied Science

Andy Martin
Ecology and Evolutionary Biology Department
College of Arts and Sciences

Brad McLain
XSci

Valerie Otero*
School of Education

Robert Parson*
JILA
Chemistry and Biochemistry Department
College of Arts and Sciences

Bill Penuel
School of Education

Kathy Perkins
PhET Interactive Simulations

Steve Pollock
Physics Department
College of Arts and Sciences

Derek Reamon
Mechanical Engineering Department
College of Engineering and Applied Science

Alex Repenning
Computer Science Department
College of Engineering and Applied Science

Diane Sieber*
Associate Dean for Education
College of Engineering and Applied Science

Beth Stade
Center for STEM Learning

Eric Stade*
Mathematics Department
College of Arts and Sciences

Rob Tubbs
Mathematics Department
College of Arts and Sciences

David Webb
School of Education

Appendix C. Draft CSL Strategy Documents

C.1. Draft Strategic Framework

The Center for STEM Learning (CSL) fosters the incubation and mainstreaming of educational transformations that support student learning in science, technology, engineering and mathematics (STEM) fields and beyond. CSL helps coordinate education transformation at CU-Boulder enhancing the recognition of the university as leader in STEM learning. Transformed education will graduate students uniquely capable of meeting and addressing the challenges of the 21st century.

Though STEM education innovation is percolating through campus, university administration recognizes that the path from innovation to normative practice is difficult for any one individual, program, or department to navigate alone. To enhance campus wide impact – and to translate CU-Boulder's success to the overall field of STEM education – requires a shared platform for knowledge capture and transfer.

CSL will offer a toolbox of resources to help STEM educators navigate the transformational process from innovation to standard practice. Transformative STEM educational practices must be designed, tested, evaluated, refined, shared, and taken to scale. CSL's tools are intended to support innovators at all three stages of transformation:

1. *Stage One* includes innovation, early testing, and refinement;
2. *Stage Two* includes broader testing and evaluation, knowledge capture, and application on a larger scale.
3. *Stage Three* includes knowledge transfer on a large scale.

To help programs through these stages, CSL develops tools, resources, and support structures for:

- *Programmatic Development and Faculty Development*: professionalizing education practice.
- *Research and Development*: fostering development in STEM education, incubating new STEM education activities.
- *Communication and Community*: building the CU-Boulder STEM education community, sharing resources among programs, promoting affiliated efforts and CU-Boulder, and connecting beyond CU-Boulder.
- *Assessment*: supporting formative development for faculty, courses, programs, departments, and the institution itself.
- *Policy and Fundraising/Development*: translating evidence-based best practice into standard practice, through policy, communication, and development channels.

C.2. Draft Mission and Vision Statement Revision

The vision of the CU-Boulder Center for STEM Learning is the transformation of science, technology, engineering, and mathematics (STEM) learning to meet the challenges of the 21st Century at the University of Colorado Boulder, and to serve as a state, national, and international resource for such efforts.

Our mission is to create and sustain an integrated, multi-disciplinary institutional infrastructure to catalyze the transformation of STEM education at CU and beyond. From the Center's interdisciplinary community of scholars and practitioners will emerge: cutting edge education research within STEM fields and departments; effective, applied strategies to promote K20 faculty recruitment, preparation, and professional development; and a powerful, evidence-based voice for meaningful, effective STEM education for the 21st Century. We seek to facilitate change in STEM education beyond CU's campus through the support for, promotion, and evaluation of existing transformation efforts at CU and beyond, sponsorship of new programs, advocacy for diversity and access, and relevant local, state and national policy, as well as fundraising, and communication with the public.

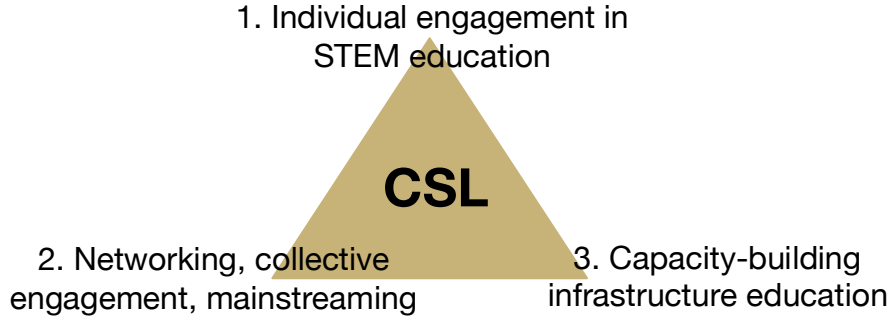
CU Boulder's Center for STEM Learning:

- *Connects*—Maintaining a system of connection on campus and across the country.
- *Experiments*—Supporting individual efforts and sponsoring experiments in priority areas.
- *Evaluates*—Supporting evidence-based practices rather than simply good sounding ideas.
- *Integrates*—Looking across successes to find common qualities and synergies between projects
- *Scales*—Identifies critical elements & Promotes dissemination and institutional transformations necessary make quality efforts sustainable.

C.3. Draft Strategic Goals

Strategic Approach: stitching together and supporting three major goals, while providing dynamic response to STEM education opportunities for CU-Boulder.

Center stitching together and supporting 3 major goals



1. **Support individual engagement in STEM education** (e.g., Engagement, or self-actualization as professionals and learners)
    a. **Support and seed individuals' engagement in STEM educational scholarship (DBER & SOTL)**

i. Increase faculty and graduate students' capacity for course transformation and evaluating outcomes
ii. Increase numbers & capacity of faculty, postdocs, grads in DBER & SOTL
iii. Increased institutional value of engagement in STEM education scholarship (and communication about value)

b. **Improve STEM educational experiences/outcomes for individual students, community, faculty members**
    i. **Course-level** outcomes:
        1. Content
        2. Affect
        3. Expectations
        4. Critical Thinking
        5. Group work
        6. Communication Skills
        7. Items determined by admin, faculty and students
    ii. **Major/degree** outcomes:
        1. Identify by departmental expected outcomes
    iii. **Interdisciplinary** outcomes
    iv. Increase student **access** to STEM majors, esp. for non dominant students
    v. Increase **retention** in fields (of participants)
    vi. Build faculty capacity for **assessing course outcomes** in a scholarly way and to use findings to inform teaching.
    vii. Develop interest, engagement, and capacity for **responsive teaching**
    viii. Improve **satisfaction** for students, staff, and faculty. Bring back the enjoyment of trying out new methods ideas in teaching
c. **Build community/culture/communication around STEM Education supporting individual faculty, staff, students** (We note this is both an action/mechanism and a goal in itself)
    i. Facilitate campus networking opportunities for all
    ii. Fellows program
    iii. Affiliates program

2. **Promote networking, collective engagement, and mainstreaming**
    a. **Sharing models Resources and Scaling across campus**
        i. Create networks across campus (linking programs)
            1. Affiliate Programs
            2. Fellows
            3. Other networks
        ii. Tech solutions for information sharing

iii. Offer a toolbox of resources to help STEM educators navigate the transformational process from innovation to standard practice.
iv. Strategic linking across strata (layers) of campus

b. **Incubating and Creating new models and program**
   i. Seed new programs, models, opportunities, networks, and infrastructure related to above

c. **Networking extramurally**
   i. Regional Efforts
      1. Foster regional community connecting with business, education policy, community, etc.
      2. Connect with State
      3. Seed Front Range coalition
   ii. National & International efforts
      1. MOUs with other institutions
      2. Link with national efforts: AAU, APLU, 100k, etc.
      3. Build national centers network

3. **Create a capacity-building infrastructure for CU-Boulder and the STEM education community more broadly**
   i. Establish mid- and long-term **business plan** (org. and budget)
   ii. **Operational structure** (short–mid term)
   iii. Establish **External Board**
   iv. Build/Enact **Communication plan & materials**
   v. Build thriving **development plan**
   vi. Build institutional identity/perspective/urgency around STEM education

Appendix D. Chancellor's Awards for Excellence in STEM Education

D.1. Faculty, Staff, and Research Scholars

John Basey, College of Arts & Sciences - Ecology & Evolutionary Biology
Variation in Working Memory and the Optimal Design of STEM Labs

Our ultimate goal is to research how cognitive load imposed on students in the form of different designs of inquiry-oriented labs interacts with individual variations in working memory among students to influence learning. As a beginning step, I am re-designing the traditional and guided, diversity-survey-labs in biology (i.e. teacher-centered with guided procedures and a guided write-up) to mirror constructs advocated by science education reform (i.e. student-centered without guided procedures and an open-ended write-up). In addition, the new survey labs begin with "the learning cycle" and are more inquiry-oriented (hypothesis-driven). I will develop and finalize a working model of this new survey lab during summer 2010 and do a test-run in the classroom with an assessment in spring 2011.

Heidi Bustamante, Janet Casagrand, and Teresa Foley, College of Arts & Sciences - Integrative Physiology
Evaluation of the Effectiveness and Success of Inquiry-Based Laboratories In IPHY

The purpose of this proposal is to request support to evaluate the effectiveness and success of the revised physiology laboratories in Integrative Physiology (IPHY). Under the direction of a formal Physiology Lab Revision Committee, the physiology laboratories in IPHY have been transformed from an expository ("cookbook") style of instruction to a more inquiry-based approach. These laboratories serve about 500 majors and non-majors each year, and employ a combination of human and animal experimentation to explore basic physiological principles. Specifically, we are requesting support for Eric Homestead to help conduct student interviews, and to analyze pre-post assessment and student attitude data on the revised physiology laboratories. Eric is currently the lead graduate teacher in IPHY and has been a teaching assistant for the physiology laboratories for several semesters.

Brian Couch, College of Arts & Sciences – Molecular, Cellular, & Developmental Biology
Development of an observation protocol to measure Scientific Teaching

Growing demands for skilled scientists and general science literacy have prompted scientists, educators, and policy leaders to issue several national calls for improving undergraduate science education. In 2003, the National Research Council's report, BIO2010, recommended several changes to undergraduate biology education in light of the increasingly interdisciplinary and quantitative nature of biomedical research. This report inspired the founding of the National Academies Summer Institute for Undergraduate Education in Biology (SI) by Jo Handelsman (Yale) and Bill Wood (CU-Boulder) under the philosophy that science education ought to reflect the nature of

scientific inquiry, incorporate our understanding of how people learn, and ensure equal learning opportunities for students of diverse backgrounds.

With on-going support from the Howard Hughes Medical Institute, the SI continues to bring together faculty members from diverse institutions to develop their teaching skills and to discuss recent innovations in undergraduate biology education. In 2007, the SI curriculum was formalized with the publication of the book Scientific Teaching. Written in plain language, this book synthesizes a large body of education reform literature and presents the reader with a coherent framework for implementing research-based teaching practices. Scientific Teaching has gained widespread influence in the education community, serving as the basis for professional development workshops and as a resource for individuals interested in improving their teaching.

Barbara Demmig-Adams, William Adams, and Sara Wise, College of Arts & Sciences – Ecology & Evolutionary Biology

Comparing the Impact of Faculty-Provided and Online Review Materials

The objectives of this project are to develop and implement an individualized, early intervention for students who have failed one of the first exams in a large biology class, and compare the impact of faculty- versus online-implemented intervention on subsequent exam performance. The interventions will take the form of a supportive, metacognitively-oriented review of specific exam items, which aims to empower students to find patterns in their exam performance and in turn, generate insights into ways to alter their study strategies towards success.

John Falconer and Garrett Nicodemus, College of Engineering & Applied Science - Chemical and Biological Engineering

Biologically-Focused Screencasts and ConcepTests for Chemical and Biological Engineering Courses

The goal of this proposal is to increase the use of biological engineering topics in three core courses in the Chemical and Biological Engineering Department: Material and Energy Balances, Chemical Engineering Thermodynamics, and Fluid Mechanics. We propose to prepare teaching materials that can be readily used by faculty who do not have backgrounds in biological topics. We propose to develop two types of teaching materials that incorporate biological concepts: 1) ConcepTests, which are multiple choice conceptual questions, used in class with clickers to emphasize the important concepts in the course, 2) Screencasts, which are short screen captures of writing and narration on a tablet PC, can be used to solve example problems and provide further explanations. Creating these teaching materials will allow students in these three courses to be exposed to biological concepts earlier in their majors. These courses are taken by both Chemical Engineering majors and Chemical and Biological Engineering majors, and were originally developed for Chemical Engineering majors and thus did not incorporate biological concepts or examples.

Virginia Ferguson, College of Engineering & Applied Sciences – Mechanical Engineering

Assessing YOU'RE@CU: A New Program to Promote Diversity in Engineering

This proposal seeks to improve training and academic preparation of engineering students, who are interested in the combined study of engineering and biology. The PI, along with the BOLD Center, will achieve this by developing a new program that targets women and minority students at the undergraduate and graduate levels: "Your Own Undergraduate Research Experience at the University of Colorado: YOU'RE@CU". We seek to establish a vibrant and diverse research community that increases the accessibility of studying biological materials and medicine from an engineering perspective. Our educational vision is that merging bioengineering research with teaching and providing a range of research opportunities will enhance new student recruitment, improve retention of engineering lower classmen – and particularly target retention of underrepresented minorities and women, encourage undergraduates to seek graduate degrees, and provide mentoring training for graduate students.

Teresa Foley, Chris Link, and Molly Welsh, College of Arts & Sciences - Integrative Physiology

Transformation of the Cell Physiology Laboratories in Integrative Physiology

The purpose of the propose research project is to transform the existing Cell Physiology Laboratories in Integrative Physiology (IPHY) to an inquiry-based approach of instruction that better aligns with the lecture material. We are requesting summer salary support for Instructor Molly Welsh to help develop the Cell Physiology Laboratory materials, including learning goals, assessments, inquiry-based labs and surveys. Mrs. Welsh has been involved with the Cell Physiology course for the past 5 years and she has extensive expertise in the laboratory protocols, ordering new instruments, maintaining inventory, staff support, and quality control.

Eric Frew, College of Engineering & Applied Sciences – Aerospace Engineering

The Sky's the Limit: An Unmanned Aircraft Laboratory ModelThe goal of the Sky's the Limit project is to create, evaluate, and then disseminate new learning material that reflects advances both in unmanned aerospace systems and in what is known about the impact of active learning on engineering education. The centerpiece of the proposed effort is the creation of a complete unmanned aircraft laboratory module. This module will reflect the current state of the art in embedded systems, wireless communication, automatic control, and unmanned systems.

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Erin Furtak, School of Education
Teaching and Learning Biology at CU: Course Evaluation and Revision Project

The proposed research supports a collaboration between two CU STEM faculty members; fosters research into the design and evaluation of instructional strategies and novel course design, and promises to promote a uniquely effective type of course/instruction with great potential to positively impact STEM education, both at CU and nationally. The proposed research will support: a) the completion of the evaluation of the TALB course, its effectiveness as a teacher education and educational research recruitment tool; b) suggest revisions of the course to be implemented when it is offered again in the fall of 2010.

John Gunther, College of Music
Enhancing the Pedagogy of Science, Math, and Technology through Music: Exploring Informal Science Education through the Arts

This proposal seeks to develop methods that enhance the teaching of science, math and technology through music. With the aid of the Boulder Laptop Orchestra (BLOrk), an electronic music ensemble at CU, we hope to expand the possibilities available to pedagogy in math, science, and technology and develop ways to engage in informal science education with students and audiences through the arts. Funds are requested to aid in the development of: 1) Visual and sonic representation of scientific data serving as a means to connect scientific research to a wider audience. 2) Development of computer applications that allow the users to explore interactive simulations of physical phenomena while performing for or with audience members. We believe that informal science education can happen in a variety of settings and mediums and we hope to form a foundation on which future instruction and performance can integrate science as a central component.

Kris Gutierrez, School of Education
When Scientific and Everyday Knowledge Grow into One Another: Designing for Robust Science Learning for Students from Non-dominant Communities

This project joins CU professors, PhD and undergraduate students, and a local school in an interdisciplinary effort to create and study an innovative technology-based after-school program called El Pueblo Mágico (EPM). Joining students from CU and Alicia Sanchez Elementary, a school with low-income and Emerging Bilingual student populations, EPM engages students collaboratively in computer, science, and health science based activities to engage students in multi modal forms of learning about science. In fall of 2010, we launched EPM, piloting new technology and science-oriented activities, supported by our CU collaborators in Computer Science: design software by Alex Repenning & Andri Ioannidou (AgentSheets); and a computer-mediated fabrication curriculum by Michael Eisenberg & Jane Meyers (Craftopolis). We aim to examine how multi-age groups learn together in technology-mediated activity as designers who will also gain valuable forms of multi modal expertise within a vibrant, technology-rich learning community. An overarching goal of this design experiment is to introduce undergraduates and children to high status knowledge about digital design, energy-use, science, and health in ways that helps them leverage their

everyday understandings to develop robust science concepts, practices, and dispositions.

Victoria Hand, School of Education
Examination of shifts in understanding and imagined trajectories for underrepresented students serving as mentors for Science Explorers

The proposed grant will support a research study that investigates a mentoring opportunity for high school students from underrepresented backgrounds who excel in mathematics and science. The STEMsation mentoring program represents a collaboration between the School of Education, the CUTeach program, Science Explorers, and several STEM-focused high schools in Colorado. The program will train underrepresented high school students as mentors for the Science Explorers workshop in their district. We hypothesize that participation in STEMsation will provide the mentors with: (1) a deeper and more connected understanding of STEM domains; (2) an ability to distinguish between higher- and lower-level scientific and mathematical reasoning, and (3) an opportunity to reflect on and potentially overcome negative stereotypes and structural barriers faced by underrepresented groups of individuals in STEM fields.

Katie Hinko, Graduate School - JILA
Characterizing the Development of University Students who Participate in Informal STEM Programming

We seek to investigate the impact on university students who participate in informal STEM programs. While University informal STEM programs geared toward K-12 children or community members often report outcomes in terms of these groups, our work will focus on the university educators (UEs) who participate in these informal programs, providing insight into the less-studied group. These findings will inform university support for and design of informal STEM programming, as well as have broad implications for all types of informal STEM environments. For this project, we will primarily study university physics students who participate in the University of Colorado Boulder (CU Boulder) Partnerships for Informal Science Education in the Community (PISEC) programs. PISEC is supported by the CU Boulder Department of Physics and the JILA Physics Frontier Center and whose main programming component consists of weekly, after school physics clubs for underrepresented populations in grades K-8. This program relies on physics undergraduate and graduate UEs to interact with children, teachers and community members as both scientists and educators. For this project, we will design assessments and implement pilot studies of the UEs by building on initial findings from our program that indicate the potential for improvement in the communication and pedagogical skills of UEs, as well as positive shifts in their affect and self-efficacy as scientific communicators and teachers.

Tiffany Ito, College of Arts & Sciences – Psychology
A Classroom Intervention to Reduce the Gender Achievement Gap in College Science

The proposed research focuses on the effectiveness and dissemination of a classroom intervention designed to reduce the gender gap in the achievement of

women in STEM disciplines. We have conducted an initial test at CU of the effectiveness of a writing exercise that affirms self-worth, finding that it raises the grades and conceptual mastery of women in introductory physics (Miyake et al., 2010). These initial findings are very promising, but we currently lack any funding to explore them further. Funds are requested to extend our findings through studies both at CU and elsewhere. This will allow us to (1) better understand the mechanisms through which women's STEM performance can be improved, focusing specifically on the psychological changes that are produced by self-affirmation which in turn improve performance. Knowing this is important theoretically and can also be used to refine and sharpen our intervention. The proposed research will also (2) test the effectiveness of our intervention in other contexts (e.g., courses with different content, professors with different teaching styles, students of various demographics), (3) provide necessary data for a larger grant focusing on dissemination of the intervention, and (4) bring psychological perspectives more explicitly into CU's work on STEM education.

Shaw Ketels, College of Arts & Sciences - Psychology
A New Approach to Teaching General Psychology at CU

This proposal describes a "flipped classroom" approach to teaching General Psychology, with the goal of promoting abstract and critical thinking, and laying the foundations for an evidence-based understanding of the world. Class time will be used for the guided completion of projects contributing to the construction of these cognitive skills. Projects will utilize various software packages that students will then use in many of their other classes in this and other departments, and will involve generating and testing hypotheses about cognition, emotion, and behavior. Students will gain skills in conducting literature reviews and questionnaire-based experiments, and get practice thinking systematically about their own hypotheses. The class will leverage the extensive expertise of faculty in the Department of Psychology and Neuroscience at CU, as well as professors from other departments who are affiliated with the Institute of Cognitive Science. Curriculum construction will involve creating digital video of these faculty lecturing on or discussing their domains of expertise. In this manner, students in the class will be exposed to a scientific approach to understanding the world from investigators at the forefront of their respective fields.

Jenny Knight, College of Arts & Sciences – Molecular, Cellular, & Developmental Biology
Development of a Capstone Concept Assessment to measure integrated content retention in biology

The intent of this proposal is to begin developing a Capstone Molecular Biology Concept Assessment (Capstone MBCA) to evaluate how well graduating seniors in Molecular Cell and Developmental Biology (MCDB) can integrate and apply concepts from all their coursework. Such an assessment tool will have widespread impact in supporting the transformation of undergraduate education and providing a resource to evaluate meaningful student learning. Some of the expected uses of this tool are: 1. To measure the level of conceptual learning in graduating biology majors, 2. To measure conceptual learning gains between beginning and end of final year of coursework, 3.

To measure the level of content retention after graduation, 4. To help determine which different models of pedagogy can help to promote long-term content retention and integrative abilities. The Capstone MBCA can be used not only at CU, but at any college or university department that teaches genetics, molecular biology, and cell biology, across the nation and internationally. It may also be valuable to science educators in other disciples, as well as to science teachers at the secondary school level.

Heather Lewandowski and Charles Rogers, College of Arts & Sciences – Physics
Learning Goals and Course Materials for Advanced Undergraduate Physics Laboratories

In Physics, we recognize and teach that experiment is an extraordinarily powerful method for judging and differentiating competing ideas. Although most physics majors are required to take an upper-level laboratory course, these courses are seldom effective at teaching students the necessary skills to carry out independent research beyond the classroom setting. We are requesting support for the development of learning goals, coordinated course materials, and a preliminary online evaluation survey for the upper-level "advanced laboratory" courses, PHYS3340, PHYS4430, and PHYS5430.

Clayton Lewis, College of Engineering & Applied Sciences – Computer Science
Video Resources for Lower Division Computer Science Curriculum

This project aims to improve the effectiveness of Computer Science pedagogy by developing, evaluating, and sharing the practice of providing short video modules that students can view before class and review after class. This two-year study will develop and evaluate materials for four lower division courses, and assess the costs of creating and using these materials. In the longer term, the project aims to extend this approach to the remaining curriculum, while at the same time providing a model for creating and sharing such materials that can be widely adopted elsewhere.

Steven Pollock, College of Arts & Sciences – Physics
Development of Pre-Post Tests for Upper Division Electricity and Magnetism Tutorials

This research study is part of a broader effort to move beyond research and development of curricular reforms at the introductory level, in order to better address the specialized needs of students in upper-division physics courses.

Beth Stade, College of Arts & Sciences – Department of Mathematics
STEM Talking: Aligning and Improving the Mathematical Education of Pre-Service Teachers

This proposal will fund the alignment with the Common Core Standards and redesign of MATH 1110: The Spirit and Uses of Mathematics, the University of Colorado mathematics content course for prospective elementary teachers, and develop an set of teaching assistant resources and professional development to assist systemic continuity and effectiveness in the course. Mathematics is the language of STEM, science, technology, and engineering. Without the fundamental understanding

of mathematics, students will struggle to have success in STEM related disciplines. Unfortunately, many elementary teachers are not only ill-prepared in mathematics, but also pass on poor attitudes and math stereotypes to their students. In 2010, a study published in the Proceedings of the National Academy of Science, made newspaper headlines showing that female elementary teachers who share their anxiety about math pass on that anxiety to their students and lower test scores. (Los Angeles Times, Jan. 26, 2010; Beilock, 2010). The need for effective pre-service mathematic content is well documented in "The Impact of Content Courses on Pre-service Elementary Teachers' Mathematical Content Knowledge" (Matthews, 2010).

Jane Stout, College of Arts & Sciences – Department of Psychology & Neuroscience
Connecting with others versus doing science: Exploring how communal goals might explain the gender gap in STEM participation

The proposed research aims to assess the degree to which students' life goals affect their interest, success and retention in STEM. Although a host of factors contribute to students' engagement in STEM, one understudied issue is whether and how congruency between students' life goals and perceptions about their ability to meet those goals in STEM might affect their engagement therein. For example, students may select their academic major based on the belief that the major will lead to a career that facilitates their ability to meet their life goals. Moreover, students might continually evaluate whether their selected major is living up to their expectations of meeting their life goals. If they perceive that it is not, they may feel as though they do not "fit" in the major, fail to see the value of the major, have low expectations for success, and, ultimately, drop out of that major. We propose that this incongruence between life goals and perceptions about a major's ability to meet those life goals occurs particularly among women in STEM, leading to (a) fewer women in some (but not all) disciplines within STEM and (b) women's tendency to drop out of certain STEM career paths. We propose two field studies that would test these suppositions in order to glean a stronger understanding of when and why gender disparities occur in STEM disciplines. Importantly, this work would pave the way for the development of empirically-rooted intervention strategies to boost students' engagement in STEM disciplines they might otherwise perceive to be inconsistent with their life goals (see Impact of Proposed Project section for more details on structuring interventions).

Ben Zwickl, College of Arts & Sciences - Physics
A comparative study of different forms of assessment in laboratory settings

Laboratory courses are unique learning environments. Compared to lecture courses, they typically involve more resources per student in terms of expense, equipment, space, contact hours with instructors, and low student/teacher ratios. They are also learning environments that emphasize a broad range of learning goals, going beyond content learning goals to include a range of scientific practices, including written and oral communication, experimental design, data analysis, and others. Despite the abundance of resources and goals that often closely align with scientific practice, laboratory courses often produce unsatisfying or uncertain outcomes of student learning. In addition, national calls have been made for lab courses that

engage students in more disciplinary-relevant activities as a mans to improve recruitment and retention of students in STEM. For decades, efforts have been made to transform laboratory environments across the sciences, with "inquiry-based" being one of the more popular approaches. However, even now, it is difficult to compare the efficacy of these innovations, and it is equally difficult for instructors to implement meaningful assessments in their laboratory courses. In spite of the need, the STEM education community has few assessment tools for laboratory teaching environments. Doing robust assessment in these environments has remained a long-standing challenge in laboratory instruction and physics education research.

D.2. Graduate Scholars

Lindsay Anderson, College of Arts & Sciences - Psychology
Adviser: **Alice Healy**
Understanding the Components of the iClicker System that Promote Learning, Retention, and Generalization of Classroom Knowledge

Nathan Canney, College of Engineering & Applied Science - Civil and Environmental Engineering
Adviser: **Angela Bielefeldt**
An assessment for teaching methodologies for instilling social responsibility in undergraduate civil engineering students

David Cheeseman, College of Engineering & Applied Science - Computer Science
Adviser: **Michael Main**
Tablet Teaching Pilot Program

Corrie Colvin Williams, College of Architecture & Planning
Adviser: **Louise Chawla**
Significant Life Experiences: Exploring the lifelong influence of environmental and science education in program participants

Ryan Grover and **Louisa Harris**, School of Education
Advisers: **David Webb** and **Victoria Hand**
A Longitudinal Study of the Implementation and Impact of LAs on Teaching in Undergraduate Mathematics

Ian Her Many Horses, School of Education
Adviser: **Valerie Otero**
What types of curriculum support do elementary students need to successfully develop computational thinking practices within 2D and 3D environments?

Heidi Iverson, School of Education
Advisor: **Erin Furtak**

What Works in Undergraduate Physics Education? A Research Synthesis

Susanna Kohler, College of Arts & Sciences - Astrophysical & Planetary Sciences
Advisor: **Seth Hornstein**
Can we train scientists to communicate effectively with the public?

Lauren Kost-Smith, College of Arts & Sciences – Physics
Adviser: **Steven Pollock**
Investigating the Gender Gap in Undergraduate Physics Courses

Jeffrey LaMarche, College of Engineering & Applied Science - Computer Science
Advisor: **Tom Yeh**
Developing User Interface and Peer Instruction: Assessing Results on Engagement, Retention, and Failure Rate for CSCI 1300 Introduction to Computer Programming

Krista Marshall, School of Education
Advisers: **Alexander Repenning** and **David Webb**
Targeting the Technology Gender Gap: Making Computer Science Engaging and Accessible for All Students

Alexandra Mass, College of Engineering & Applied Science - Civil, Environmental, and Architectural Engineering
Adviser: **Diane McKnight**
Enhancing Environmental Literacy and Interest in Polar Sciences for Primary School Children in the Boulder Valley School District and Beyond

Jane Meyers, College of Engineering & Applied Science - Computer Science
Adviser: **Michael Eisenberg**
Learning Computer Science the Craftopolis Way

Calvin Pohawpatchoko, College of Engineering & Applied Science – Computer Science
Adviser: **Clayton Lewis**
Digital Age: An Old Method New Again - Rethinking Nation Building in a Digital Age: Piloting Cognitive Apprenticeship in Indigenous Nation Building

Ian Renga, School of Education
Adviser: **Jennie Whitcomb** and **Erin Furtak**
A Study of STEM Teacher Candidates' Learning in a Course Facilitating Collaborative Inquiry into Teaching Practice

Sarah Roberts, School of Education
Adviser: **Erin Furtak**
Reforming Undergraduate Biology Teaching Through Formative Assessment

Michael Ross, School of Education
Adviser: **Valerie Otero**
Transforming the Classroom Power Structure to Impact Physics Learning

Benjamin Spike, College of Arts & Sciences – Physics
Adviser: **Noah Finkelstein**
An Examination of Conceptions of Teaching and Learning Physics in Graduate TAs and Undergraduate LAs

Seyitriza Tigrek, College of Engineering & Applied Science - Electrical Engineering
Advisor: **Frank Barnes** and **Melinda Piket-May**
Developing an Adaptive Method for Teaching Mobile (Phones) Programming to Freshman Engineering Students

Kim Trenbath, College of Arts & Sciences – Atmospheric & Oceanic Sciences
Adviser: **Linnea Avallone**
Undergraduate Students' Climate Change Conceptions

Ben Van Dusen, School of Education
Adviser: **Valerie Otero**
Empowering Students through the Use of iPad Technology

Colin Wallace, College of Arts & Sciences – Astrophysical & Planetary Sciences
Advisor: **Doug Duncan**
Understanding Students' Difficulties with Cosmology

D.3. Resulting Peer Reviewed Papers and Publications

Anderson, L. S., Healy, A. F., Kole, J. A., & Bourne, L. E. (2011). Conserving time in the classroom: The clicker technique. The Quarterly Journal of Experimental Psychology, 64(8), 1457-1462.

Anderson, L. S., Healy, A. F., Kole, J. A., & Bourne, L. E. (2013). The Clicker Technique: Cultivating Efficient Teaching and Successful Learning. Applied Cognitive Psychology, 27(2), 222-234.

Stephanie Chasteen, Steven Pollock, Rachel Pepper, Katherine Perkins. "Thinking like a physicist: A multi-semester case study of junior-level electricity and magnetism," American Journal of Physics, v.80, 2012, p. 923.

Stephanie V. Chasteen, Steven J. Pollock, Rachel E. Pepper, and Katherine K. Perkins. "Transforming the junior level: Outcomes from instruction and research in E&M," Phys. Rev. ST Phys. Educ. Res., v.8, 2012, p. 020107.

Stephanie V. Chasteen, Rachel E. Pepper, Marcos D. Caballero, Steven J. Pollock, and Katherine K. Perkins. "Colorado Upper-Division Electrostatics diagnostic: A conceptual assessment for the junior level," Phys. Rev. ST Phys. Educ. Res., v.8, 2012, p. 020108.

Chasteen, S.V., S. J. Pollock, R. E. Pepper, and K. K. Perkins, “Thinking like a physicist: A multi-semester case study of junior-level electricity and magnetism”, American Journal of Physics 80#10, p. 923 (2012)

Chasteen, S.V., S. J. Pollock, R. E. Pepper, and K. K. Perkins, “Transforming the junior level: Outcomes from instruction and research in E&M”, PhysRev: ST Phys Ed. Rsrch 8, 020107 (2012)

Brian A. Couch, William B. Wood, and Jennifer K. Knight. The Molecular Biology Capstone Assessment: A Conceptual Assessment for Upper-Division Molecular Biology Students. Submitted to CBE-Life Sciences.

Brian A. Couch, Tanya L. Brown, Tyler J. Schelpat, Mark J. Graham, Jennifer K. Knight. Scientific Teaching: Defining a Taxonomy of Observable Practices. CBE-Life Sciences Education

Brian A. Couch, William B. Wood, and Jennifer K. Knight. The Molecular Biology Capstone Assessment: A Conceptual Assessment for Upper-Division Molecular Biology Students. Submitted to CBE-Life Sciences.

J.L. Falconer, G. Nicodemus, J. deGrazia, J.W. Medlin, “Chemical Engineering Screencasts”, Chemical Engineering Education 46, 58-62 (2012).

Kost, L., S. Pollock and N. Finkelstein, “Gender Differences in Introductory Physics: The Impact of a Self-Affirmation Intervention”, APS CSWP Gazette Newsletter, Fall 2011.

L. Kost, S. Pollock and N. Finkelstein, "Gender disparities in second-semester college physics: The incremental effects of a smog of bias," Phys. Rev. ST Physics Ed. Research, 6, 020112, (2010).

L. Kost, S.J. Pollock, and N. Finkelstein, “Characterizing the gender gap in introductory physics,” Physical Review ST: Phys Educ. Research, 5, 010101 (2009).

A.Mikaye, L. Kost, N.D. Finkelstein, S. Pollock, G. Cohen, T. Ito, “Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation" Science 330(6008) pp. 1234-1237 (Nov 26, 2010)

G. D. Nicodemus, J.L. Falconer, J.W. Medlin, J. deGrazia, K, McDanel, “Screencasts for Enhancing Chemical Engineering Education”, Proceedings of American Society of Engineering Education, in press (2014).

Rachel E. Pepper, Stephanie V. Chasteen, Steven J. Pollock, and Katherine K. Perkins. "Observations on student difficulties with mathematics in upper-division electricity and magnetism," Phys. Rev. ST Phys. Educ. Res, v.8, 2012, p. 010111.

B. Spike and N.D. Finkelstein, “Preparing Tutorial and Recitation Instructors: A Pedagogical Approach to Focusing Attention on Content & Student Reasoning,” Am. J. Phys. 80, 1020 (2012).

Stoll, K., Spuck, T, (editors), 2013, The Power of Partnerships: A Guide from the NSF Graduate STEM Fellows in K-12 Education (GK-12) Program, American Association for the Advancement of Science (AAAS), Pohawpatchoko, C. C. Jr. (Contributor), Retrieved from: http://www.gk12.org/2013/06/10/the-power-of-partnerships-a-guide-from-the-nsf-gk-12-program/

C. Wallace and S. Chasteen (2010), "Upper-division students' difficulties with Ampere's law", Physical Review ST PER, 6, 020115.

"An epistemology and expectations survey about experimental physics: Development and initial results," B. Zwickl, T. Hirokawa, N. Finkelstein, and H. J. Lewandowski, under review PRST-PER (2014)

"Incorporating Learning Goals about Modeling into an Upper-Division Physics Laboratory Experiment," B. Zwickl, N. Finkelstein, and H. J. Lewandowski, in press American Journal of Physics (2014)

"The Process of Transforming an Advanced Lab Course: Goals, Curriculum, and Assessments," B. Zwickl, N. Finkelstein, and H. J. Lewandowski, American Journal of Physics 81, p 63 (2013)

D.4. Resulting NSF Grants

Award #	Title	Start Date	End Date	Amount	Principal Investigator(s)
1023028	Developing research-based Tutorials in Upper-division Electricity and Magnetism	9/15/10	8/31/13	$530,906.00	Steven Pollock (PI), Paul Beale, Michael Dubson, and Katherine Perkins
1043028	Using a Research-based Approach to Reform Upper-division Laboratory Courses	5/1/11	4/30/13	$199,747.00	Heather Lewandowski (PI), Paul Beale, Noah Finkelstein, and Katherine Perkins
1055989	CAREER: Reverse-Engineering the Bone-Cartilage Interface for Successful Joint Repair - Coupled with a New Program to Promote Diversity in Rehabilitative Engineering	2/1/11	1/31/16	$445,024.00	Virginia Ferguson
1140789	Investigating Instructional Influences on the Productivity of Clicker Questions	6/1/12	5/31/15	$196,672.00	Jennifer Knight (PI), Sarah Wise, and Erin Furtak
1244183	Resources to Implement Flipped Chemical Engineering Classrooms	2/1/13	1/31/15	$200,000.00	John Falconer (PI), Janet deGarazia, J. William Medlin, and Garret Nicodemus
1251590	Broadening Women's Participation in STEM: The Critical Role of Belonging	9/1/13	8/31/16	$1,030,439.00	Tiffany Ito (PI), Steven Pollock, Noah Finkelstein, and Jane Stout
1322300	Collaborative Research: Screencasts for Enhancing Chemical Engineering Education	9/15/13	8/31/16	$546,718.00	John Falconer (PI), Janet deGarazia, J. William Medlin, and Garret Nicodemus
1322364	Collaborative Research: Navigating from Vision to Change with Bio-MAPS	9/15/13	8/31/16	$153,236.00	Jennifer Knight (PI), and Brian Couch

1323019	Collaborative Research: Impact of Summer Institutes on Faculty Teaching and Student Achievement	1/1/14	12/31/17	$476,146.00	Jennifer Knight (PI) and Brian Couch
1323101	Incorporating Modeling Into Upper-division Physics Labs	9/15/13	8/31/16	$599,920.00	Heather Lewandowski (PI), Noah Finkelstein, and Katherine Perkins
1423496	Pathways: Measuring the Impact of Participation in Informal STEM Programming on University Students	9/1/14	8/31/16	$299,780.00	Kathleen Hinko (PI), and Noah Finkelstein
				$4,678,588.00	

Appendix E. New Grant Proposals Submitted

PI	Status	Sponsor	Title	Total
Dancy, Melissa	FUNDED	NSF	Collaborative Research: Community College Roots of STEM: Interactive Influences of Individual, Secondary School, and College Factors that Predict the Success of Underrepresented Groups	$287,116
Hinko, Kathleen	FUNDED	NSF	Pathways: Measuring the Impact of Participation in Informal STEM Programming on University Students	$299,780
Perkins, Katherine	FUNDED	Royal Society of Chemistry	2013_RSC-PhET HTML5 Chemistry Simulation Project	$80,000
Perkins, Katherine	FUNDED	Gordon and Betty Moore Foundation	Pioneering Next-Generation Assessments of STEM Learning	$871,133
Perkins, Katherine	FUNDED	NSF	Using Research-based Simulations to Transform Undergraduate Chemistry Education	$40,868
Chasteen, Stephanie		NSF	Scalable Transformation: Developing a Model of Effective Faculty Development through Online Multimedia Resources	$676,361
Hertzberg, Jean		University of Washington	Reflection in Engineering Education	$200,000
Hinko, Kathleen		NSF	Pathways: Measuring the Impact of an Informal Physics Program on University Students	$248,866
McLain, Bradley		Twin Cities Public Television	Latina SciGirls	$241,449
McLain, Bradley		Twin Cities Public Television	VideoPower: Participatory Video and Video Narratives as a Novel Approach to Engaging Underrepresented Minority Girls in STEM	$24,026
Moore, Russell		NSF	WIDER: Scaling Undergraduate STEM Transformation and Assessment through Institutionalizing Norms [SUSTAIN]	$1,293,587
Otero, Valerie		NSF	Collaborative Research: Multiple Pathways - How Does Reform-oriented Teaching Develop and Persist?	$481,891
Otero, Valerie		NSF	Collaborative Research: Teaching Assistants as a Catalyst for Institutional Transformation (TACIT)	$160,862
Otero, Valerie		NSF	Collaborative Research: Teaching Assistants as a Catalyst for Institutional Transformation (TACIT)	$567,621

Perkins, Katherine	NSF	Collaborative Research: Educational transformation through online faculty development: A research-based approach using PhET Interactive Simulations and the PER User's Guide	$2,998,870
Stade, Elisabeth	NSF	Pathways STEM Rooted in the Community - A Math Exhibit in a Public Park	$249,955
Stade, Elisabeth	NSF	Photo Origami Research for Teachers and Students (supplement to NSF Award 1240374)	$99,992
			$8,822,377

Appendix F. CU-Boulder STEM Education Programs

F.1. Pedagogy- and Tools-centered Programs

Screencasts for Flipped Engineering Classes

Department of Chemical and Biological Engineering

The flipped classroom approach utilizes screencasts to provide lecture materials (i.e. introductory topics, example problems, etc.) to students prior to class. Students receive instruction through videos at their own pace and come to class prepared to work through problems and conceptual questions. Instructors utilize class time to work out examples similar to those in homework and tests, and address students misconceptions using conceptests and clickers. Class time is spent working with students rather than lecturing, and this all starts with creating useful screencasts. 675 screencasts we have already created and posted online at www.learncheme.com, YouTube, and iTunesU. To date, there have been over 750,000 views/downloads of the videos and the current monthly average is over 100,000.

BSI Undergraduate Research - Outcomes and Evaluation

Biological Science Initiative, and Ethnography & Evaluation Research

UCB's Biological Sciences Initiative (BSI) (http://www.colorado.edu/Outreach/BSI/) envisions scientific literacy among all citizens, increasing their understanding of the relevance of science to their lives and empowering them to make informed health, environmental and political choices. To promote diversity and inclusiveness in the sciences and scientific literacy, BSI provides research, classroom and professional development experiences to those interested in the biosciences at all levels, while particularly serving those with limited opportunities and/or from groups traditionally underrepresented in the sciences.

Teaching New Tools to Majors: Computational Instruction in Upper-Division Physics

Department of Physics

Scientific programming is a key skill for our majors to develop in a research environment that relies increasingly on computational models and complex data analysis. Broad consensus of physics faculty at CU-Boulder is that instruction in scientific programming should not be limited to a single course (i.e., a computational physics course), but rather be embedded in the major sequence. This sentiment is echoed by a survey of physics majors. At CU-Boulder, we have begun systematic instruction in scientific programming in our middle-division classical mechanics and upper-division senior laboratory courses.

What we learned when transitioning psychology labs from a cookbook to inquiry-based format

Department of Psychology and Neuroscience

The purpose of this project was to evaluate the effectiveness and success of the revised physiology laboratories in Integrative Physiology (IPHY). These laboratories serve about 500 IPHY majors and non-majors each year, and employ a combination of human and animal experimentation to explore basic physiological principles. Under the direction of a formal Physiology Lab Revision Committee, the physiology laboratories in IPHY were transformed from an expository or "cookbook" style of instruction into a more inquiry-based approach.

Transforming Upper-Division Electrodynamics
Department of Physics

We are researching student learning in the context of advanced undergraduate electrodynamics, and developing course materials designed to actively engage students during lecture (including clicker questions and other in-class activities) and assessments for an active-learning curriculum, such as an instrument for assessing whether our faculty-consensus learning goals are being met.

University of Colorado Museum's Fossils in the Classroom Project
CU Museum and Department of Geological Sciences

The aim of the Fossils in the Classroom Project is to engage elementary students and teachers in communities across Colorado in the study of the ancient prehistory of Colorado through hands-on experiences with fossil animals and plants that once lived in the state, and to get students turned on to science through paleontology. In 2009, the Colorado Department of Education adopted new state academic standards that, for the first time, specifically included the study of fossils. Unfortunately, there were very few resources available to address this new standard, and teaching resources were limited. The University of Colorado Museum's Fossils in the Classroom project directly addresses this new Colorado State Curriculum Standard related to fossils for 4th grade students and provides a much needed resource for students and teachers statewide.

The Process of Transforming an Advanced Lab: Goals, Curriculum, and Assessments
Department of Physics and JILA

A thoughtful approach to designing and improving labs, particularly at the advanced level, is critical for the effective preparation of physics majors for professional work in industry or graduate school. With that in mind, physics education researchers in partnership with the physics faculty at the University of Colorado Boulder have overhauled the senior-level Advanced Physics Lab course. The transformation followed a three part process of establishing learning goals, designing curricula that align with the goals, and assessment. Similar efforts have been carried out in physics lecture courses at the University of Colorado Boulder, but this is the first systematic research-based revision of one of our laboratory courses. The outcomes of this effort include a set of learning goals, a suite of new lab-skill activities and transformed optics labs, and a set of assessments specifically tailored for a laboratory environment. While the particular selection of advanced lab experiments varies widely

between institutions, the overall transformation process, the learning goals, and the assessments are broadly applicable to the instructional lab community.

Introduction to Engineering: Preparing First-Year Students
College of Engineering & Applied Science

Based upon research into how the first-year experience influences engineering-discipline major choices and retention a 1-credit course, designed to introduce the engineering profession and to prepare students to make an informed discipline-major choice was piloted in fall 2011. A second, 2- credit pilot is currently underway with an enrollment of about half the incoming freshman class that includes the majors of aerospace engineering and mechanical engineering, and those choosing the open option. In the original pilot, each student attended a 50-minute plenary session and a 50-minute discipline module each week. These are now expanded such that each student now attends a 75-min plenary session and a 75-minute "discipline module each week.

Leveraging Horizontal Expertise to Cultivate STEM Knowledge and Practices among CU Undergraduate and Elementary School Students
School of Education

This program fosters a partnership among professors, researchers, and students at CU-Boulder in Computer Science and Education with k-5 students at a local Lafayette elementary school serving low income and Hispanic students. The partnership aims to leverage university expertise to cultivate STEM knowledge and practices among CU undergraduates and elementary school students. CU undergraduates and grade 2 – 5 students work, play, and learn together as they engage with STEM and new media technologies within intergenerational ensembles at an after school club. A goal of the partnership is to expand practices among all partners, and to generate new perspectives on teaching and learning across contexts. Together we are working to find ways to engage elementary aged students in computational thinking and science content areas through the new media practices and technologies that permeate youthful media ecologies.

T*eaching the Greenhouse Effect*
CIRES

The greenhouse effect comes up in most discussions about climate change – whether or not a person accepts the evidence about anthropogenic climate change. It is a key concept related to climate change. To support students' understanding of the greenhouse effect, educators need scientifically accurate and pedagogically effective lessons. Research shows that hands-on experimental exercises are one powerful way to reinforce student learning. Unfortunately, the greenhouse effect is a challenging concept around which to design hands-on activities. There are two basic approaches readily available to teachers (a hands-on experiment and a numerical Phet-simulation).

Integration of Science, Technology, and Society (STS) Courses into the Engineering Curriculum and Beyond

University of Colorado Denver, and University of Georgia

The Accreditation Board for Engineering and Technology (ABET) requires core classes in the humanities and social sciences for accredited engineering programs. A unique set of course offerings at the University of Colorado Denver speaks to these requirements by addressing race, gender, and cultural differences in the context of societal change, contemporary issues, and technology. Professional engineers are responsible for the design of safe and reliable infrastructure, public health and safety, and the environment. As a result, it is critical that engineering graduates understand the impacts that technology has on individuals, society, and the environment.

Exploring Informal Science Education through the Arts

College of Music

This is an effort to develop methods that enhance the teaching of science, math and technology through music. With the aid of the Boulder Laptop Orchestra (BLOrk), an electronic music ensemble at CU, we hope to expand the possibilities available to pedagogy in math, science, and technology and develop ways to engage in informal science education with students and audiences through the arts. The project focuses on the development of: 1) Visual and sonic representation of scientific data serving as a means to connect scientific research to a wider audience, and 2) the development of computer applications that allow the users to explore interactive simulations of physical phenomena while performing for or with audience members. We believe that informal science education can happen in a variety of settings and mediums and we hope to form a foundation on which future instruction and performance can integrate science as a central component.

Art for the Sake of Improving Attitudes Toward Engineering

Department of Mechanical Engineering and the School of Education

Since 2003, a course called Flow Visualization (Flow Vis) that incorporates art and engineering has been offered to mixed teams of engineering and fine arts photography and video students at the University of Colorado, Boulder. The course is focused on the art and physics of flow visualization.

Conceptually-oriented, scaffolded, and socially-interactive course design with embedded Socratic formative assessments

Department of Molecular, Cellular, & Developmental Biology, University of Colorado Boulder, Departments of Computer Science and Chemistry, Clemson University

Scientific concepts are generally counter-intuitive and require hard and slow, rather than fast and easy thinking. Moreover, and particularly in biology, these ideas can have personally and socially disconcerting implications. To help students master difficult ideas and skills requires a scaffolded, targeted approach with clear and well articulated goals defined in terms of a coherent curriculum and realistic performance expectations (and the implied knowledge required to perform them). It also requires that student are encouraged to engage, and practice using the ideas and facts to be mastered.

Inquiry Hub: Customizing Curriculum and Digital Resources for STEM Education
University of Colorado Boulder, and University Corporation for Atmospheric Research

The Inquiry Hub (iHub) is an online instructional tool designed by teachers, for teachers, to assist in planning and implementing differentiated instruction for diverse student populations. Through an ongoing participatory design process, classroom teachers provide feedback on the system and propose new development ideas based on their current needs. The iHub provides educators with access to materials aligned to standards and the curriculum, including publisher materials (i.e. electronic text books, assessments), vetted digital STEM resources (i.e. animations, videos, images, and data) from the Digital Library for Earth System Education and the National Science Digital Library, and teacher-contributed materials (i.e. PowerPoints, images, homework assignments).

ECSITE - Engaging Computer Science in Traditional Education
Department of Computer Science, University of Colorado Boulder

Computing, computational thinking, and computer science have become essential to many fields, but this fact has not been communicated clearly to the public. In particular, K-12 students and teachers are largely unaware of the current ubiquity of computing and the revolution it has on the different areas of science. There are two ways this is apparent - the dramatic decline in the number of students directly entering computing related majors, and the only limited integration of computing into existing curricula.

Baker RAP Fosters Involvement of CU Freshmen in Science Research and Internships
Baker RAP

Baker Residential Academic Program is an academic program in Baker Hall that focuses on Natural History and the Environment. We specialize in offering freshman introductory courses in Biology, Chemistry, Math, and Environmental Studies. We offer internships for academic credit during which students can learn about various professions in the sciences: Wild Animal Experience, Denver Zoo, Denver Museum of Nature and Science, Denver Aquarium, Greenwood Wildlife Rehabilitation, etc. We hold a research symposium each fall to encourage students to begin doing research with professors in various majors. We have noted that such opportunities have led previously open-option students to chose to major in a science field

AVID Tutoring
http://outreach.colorado.edu/programs/details/id/179

This is an outreach program that meets a requirement for a course taught in the School of Education. The collaboration involves sending CU-Boulder students that are participating in the Knowing and Learning teacher licensure course to various middle and high schools in BVSD to serve as AVID tutors. AVID is a nationwide program designed to provide extra academic support for first-generation college bound high school students who show promise in their academic careers. CU-Boulder students

are required to tutor five times over the course of the semester and develop a portrait of one adolescent that they have worked with consistently.

Colorado Momentum
Applied Mathematics Department

This program implements oral assessment in courses in Applied Math that have improved students' passing rate in Calculus I and Calculus II.

Colorado Space Grant Consortium
http://spacegrant.colorado.edu/index.php/outreach

Colorado Space Grant is a NASA-funded program in the College of Engineering and Applied Sciences. Outreach is just a small part of what Space Grant does at CU.

Digital Library for Earth System Education
http://dlsceinces.org/

Researchers at the Institute of Cognitive Science and the University Corporation for Atmospheric Research are working with 124 middle and high schools in the Denver Public School system to provide a new online resource system. The system, called the Curriculum Customization Service, offers teachers access to about 13,500 resources, including lesson plans, scientific data, visualizations, interactive computer models and virtual field trips. Many of the resources come from the Digital Library for Earth System Education, created in 2000.

Energy Certificate Programs
http://rasei.colorado.edu/

CU-Boulder's undergraduate and graduate energy certificate programs provide a broad exposure to energy issues, with an emphasis on renewable and sustainable energy.

Neuroscience Undergraduate Program
http://neurocloud.org/teaching/

The Neuroscience Undergraduate Program is interested in engaging select Colorado high school students and teachers. Participants learn about how the brain changes in response to psychoactive drugs and engage in a project to detect trace amounts of cocaine and other drugs on US currency. The technology and ethics of voluntary and covert drug testing are discussed.

Ozone and Snow
http://instaar.colorado.edu/outreach/ozone-and-snow/

Scientists and graduate students from INSTAAR and Michigan Tech are working at research stations at Summit, Greenland and Toolik Lake, Alaska--both in some of the world's most pristine environments. They are looking for answers about how ozone is created and destroyed in snow.

F.2. Assessment and Discipline-based Education Research (DBER) Programs

Impacts of Curricular Change: Implications from 8 Years of Data in Introductory Physics

Department of Physics

Introductory calculus-based physics classes at the University of Colorado Boulder were significantly transformed beginning in 2004. They now regularly include: interactive engagement using clickers in large lecture settings, Tutorials in Introductory Physics with use of undergraduate Learning Assistants in recitation sections, and a staffed help-room setting where students work on personalized CAPA homework. We compile and summarize conceptual (FMCE and BEMA) pre- and post-data from over 9,000 unique students after 16 semesters of both Physics 1 and 2. Within a single institution with stable pre-test scores, we reproduce results of Hake's 1998 study that demonstrate the positive impacts of interactive engagement on student performance. We link the degree of faculty's use of interactive engagement techniques and their experience levels on student outcomes, and argue for the role of such systematic data collection in sustained course and institutional transformations.

Assessing Engineering Students' Beliefs of Personal and Professional Responsibility

Department of Civil & Environmental Engineering

Engineers are working to address complex issues such as global warming, urban overcrowding, and poverty reduction, which require skills that go beyond technical skills to include professional skills and systems thinking. How to instill these skills into engineering students is unclear. Different pedagogical approaches are being used towards the achievement of these goals including Project Based Learning and Service-Learning, but there are few tools that are able to assess the effects of these approaches on students' professional development.

An analysis of student learning and attitudes from two hands-on lab styles and two methods of visualization for plant biodiversity labs

Department of Ecology and Evolutionary Biology and the National Evolutionary Synthesis Center

Biodiversity education is a worldwide priority called for by the United Nations Decade of Education for Sustainable Development. There is thus a pressing need for engaging, inquiry-oriented, hands-on, learning experiences in biodiversity. We evaluated the impact on student learning and attitudes of two hands-on lab styles (guided versus the learning cycle) and two modes of visualization (digital photography versus drawing) for plant biodiversity labs in a first-semester, university, general-biology lab class for science majors.

Differences in discourse in physical and life sciences can be confusing for biology students

University of Colorado Boulder, New Hampshire College, North Dakota State University, Point Loma Nazarene University

This project sought to understand why students have a difficult time understanding the flow of matter and energy through biological systems, as evidenced by their poor performance on published concept inventories. Students who take our biology courses typically take introductory chemistry and physics courses during their first two years of college. To explore whether the various and sometimes conflicting discourse about and explanations of matter and energy in these STEM subjects may contribute to confusion in biology learners, we synthesized the research literature about student understanding of matter and energy, analyzed textbook treatments of matter and energy, and conducted interviews of biology, ecology, chemistry, and physics faculty. We found both similarities and differences regarding contexts and discourse practices among the disciplines with respect to matter and energy.

Beliefs about physics intelligence differentially influence women and men's self perceptions and performance in physics

Departments of Psychology & Neuroscience and Physics, University of Colorado Boulder, and Stanford University

This project seeks to better understand the many possible antecedents of students' sense of belonging in physics, and why this sense of belonging tends to be lower among women than men. To do so, we measured students' preexisting beliefs about the nature of physics intelligence as well as students' tendency to endorse the cultural stereotype that women are less apt at physics than men. We sought to understand how these two belief systems (a) relate to one another and (b) their respective effects on students' sense of belonging and self-efficacy in physics. 656 students who were enrolled in an introductory, calculus-based physics class at CU Boulder completed a survey assessing our constructs of interest at the beginning of the academic semester.

Development of a Scientific Teaching Observation Protocol

Department of Molecular, Cellular, and Developmental Biology

The Summer Institute for Undergraduate Biology Education (SI) is a professional development workshop that brings together faculty members from diverse institutions to develop their teaching skills. The SI is guided by the philosophy that biology education ought to reflect the nature of scientific inquiry, incorporate our understanding of how people learn, and ensure equal learning opportunities for students of diverse backgrounds.

Development of a Molecular Biology Capstone Assessment

Department of Molecular, Cellular, and Developmental Biology

Students majoring in molecular biology take a semi-prescribed series of courses aimed at helping them to master central concepts, develop practical competencies, and pursue interests in various subdisciplines. We are developing a capstone assessment to measure how well students understand core molecular biology concepts and their ability to apply these concepts to novel scenarios. Targeted at senior-level students, this assessment has been designed to cover fundamental concepts that faculty value as essential, as determined through interviews of twenty

faculty members. For each concept, we have generated multiple-response items consisting of a question stem followed by 4-5 true-false statements. This question format is aimed at better capturing the range of student thinking, including mixed conceptions, and better controlling for related knowledge that affects the ability of the student to address the core concept. Both open-ended and think-aloud interviews of students have been used to generate distractors for the questions, and the questions have been pilot-tested and refined through multiple administrations. Once complete, the MBCA will provide a tool that can be used to measure student learning and discover areas of conceptual difficulty.

Digital Devices and Student Performance

The recent increase in use of digital devices such as laptop computers, iPads and web-enabled cell phones has generated concern about how technologies affect student performance. Combining observation, survey and interview data, we assess the effects of technology use on student learning. We report initial data, gathered in eight large introductory science courses, showing a significant negative correlation between in-class phone use and final grades, with use of cell phones corresponding to a drop of 0.36 + 0.08 on a 4-point scale. These findings are consistent with research suggesting students cannot multitask effectively. An additional round of data collection was aimed at replicating the initial finding in six additional courses, representing a more diverse set of learning environments. Findings from this final iteration address many outstanding questions, including the effects of various classroom layouts and course levels on digital device use in the classroom, as well as whether students accurately report the frequency of their in-class cell phone use.

BeSocratic

This collaboration between Clemson University and CU-Boulder offers examples of various Socratic (i.e. metacognitive), exercises and activities designed to provoke explicit articulation and reflection on various scientific and mathematical ideas and skills. This NSF funded project is based on easily authored, graphical-based activities with dynamic, research based responses to students and robust data collection systems for researchers.

Critical Thinking Analysis Test

http://www.tntech.edu/cat/home/

For the past several years, we have had an ongoing project focused on measuring critical thinking where critical thinking is broadly defined. It includes evaluating information by separating factual information and recognizing inferences, understanding the strengths and deficiencies of correlations, grasping the nature of appropriate vs inappropriate conclusions, recognizing alternative interpretations for observations, identify possible sources of useful new information, learning information integration skills and learning to communicate ideas effectively. The strategy here at CU-Boulder has been to use the NSF sponsored and developed Critical Thinking Analysis Test (http://www.tntech.edu/cat/home/) as a well-developed, thoroughly tested and validated instrument designed to measure those attributes enumerated

above. We have employed a 'before/after' design with a crossed 'course emphasis' component where we measured student scores during the first week of class and again during the last week of class (approximately) in courses which (a) critical thinking is explicitly acknowledged as a major element, (b) civic engagement/service learning is a major pedagogical component, and (c) control courses which do not emphasize either of the above points. In addition to quantifying student gains (or not) along the dimensions of critical thinking skills (which often parallel scientific thinking in general) the project aims at faculty development. Faculty score the instrument jointly in a group setting and lively discussion always ensues about student thinking, errors, achievements, etc. To date, every faculty member who has participated (about 3 dozen to date) has volunteered that they have significantly changed the way they teach their own courses as a result of the experience. One major conclusion has been that a common faculty view—my discipline requires critical thinking so it just happens—is quite erroneous. It has to be explicitly addressed, made an object of focus and thoughtfully added to course content.

F.3. Community Partnerships and Networks

Conference on World Affairs

The Conference on World Affairs is an annual conference, open to the public, featuring panel discussions among experts in international affairs and other areas, hosted since 1948 by the University of Colorado Boulder.

El Pueblo Mágico

El Pueblo Mágico is an innovative after-school program where undergraduates and children learn together in a technology-mediated learning club at Alicia Sanchez Elementary School in Lafayette, Colorado. The after-school club at Sanchez promotes K-5 children's appropriation of a range of skills and knowledge with particular emphasis on new media and technological design, scientific knowledge, and specifically, health sciences and energy -- areas of need as identified by the school. El Pueblo Mágico draws on an interdisciplinary team of CU-Boulder faculty and students to bring innovative technologies to the program. In addition to Professor Kris Gutiérrez of the School of Education, program partners include Computer Science Professors Alexander Reppening, Gerhard Fisher, and Michael Eisenberg.

Boulder Area STEM Education Coalition (BASEC) and the Latin American Center for Arts, Science, and Education (CLACE)

BASEC and CLACE

The Boulder Area STEM Education Coalition (BASEC) facilitates communication and collaboration among businesses, communities, families and the media to promote STEM and STEM Education in the Boulder region. The Latin American Center for the Arts, Science and Education (CLACE) seeks to inspire and encourage diverse youth to learn, love, live and embrace science as an everyday experience. CLACE develops bilingual programs for local students and families who differ culturally and linguistically from the norm and promotes proactive interactions between diverse communities.

K-12 Engineering Education Initiative: Programs that Make a Difference
College of Engineering & Applied Science

These efforts link university-based education of undergraduate and graduate students to the K12 transformations in local schools by brining engineering to the schools. These efforts include Engineering K12 materials and GK12 program to support graduate students.

Highlights from the CIRES Education Outreach Group
CIRES Education & Outreach

The Education and Outreach group of the Cooperative Institute for Research in Environmental Sciences (CIRES) is active across the spectrum of geoscience education, including teacher and scientist professional development, digital learning resources and courses, graduate student fellowships, exhibits, student events and after-school clubs, and project evaluation. Our climate education projects are bearing fruit; for example, the Climate Literacy and Energy Awareness Network (CLEAN) digital resource collection contains over 500 resources. CIRES scientists are engaged in our work through broader impacts components on research projects as stars of the video screen, presenters, reviewers, and learning resource providers. We support young scientists through GK-12 fellowships, conduct climate communication trainings, and provide educational expertise to research projects. We have a series of workshops scheduled throughout the year, including workshops on climate, and workshops to review climate and energy learning resources. The ICEE project is developing self-directed online modules for teachers through NASA and NSF broader impacts funding. A traveling exhibit about the changing Earth tours rural libraries nationally. Kits and curricula to be used after school that are available or under development are focused on space weather, geomagnetism, weather, and water.

Learn More About Climate Initiative
Office for University Outreach

The Learn More About Climate initiative is a collaboration among many of CU-Boulder's leading climate scientists that offers educational resources for teachers, citizens and policymakers. The LearnMoreAboutClimate.colorado.edu website includes short videos, interviews with scientists, model lessons for teachers, and opportunities for community members to connect with campus projects, research, and resources. The initiative also provides support and exposure for climate-focused campus programs interested in connecting with each other and external groups.

The Partnership between the University of Colorado and the Boulder Valley School District
Departments of Environmental and Evolutionary Biology, Computer Science, CIRES, University of Colorado Boulder, and Inverness Research Associates

Partnerships between the University of Colorado and local school districts, such as the National Science Foundation's GK-12 Fellowship Program for STEM graduate students, provide many benefits for the university and the community. They help

improve Town-Gown relationships; they train graduate students to be better science communicators; they stoke K-12 student's interest in STEM; and they provide content knowledge professional development for teachers. Project EXTREMES (Exploration, Teaching and Research for Excellence in Middle and Elementary Science) is a successful collaboration between CU (CIRES, EBIO, Computer Sciences) and the Boulder Valley School District. Twelve graduate students serve as Fellows in each of five of BVSD's more diverse elementary and middle schools. Elementary students are exposed to field research at the Mountain Research Station. Throughout the school year, Fellows visit the classrooms to expose them to their cutting-edge research, as well as participate in after-school science clubs and field trips to scientist's labs at the university. Entering the final year of funding, we are exploring ways to broaden this model across the university.

Measuring the Success of Girls at the Museum Exploring Science (GAMES)
University of Colorado Museum of Natural History

Girls At the Museum Exploring Science (GAMES) is a unique program designed to encourage interest and excitement about science in 4th and 5th grade girls. This study aims to investigate the role of informal education programs in increasing science participation among women, as well as ways in which schools and universities can collaborate to close the achievement gap by effectively serving populations who are traditionally underrepresented in the sciences.

IDREAMS
Integrative Design-based Reform-oriented Educational Approach for Motivating Students

IDREAMS strives to engage students' interest in computer science through video game design. The ultimate goal is to encourage students to pursue careers in the field of information technology.

LASP Education and Outreach
http://lasp.colorado.edu/education/community/K-12/

LASP is a solar system science research institution where spacecraft and spacecraft instrumentation are built to support our research mission. The researchers explore planets and planetary bodies, the sun, space weather, and Earth's atmosphere and magnetic field. The Office of Communications and Outreach at LASP creates programming surrounding the research efforts. It serves K-12 teachers, undergraduate students, journalists, and the general public. The program creates and distributes curriculum based upon LASP's research efforts. The office's mission is to improve the quality of space science education at all learning levels.

Making Global Local
http://learnmoreaboutclimate.colorado.edu/for-educators

This project supported a teams of Colorado middle and high school teachers to collaborate with CU-Boulder scientists and science educators to develop problem-

based model lessons based on local content. Each lesson has been taught and tested in the classroom and can be scaled to fit your learners (5th-8th and 9th-12th).

Materials Science from CU-Boulder
http://lcmrc.colorado.edu/outreach/classroomprograms1.html

Presented throughout the state, these classroom programs are based on physical science topics that are used as an introduction to the world of materials science. Students in grades 5-9 use this inquiry-based curriculum and hands-on activities to learn about interdisciplinary topics.

Partnerships for Informal Science Education in the Community (PISEC)
http://www.colorado.edu/physics/PISEC

PISEC provides opportunities for university students (undergraduates, graduate students, and post docs) to teach inquiry-based science activities to K-12 populations under represented in science, such as Hispanic, African American, and economically disadvantaged youth.

A Community of Mathematics Teachers and Learners (CMTL)
http://outreach.colorado.edu/programs/details/ld/78

This program recruits students from The Spirit and Uses of Mathematics, the CU-Boulder mathematics course sequence designed for prospective elementary school teachers (typically the only math courses future elementary school teachers will take at the university), into a service learning project at several Boulder Valley Elementary Schools: Escuela Bilingue Pioneer, a bilingual elementary school in East Boulder County; Lafayette Elementary; Boulder Community School of Integrated Studies (BCSIS); and Whittier International Elementary.

Alternative Breaks
http://www.colorado.edu/vrc/altbreaks/index.html

Alternative Breaks is a program of the Volunteer Resource Center. The program sends trips across the country (Spring) and abroad (Summer) to take place in a week long service project with a group of peers. Alternative Breaks accepts and trains leaders each fall. It is these leaders that guide their peers on a trip of a lifetime! What makes Alternative Breaks stand out from all the rest? Alternative Breaks is committed to fostering a leadership and life long learning component; the program works with a national chapter (Break Away) and are guided by their ongoing expertise. Leaders are trained over the course of the year on how to educate their peers before hand and facilitate reflective discussions with participants on trips so that each person dives into a unique and life transitioning experience through the act of giving. Students are then guided on how to best implement the passions fostered while outside of their comfort zone into a local and/or personal community.

Astronomy Day at CU
http://cosmos.colorado.edu/sbo/public.astroday.html

Every year for the past decade, Sommers-Bausch Observatory and Fiske Planetarium have opened their doors to the public for a free, day-long CU Astronomy Day celebration. The Saturday date varies from year to year, but is usually held during the last two weeks in April shortly before school lets out. Activities begin around noon and continue through the late evening hours.

CARLA Lab
http://carla.colorado.edu

The CARLA Lab is located at Institute of Cognitive Sciences (ICS) in Computational Language and Education Research (CLEAR) and is headed by Dr. Barbara Wise. Her team has conducted studies in computer-delivered reading assessment and intervention since 2004, working with other CU researchers and with St. Vrain Valley Schools, the Archdiocese schools of Denver, and Boulder Valley Schools. All programs described below gain independence through the use of an animated coach, as well as through vivid, engaging, and adaptive programs developed at the lab.

Colorado Bioneers
http://ecenter.colorado.edu/bioneers

Colorado Bioneers Conference is a regional event for students, faculty, staff, and the broader community to connect with visionary and practical solutions for restoring people and the planet. Focusing on successful and innovative models, examples, stories, and research, Bioneers celebrates, networks, and inspires.

Colorado Math Circle
http://www.coloradomath.org/

The Colorado Math Circle offers math enrichment to high school and middle school students interested in expanding their knowledge of mathematics. Through math talks and problem solving sessions, students learn about number theory, geometry, graph theory, combinatorics, knot theory, olympiad problems, and many other topics. In a collaborative group setting, math enthusiasts have an opportunity to meet others who share their love of mathematics.

Colorado Space Science Teacher's Summit
http://lasp.colorado.edu/education/teacherssummit/index.html

Continuing Education – ACCESS Program
http://conted.colorado.edu/programs/access

ACCESS (Available Credit Courses for Eligible Special Students) enables non-degree students to take Boulder main campus undergraduate or graduate courses for personal or professional development. Some students will use the ACCESS program to work toward enrolling in a degree program in the future, to "test out" the university, or to learn from some of the best faculty in the country.

CU on the Weekend

http://conted.colorado.edu/programs/cu-on-the-weekend/

CU on the Weekend is a series of one-day classes from CU-Boulder faculty offered on Saturdays and open to the public. The series provides a unique opportunity to interact with some of CU-Boulder's best faculty and learn more about their teaching, research, and creative work. Running from 3 to 6 hours, these one-day classes allow for in-depth conversations on a range of engaging subjects.

GK12 Project EXTREMES

http://cires.colorado.edu/education/outreach/extremes/index.html

Free Public Open Houses are held on Sommers-Bausch Observatory's Observing Deck on Friday evenings (weather permitting) throughout the year whenever the University of Colorado is in session. Starting time is 8:00 p.m. (fall and spring semesters) and 9:00 p.m. (during the summer). You're also invited to drop by from next-door Fiske Planetarium after its Friday evening starshow ends.

Observatory Field Trips for Schools

http://cosmos.colorado.edu/sbo/public/openhouse.html

Sommers-Bausch Observatory (SBO) on the CU-Boulder campus offers a limited number of tours and educational programs each year for school groups and nonprofit organizations during daytime hours. Program coordinators can tailor the presentation to meet the special needs, interests, and educational background of the group. Topics range from "how does a telescope work?" to solar observations, atoms and spectroscopy, phases of the moon, and understanding solar and lunar eclipses. Presentations can range from one-half hour to 1.5 hours in length.

Saturday Physics Program

http://www.colorado.edu/physics/Web/Saturday/index.html

The Saturday Physics Program offers talks by faculty in the Physics Department and associated units at CU-Boulder once a month during the academic year. The program was created for high school students and adults who are interested in the physical sciences. Each month, on a Saturday afternoon from 2:00-3:00 p.m. in the Duane Physics building on the CU-Boulder campus, lectures are presented free of charge on cutting edge research happening today right here on the CU-Boulder campus. Topics have included "Atom Computers," "Black Holes," "Lasers," and the "Subatomic Universe." The program creates an opportunity for high school students and community members to hear about the most current topics of research from faculty members actively involved in research. After the lecture finishes, there is always time for additional questions and clarification to deepen the understanding by the audience. The series provides an occasion for personal interaction with faculty, furthering an individual's connection to the university, as well as provides the faculty a chance to discuss their research with an interested audience.

Sustainable Practices Program

http://ecenter.colorado.edu/education/sustainable-practices/

The Sustainable Practices program is a professional development training program in sustainability offered by the award-winning CU-Boulder Environmental Center.

Teach Engineering Digital Library Collection
http://teachengineering.org/

Free engineering lessons and activities for teaching K-12 science and math are just a click away. The Teach Engineering digital library is a searchable, educational standards-based repository of high-quality, classroom-tested curricula for use by teachers and engineering faculty to teach engineering in K-12 settings.

TEAMS Program
http://ucblibraries.colorado.edu/news/index.htm

The Integrated Teaching and Learning Program's TEAMS initiative (Tomorrow's Engineers... creAte. iMagine. Succeed.) offers academic year (in-class and afterschool) and summer engineering instruction to elementary, middle and high schools in Longmont, Lafayette and Denver that serve diverse populations. Their goal: to improve science and math literacy, and increase the number of high school students prepared to choose an engineering and/or technology college path.

F.4. Systemic Projects

The CU Science Education Initiative: Departments and Faculty Take Action to Improve Science Education
Science Education Initiative

Funded by Chancellor DiStefano and President Benson, the Science Education Initiative (SEI) at University of Colorado Boulder aims to engage and support faculty in applying a scholarly-approach to teaching, and ultimately, to achieve sustainable institutional change towards effective, evidence-based science education. The program funds departments to take a four-step, scientific approach to undergraduate education: 1) Establish what students should learn; 2) Scientifically measure what students are actually learning and thinking; 3) Use instructional approaches guided by research on learning and evidence of student thinking; and 4) Disseminate and adopt what works. Over the past 6 years, the SEI has funded 7 departments, including the departments of Geology, Integrative Physiology, Chemistry, MCD-Biology, Physics, Astrophysical and Planetary Sciences, and Ecology and Evolutionary Biology. Outcomes include substantial adoption and adaptation of research-based instructional practices by faculty across numerous courses that were previously taught in a traditional style, impacting over 10,000 student-courses per year.

National Center for Women in IT (NCWIT)

The National Center for Women & Information Technology is a non-profit community of more than 300 prominent corporations, academic institutions, government agencies, and non-profits working to increase women's participation in technology and computing. NCWIT helps organizations recruit, retain, and advance

women from K-12 and higher education through industry and entrepreneurial careers by providing community, evidence, and action.

Broadening Opportunities through Leadership and Diversity (BOLD Center)

The BOLD Center promotes diversity in race, socioeconomic representation, and gender within the School of Engineering and Applied Sciences. The BOLD Center fosters success through academic resources, student leadership opportunities, and a supportive community in order to break down barriers that prevent or hinder achievement.

CU Teach Collaborative

School of Education and CU Teach

New teachers frequently assert their most powerful learning moments occur during hours spent in local classrooms. Yet many lament the paucity of quality teaching pre-service teachers encounter in university practicum and student teaching experiences. The low number of truly outstanding veteran math and science teachers is partially explained by the high attrition rate of new teachers. We recognize that in order to provide high quality practicum and student teaching experiences, we need to "grow our own" Mentor Teachers.

Computational Optical Sensing and Imaging, a NSF's Integrative Graduate Education and Research Traineeship in Boulder

Computational and Optical Sensing and Imaging IGERT

The Computational Optical Sensing and Imaging program at the University of Colorado Boulder is funded by NSF through their Integrative Graduate Education and Research Traineeship (IGERT) program. This IGERT, which started in August of 2008, involves students and faculty from 6 different departments, ECEE, Physics, App. Math., MCDB, Chem. & Biochem., and ME. The students are required to take two specific classes and a lab, with which they acquiring a common language and knowledge, and 3 more elective classes that they choose. They are also required to attend and participate in the seminar series, a highly regarded activity that not only reunites the program students on a weekly basis, but also attracts faculty and field professionals working in companies in the Boulder-Denver area.

PhET Interactive Simulations, University of Colorado Boulder

http://phet.colorado.edu

The PhET Interactive Simulations Project has developed over 120 simulations for teaching and learning science and mathematics, all of which are available free of charge at http://phet.colorado.edu. The simulations are interactive, game-like environments in which students learn through scientist-like exploration and experimentation. They emphasize the connections between real life phenomena and the underlying science and mathematics, make the invisible visible (e.g., electrons, atoms, field vectors), and utilize the visual models that experts use to aid their thinking. PhET simulations are created by a team of scientists, developers and educators, and are informed by student interviews. Here we present recent developments in new

simulation topics and research projects, as well as highlight the use of PhET simulations in classroom, lecture, and laboratory environments to effectively enhance student learning and engagement.

CU-Boulder Learning Assistant (LA) Model
LA Program, School of Education

The CU-Boulder Learning Assistant (LA) Model uses the transformation of large-enrollment science courses as a mechanism for recruiting and preparing talented science majors for careers in teaching, to engage science faculty in the recruitment and preparation of future teachers, to improve the quality of science education for all undergraduates, and to transform departmental cultures to value research-based teaching for ourselves and for our students.

Engineering for Society: A Proposed Undergraduate Engineering Degree and Teacher Licensure Pathway
College of Engineering & Applied Science

A new engineering pathway for undergraduate degrees in engineering with a specialization in another area, such as: teaching, business, pre-medicine, or law.

Alliance for Technology, Learning and Society
http://www.colorado.edu/ATLAS

ATLAS creates and facilitates innovative interdisciplinary research, education, and creative outreach programs in which information and communication technology is an enabling force.

Center for Integration of Research, Teaching, and Learning (CIRTL)
http://www.cirtl.net/colorado

CIRTL works to improve excellence in the education of undergraduates by developing a nation wide committee that enacts and advances the teaching practices for diverse learners. The CU-Boulder CIRTL program is working to connect with other research institutions through the national CIRTL Network, to expand current graduate student professional development activities in CU-Boulder STEM disciplines, to encourage STEM faculty to develop their own courses through teaching as research, diversity, and learning communities, to encourage graduate students in the STEM disciplines to view college teaching through the lens of teaching as research, and to develop an institute that supports and develops research on graduate education on the CU-Boulder campus.

Colorado Diversity Initiative (CDI)
http://www.colorado.edu/GraduateSchool/DiversityInitiative/index.html

CDI in science, math and engineering is the overseer for two major grants that support diversity initiatives. Both the National Science Foundation Alliance for Graduate Education and the Professorate (AGEP) and the National Institutes of Health Initiative for Minority Student Development (IMSD) grant award assistantships to

incoming underrepresented graduate students, offer professional development opportunities, and support undergraduate research efforts.

Outreach and Engagement at CU-Boulder
Office for University Outreach

The Outreach and Engagement Website serves as a gateway for campus and community members to learn more about the range of outreach initiatives that CU-Boulder has to offer. It promotes and highlights outreach activities, events, and success stories and allows audiences to connect directly with campus programs. STEM Symposium participants will have an opportunity to learn how to access outreach projects specific to their interests and to ensure that their campus projects reach a range of audiences that include the general public, CU administrators and faculty, legislators, and the media.

CU Science Discovery
http://www.colorado.edu/ScienceDiscovery/
CU Science Discovery offers a myriad of summer, after-school, and overnight informal science camps. Science Discovery brings the expertise of CU into the community.

Discipline-Based Education Research (DBER)
http://www.colorado.edu/istem/DBER.html

Discipline Based Education Research is a weekly working seminar where faculty engaged in discipline-based education research can present their work, share their ideas, and coordinate with each other.

Ethnography and Evaluation Research (E&ER)
http://www.colorado.edu/eer/

E&ER draws upon a network of colleagues through STEM Education and University of Colorado at Boulder to distribute research findings to other programs looking to improve their own STEM programs.

Faculty Teaching Excellence Program (FTEP)
http://www.colorado.edu/ftep/

FTEP develops the art and craft of teaching among faculty and has been "teaching teaching" to professors, because good teaching is rarely innate, but is rather a learned skill. FTEP is founded on the principles that there is no one right way to teach and that faculty learn best from one another. These processes vary by discipline and vary with faculty members' own styles.

Fiske Planetarium and Science Center
http://fiske.colorado.edu/

The planetarium is a resource for STEM faculty wishing integrate hands-on learning in non-lab courses. A popular field trip destination, Fiske has a strong K12 outreach program and also develops nationally disseminated planetarium curriculum.

Graduate Teacher Program (GTP)
http://www.colorado.edu/gtp/

GTP Provides professional development opportunities for all graduate student from all colleges based on students' current teaching, research, and service responsibilities and on future career goals.

Integrated Teaching and Learning Program & Laboratory (ITLL)
http://itll.colorado.edu

ITLL provides a hands on learning environment for introductory engineering courses. In addition to the lab and all of its resources, the ITL program offers a K12 outreach program that utilizes GK12 funding.

Miramontes Arts and Sciences Program (MASP)
http://www.colorado.edu/masp/

Miramontes encourages students to develop a collaborative community while giving them a challenging program that enriches their academic experience.

Mortenson Center in Engineering for Developing Communities
http://ceae.colorado.edu/mc-edc/

The Mortenson Center presents a unique opportunity for educating a new generation of engineers who contribute to the relief of the problems faced by developing communities worldwide. The center emphasizes an integrated and participatory nature of humanitarian development.

PER: Physics Education Research at Colorado
http://www.colorado.edu/physics/EducationIssues/index.html

PER@C is one of the most productive and largest research groups in physics education. The group engages in foundational research studies, the development of research based instructional materials and assessments, and studies faculty development and systemic change.

National Education Policy Center
http://npec.colorado.edu/

The mission of the National Education Policy Center is to produce and disseminate high-quality, peer-reviewed research to inform education policy discussions. The program is guided by the belief that the democratic governance of public education is strengthened when policies are based on sound evidence.

NOYCE
http://noyce.colorado.edu

The University of Colorado Noyce Teacher Scholarship Program strives to address the need for excellent high school and middle school educators in science, technology, engineering, and mathematics (STEM). The program offers support to prospective teachers in the form of a generous scholarship, collaborative education research opportunities with university faculty, professional development and

networking with past and present Scholars. In exchange for this support, Noyce Scholars agree to work on a Noyce project of their choosing, participate in regular meetings, and upon graduation, work in a high-need school district for two years for each year they receive the scholarship.

Renewable & Sustainable Energy Institute
http://rasei.colorado.edu/

RASEI (pronounced RAY-see) is a joint institute of CU-Boulder and the National Renewable Energy Laboratory (NREL) to expedite the energy industries of the 21st century by advancing renewable energy research, engineering, and analysis. RASEI forms the center of an integrated energy campus by combining the best of NREL's mission and capabilities with the education and scholarship of CU-Boulder in partnership with industry and other federal research labs for a new generation of research.

The Herbst Program of Humanities for Engineers
http://engineering.colorado.edu/herbst/

Herbst equips engineering students with the right tools to gain intelligent and relevant access to the great ongoing conversations of human existence. They offer small core classes (12-14) that are highly interactive and practical.

International Baccalaureate

Boulder has created thirteen new International Baccalaureate degrees (all the sciences), a unique model for undergraduate degrees. There are three universities who have formed a team-based approach to international science education: The University of Colorado Boulder, The University of Wollongong, Wollongong, Australia and Dublin City University, Dublin, Ireland. This collaborative degree option now exists for all our science majors (in A&S) that retain the standard 120 credit hour set of requirements but specifies more narrowly had electives are to be chosen. For example, each IBA student must spend at least one semester, and preferably, two semesters at each of the 'other' institutions, they must take three interactive, live, video classes, each taught by faculty at each of the three schools and they must choose elective coursework which provides strong background in international perspectives and scientific tools (e.g. GIS systems, mathematical modeling, remote sensing, etc.). We are currently working on faculty exchange program, too, to complement these interactive video classes. Student exchanges are already occurring successfully. This project was the culmination of 5 years of testing and piloting and is just now underway at this institution.