



Center for STEM Learning

UNIVERSITY OF COLORADO **BOULDER**

i³: Towards a Center for STEM Education
Award Number: DRL 0833364

Annual Report Year 5

Executive summary of success for year 5

In its fifth year, the University of Colorado Boulder's NSF i³ effort, "Towards a Center for STEM education," has made great strides.

Foremost:

As of December 2012 the CU NSF i³ effort Integrating STEM (iSTEM) transitioned to become an officially sanctioned Center, the Center for STEM Learning (CSL) for the University of Colorado Boulder campus. Establishing a center has been a key objective of this NSF i³ grant.

Because of a shift in the timing of how the project began, we have secured a 1-year no-cost extension. This additional time will be spent, as detailed in the original proposal, to create a sustainable infrastructure and to help externalize this model of institutional integration and institutional change.

The mission of the CSL is 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 in STEM education.

We achieve this mission through: the creation of an infrastructure of institutional support in order to transform STEM education; the support of education research within and across STEM fields and departments; and K20 teacher recruitment, preparation, and professional development through CU Teach (our science and math teaching certification program). CSL facilitates 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.

For the last five years members of the CU-Boulder community (through the NSF i³ funded program: iSTEM) have been working towards establishing a national scale Center for STEM Learning. Below is a summary of some of the accomplishments of this effort.

Building the national reputation of CU Boulder as a leader in STEM education.

CU-Boulder is recognized as a national leader by professional organizations, funding organizations, and universities across the country. Most recently, CU-Boulder, through the NSF i³ CSL was selected as a project site for the Association for American Universities (AAU) STEM Education Initiative. CU was selected as one of 8 lead demonstration sites nationally. At the same time, the Association of Public and Land-grant Universities (APLU) draws on the expertise of individuals and programs at CU-Boulder (for its work on the Science and Math Teacher Imperative, the Math Teacher Education Partnership, and the efforts to address the Next Generation Science Standards), and is now launching an initiative to create a national network of Centers.

The CU-Boulder CSL is helping to frame this network and will serve as a national hub. Members of the CSL advise national leaders and organizations (including: OSTP, NSF, APS, ACS, ASEE, NAS, SABER, AAU, & APLU) on the role and promise of university-based national centers for STEM education. The Center staff have acted in an advisory capacity to approximately a dozen other such centers as they work to establish themselves, drawing from our center's model. Organizations include Penn State, Florida International, Arizona State, Rochester Institute of Technology, Colorado State, University of Maryland System, Auburn, Michigan State, and North Dakota State. Members of the CU-Boulder STEM education community have given more than 50 talks on the CU Center and its related initiatives across the country and internationally (from Harvard to Cal State, in Puerto Rico, in South Africa, Japan, Europe, and the Middle East). The CU-Boulder initiatives have caught the attention of major funding sources including NSF, Sloan, Helmsley Trust, Moore Foundation, 100Kin10, and the Carnegie Foundation.

Building a statewide reputation of CU Boulder as a leader in STEM education.

The CSL serves the interests of the state and builds growing ties throughout the state and the government. CSL staff members have served on the state's application to the federal Race to the Top, the Governor's Taskforce on STEM education, and grassroots efforts throughout the state (e.g., Colorado STEM Network, and Morgridge efforts such as the Northglenn Teacher Initiative launched in late 2012). CSL/iSTEM also founded and developed the largest regional program in STEM education, the Boulder Area STEM Education Coalition (BASEC), which is part of the Colorado STEM Network. Center and affiliate STEM Education efforts at CU-Boulder have been showcased in sessions of the Board of Regents and at the Joint Education Committee of the Colorado state legislature. CSL staff and the Boulder STEM community are advising the CU-system President's Taskforce on New Technologies in higher education.

Building the campus infrastructure for STEM education.

In preparation for the launch of the Center, iSTEM (the NSF i³) has built campus infrastructure and capacity over the past five years. Through the development of the infrastructure, more than 75 programs devoted to STEM education have been identified, a needs-analysis conducted, and key stakeholders have been brought in to shape the structure of the CSL. Seed development efforts have included regular (weekly to bi-weekly) meetings of a project management team to design the center. There have been regular (bi-weekly to monthly) meetings among University Communications, Strategic Relations, Government Relations, and the Center staff. These coordinated efforts have helped establish a brand, an identity, and a commitment to STEM education at CU—developing branded materials, web-presence, talking points, brochures, staff roles, and language for CU and national efforts. STEM education is now identified in the university's strategic plan for the coming year.

Building the campus efforts for STEM education.

Despite being at the very beginning stages of this effort, the Center precursors have had vast direct and indirect impact on CU-Boulder STEM education transformation and

research. The iSTEM (precursor to CSL) has supported more than 35 faculty and graduate students with Chancellor's Awards for Excellence in STEM Education (the award itself is a product of infrastructure building). These awards have supported the educational transformation of more than a dozen educational environments, supported 20 graduate students in STEM education research (with 12 PhDs so far, and at least 4 new lines of PhD research in departments on campus), and provided seed funding for more than 15 faculty to engage in STEM education research and transformation. These awardees have subsequently brought in eight NSF Awards (over \$3.5M) on research related to and drawing from their Chancellor Awards.

Developing campus community and identity around STEM education.

While harder to measure directly, the NSF i³ efforts have supported community development through two annual symposia (bringing hundreds of campus community state and national stakeholders), mini-symposia on targeted areas (such as teacher professional development), a dedicated staff, web-portal / presence, and advising on individual efforts. iSTEM has supported the development and expansion of the Discipline-Based Education Research community on campus, which now includes hundreds of faculty, staff and students, across dozens of departments and programs and at least six colleges on campus. iSTEM has already supported interdisciplinary partnerships between physics and social psychology, between engineering and education, and outreach, education, arts & sciences and engineering. CSL will be a partner in the newly formed (and iSTEM-advised) General Engineering + program. Two significant grants (~\$3-\$4M) are slated to run through the Center as it is established, and four more grants have been submitted to the NSF running (at least in part) through the Center.

Future prospects for the Center for STEM Learning

As the national attention to STEM education will likely continue and grow, CU-Boulder is positioned to lead. This NSF i³ sponsored Center for STEM Learning will provide capacity for such leadership (e.g. the CSL serves as host to the CU-Boulder AAU STEM Education Initiative project site). In the short term, the CSL will continue and expand the productive elements of the iSTEM efforts outlined above. Additional efforts will focus on development (STEM education is a largely untapped area of extra-mural funding from foundations and individuals in the state) and communication, building campus community and participation (through the Fellows and Affiliates program) and expansion of programmatic activities and impacts. The CSL is positioned to grow in the coming years bringing in more resources for educational transformation and for leading research and evaluation efforts. In the longer term, the Center is positioned to grow into an Institute (should this be an institutional priority). As an institute it would continue to promote the development of all faculty, establish more faculty lines in discipline-based educational research, grow graduate and postdoctoral work in STEM education transformation and research, and yield the associated outcomes of a nationally productive Institute which serves the university, the region, the state, the nation and the world.

1. Project objectives and summary

The NSF i³ project at the University of Colorado Boulder works primarily to integrate three existing lines of work supported by NSF: (1) the efforts in undergraduate and graduate course transformation, particularly at the undergraduate and graduate levels, (2) the programs in professionalizing teaching - undergraduate and graduate teacher preparation for K12 and college, and (3) the STEM education and discipline-based education research among faculty, students, and post-doctoral scholars. Notably, each of these three lines of inquiry into STEM education supports the other two. One of the distinctive aspects of these multidisciplinary efforts at CU-Boulder is that they are located largely in the disciplinary and education departments, rather than in an external center or department. This NSF i³ effort is building a *distributed* center of STEM education research and transformation. This center will: (a) integrate the three lines of inquiry and development described above, (b) retain the status and rigor offered through science and engineering departmental identity, and (c) expand the reach of thriving STEM education community to include more departments and participants. The NSF i³ program is designed to establish CU-Boulder as a national hub of STEM education by broadening participation, bridging critical educational junctures, developing a better prepared workforce, and integrating discipline-specific education and research, all in the context of a sustainable model of institutional practice.

A proposal to establish the CU-Boulder Center for STEM Learning (CSL) was approved by the provost and associated senior personnel in December 2012. For the full text of this proposal including by-laws, see 7.A. Proposal to establish the CU-Boulder Center for STEM Learning (CSL). The 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:

- 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.
- 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 more than 50 research projects and programs, and built a community of scholars in STEM education that spans roughly 75 programs and departments. In the last year this community has produced 11 publications on STEM education research and reform. In conjunction with previous years, affiliates of the Center for STEM Learning have more than 175 total publications. The NSF i³ has supported the inclusion of a scholarly approach to educational practice that is spreading throughout our campus and throughout institutions that are replicating our educational models.

1.D. Broader Impacts

Funding from the NSF i³ has built a cohesive organization among roughly 75 different programs and departments on campus focusing on STEM education. These programs impact well more than 10,000 undergraduates per year, hundreds of faculty and graduate students, and thousands of pre-college children through our community partnerships. The efforts in policy, communication and fundraising are impacting the university's identity and perception of the university's role in the community. The establishment of the CSL has begun to further these efforts through the following activities, which are designed to support the mission mentioned above:

- *Programmatic*: programs designed to integrate existing efforts, nucleate new efforts, and build a STEM education community at CU-Boulder.
- *Diversity and Access*: programmatic activities and policy actions to support the inclusion of under-represented minorities, women, and students from non-dominant populations in STEM.
- *Infrastructure development/university policy*: efforts to secure sustainable long-term support for these efforts.
- *Dissemination*: beyond outreach to constituents we externalize our efforts and are building a web portal for sharing of resources.
- *Public Policy and Outreach*: efforts to support STEM education in the region, state, and nation.
- *Evaluation*: both formative (largely internal) and summative evaluation of our effort to achieve our mission.

2. Programmatic activities

2.A. Integrating, incubating, supporting, and running programs

The NSF i³ supports individual programs that span a broad section of campus (such as the Colorado Learning Assistant Program, a new general engineering degree, and community partnership programs in STEM education, described below), while simultaneously serving to link, coordinate, and integrate these constituent programs. By creating a network of programs, we strengthen individual programs, leverage resources, gain broader attention, and nucleate new programs. For a complete list of current affiliate and supported programs, see 7.D. List of affiliated programs.

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

A key and innovative component of the NSF i³ is the Chancellor's Awards for Excellence in STEM Education program. Each year, these mini-awards provide funding to faculty (up to \$10,000) and graduate students (25% research assistant appointments) who excel in discipline-based education research and/or promoting education within their department through course transformation. These awards have supported and encouraged STEM education research at CU-Boulder.

For faculty, the award money supports course release, summer salary, or research costs associated with STEM education projects. Funds also support projects in the early stages, the coordination of existing projects, and efforts that can continue beyond the funding period. Grants of up to \$10,000 are awarded for a period of up to one year.

Over the past five years, the NSF i³ has funded 19 faculty awards (see 7.E. Chancellor's Awards for Excellence in STEM Education). We recently accepted five new faculty projects on STEM education for the 2012-2013 academic year. The 2011-2012 Chancellor's Scholars have completed their projects (see 7.F. Outcomes of the Chancellor's Awards). Following is an example of a newly funded faculty award:



Dr. Kathleen Hinko from the JILA NSF-sponsored Physics Frontier Center and the Department of Physics is assessing how students' participation in informal STEM activities promotes their interest and understanding of STEM fields of study. Dr. Hinko is specifically analyzing students who participate in the CU Boulder Partnerships for Informal Science Education in the Community (PISEC) program. Though the program is especially geared toward K-12 children in the community, her NSF i³-sponsored work will focus on the university educators in the program, providing critical insight into the less-studied group. Information based on this research will be applied to course design and programming while providing the university educators with opportunities for improvement in communication and pedagogical skills.

Twenty-two graduate awards have been made over the past five years (see 7.E. Chancellor's Awards for Excellence in STEM Education). These awards 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 award given to doctoral student Jeffrey LaMarche for his project, Developing User Interface Computation and Peer Instruction: Assessing Results on Engagement, Retention, and Failure Rate for CSCI 1300 Introduction to Computer Programming, is especially unique. The focus will be on creating an introductory computer-programming course based on peer instruction and assessing its effectiveness on improving interest and enrollment in computer science classes. Moving the course from a lecture-based format to a more student-centered forum will require implementing various tools and software, like iClickers, that are commonly unused in such fields.

For both faculty and graduate students, the complete text of funded proposals is available at <http://www.colorado.edu/csl/scholars.html>.

Many of these Chancellor awards have been used to seed additional projects and garner funding. A minimum of eight different Chancellor awards, have been turned into broader NSF, or CU-Innovative Seed Grant proposals that represent roughly \$3.5M in additional funding.

2.A.ii. Discipline Based Education Research

Year five continued the sustained success of the Discipline-Based Education Research (DBER) seminar series. In total, DBER held 36 seminars during the 2012-2013 academic year. Participation in these seminars averaged 25 people, which spanned more than 100 faculty, graduate students, university researchers, and community members and guests. DBER seminars have continuously promoted communication between education research programs at other institutions. In the past year, DBER has hosted guests from: the American Physical Society, the American Association of Physics Teachers, Clemson University, the City University of New York, Colorado State University, Florida International University, Georgia Tech, North Dakota State University, Rutgers University, Seattle Pacific University, the University of Central Arkansas, the University of Kaiserslautern, the University of Maryland, and the University of Utrecht. 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.A.iii. Additional collaborative STEM education projects at CU

Over the last year, the NSF i³ has supported and collaborated with a variety of interdisciplinary efforts in science, technology, engineering, and math education, including:

2.A.iii.a. The LA Program

The Learning Assistant (LA) Program is a flagship program of the NSF i³. Co-founded and co-directed by PMT member Valerie Otero and Professor Emeritus Richard McCray, the LA Program embodies the NSF i³'s three-part mission of course transformation, educational research, and teacher recruitment and preparation. With the support of the NSF i³, the LA Program made 104 undergraduate appointments in Fall 2011 and 106 appointments in Spring 2012. These appointments spanned 11 departments within two colleges (Arts & Sciences and Education). Last year the program expanded into two new departments (Atmospheric & Oceanic Sciences; Ecology & Evolutionary Biology) as well as into two educational psychology courses in the School of Education. In Fall 2012, 115 LAs were hired and Mechanical Engineering began participating in the program. The LA program hired 118 LAs for the Spring 2013 semester, incorporating ten departments. Projections for the Fall 2013 semester predict 116 LAs will be hired for 33 courses across nine departments.

We continue to collect data, documenting the positive impact of LA-supported courses that feature interactive, research-based practices not only at the University of Colorado Boulder, but also around the nation. Currently 37 institutions in the United States have existing or developing Learning Assistant programs similar to the one created specifically for CU-Boulder. Information about the LA Program is available at: <http://laprogram.colorado.edu/>.

2.A.iii.b. CU Teach

The CU Teach program, a key affiliate program of the NSF i³ effort at CU-Boulder, continues to grow and establish itself as an integrated effort across Education, Arts and Sciences, and Engineering. NSF i³ project directors have facilitated the development of cross-listed courses, synergies between the LA program and CU Teach, and the development of new tracks for teacher certification in engineering (discussed below). More information about CU Teach is available at <http://cuteach.colorado.edu>.

2.A.iii.c. Physics Education Research Group at Colorado

The NSF i³ also continues to support the Physics Education Research Group at Colorado (PER@C), which is one of the largest PER research programs in the nation. The research group develops and studies: uses of technology in physics education, assessments (conceptual, epistemological, and belief oriented), theoretical models of students learning physics, social and contextual foundations of student learning, examination of successful educational reforms and replication studies of such reforms, and student problem-solving in physics. They sponsor a number of educational reforms in physics, which range from pre-college to post-doctoral. The research group includes faculty, staff, and students from both the Department of Physics and the School of Education. In partnership with the NSF i³, the last year's efforts have expanded to include significant funding (e.g., Phase 2 CCLI/TUES) for: course transformation (upper division physics), computer simulation development (PhET), and

other efforts such as a Phase 1 TUES grant on upper division laboratory reform. See www.per.colorado.edu for more information.

2.A.iii.d. Teaching and learning science courses

The University of Colorado Boulder offers three courses in disciplinary-specific teaching: *Teaching and Learning Physics*, *Teaching and Learning Biology*, and *Teaching and Learning Chemistry*. These courses are geared towards current and prospective teachers in these specific sciences to delve deeper into big science ideas and to provide them with adequate tools and techniques to use in their own classrooms. These courses are now offered annually, serve as models for other universities around the country, and serve as a core disciplinary course in the teacher certification program at CU, CU-Teach.

2.A.iii.e Partnerships with other NSF centers and grants at CU-Boulder

The NSF i³ offers consulting and community and research-based educational support for a variety of centers and institutes at the University of Colorado Boulder, including the JILA Physics Frontier Center, COSI-IGERT, the Renewable and Sustainable Energy Institute, the Colorado Initiative in Molecular Biotechnology (CIMB-IQ), the Center for Engineering Educational Research and Assessment, and Colorado's expanded efforts through Science Discovery.

2.A.iv. Seeding new STEM Education collaborations and programs nationally

The NSF i³/ iSTEM/CSL efforts are designed to incubate new programs on campus and nationally and to link these efforts to other programs on campus and nationally. In the past year, NSF i³ efforts have been supportive of a new engineering track, other national centers, and a new national network of STEM education centers.

2.A.iv.a. Creating an engineering teacher certification track

With the support of the NSF iSTEM team (and subsequent CSL structure), the CU School of Engineering and Applied Sciences created a new major, General Engineering Plus, that is specifically designed to support students earning teacher licensure along with an ABET accredited engineering degree. The effort linked faculty/administrators in the College of Engineering and Applied Science, CU Teach, and the School of Education and identified essential features of a teacher certification program. The project was seeded with initial support from the Battelle Foundation, and is now followed up with a multi-million dollar award (June 2013) from Battelle to create this national model program for all schools of engineering. We anticipate a full program running by summer 2014.

2.A.iv.b. Partnerships with other NSF centers nationally

The CU-Boulder NSF i³ project is serving to develop STEM education centers across the nation and to develop a national network of these centers. Members of the PMT have been in consultation with newly developing centers at universities in Texas, Arizona, Maine, New York, Illinois, Maryland, California, Florida, Pennsylvania, Georgia, and other institutions to help support their development. Most recently, Jun 5, 2013,

the CU NSF i³ program was a featured program that served to advise a coalition of Philadelphia area universities investing in STEM education – supporting its proposal to the WIDER regional program.

2.A.iv.c. Towards a national network of STEM education Centers

With the support of the Alfred P. Sloan Foundation, the Association of Public and Land-grant Universities (APLU) has launched a national discussion on university-based science, technology, engineering, and mathematics (STEM) education centers. Our goals are to foster communication and interaction among STEM education centers as well as to enhance their capacity to support effective undergraduate education. The Center for STEM Learning (the NSF i³ seeded program at CU-Boulder) has served as a model and is a leading institution in this national discussion and network.

2.B. Hosting events

The Center for STEM Learning regularly holds events to support, link, coordinate, and integrate constituent programs on campus, link with external programs and collaborators, and to build external awareness of CU-Boulder's STEM education efforts. Several of these events were held in the last year.

2.B.i. Annual symposia

A cornerstone of our NSF i³ program is an annual symposium celebrating STEM education at the University of Colorado Boulder. Our Fourth Annual Symposium was held September 30 and October 1, 2012 and was a celebration of the launch of the CU-Boulder Center for STEM Learning. This year's event highlighted some of the groundbreaking STEM education projects on campus, introduced a new generation of STEM education scholars, and brought together key CU-Boulder stakeholders. It was an opportunity to learn about how we are redefining learning and discovery in a global context, and setting new standards in education, research, scholarship, and creative work to transform STEM education.

This year's symposium and Center launch celebration was attended by approximately 200 people representing more than 60 departments, programs, and partners. Attendees included the CU-Boulder chancellor and provost, the vice chancellor for research, six deans, two state representatives, several donors, and faculty, staff, and students from across 12 academic colleges/schools.

The Center launch celebration on September 30, 2012 included an introduction and endorsement from United States Congressman Jared Polis and Peter Lorenzen, Senior Vice President and Executive of IBM. More than 60 people attended the launch celebration.

The October 1, 2012 symposium began with a poster session highlighting 52 programs, which provided networking opportunities among STEM education constituents. An award ceremony recognized recipients of the Chancellor's Award for Excellence in STEM Education. Scott Green, the engineering site director for Google

Boulder, provided the keynote address for the event. The CU-Boulder chancellor, provost, and deans of the College of Arts and Sciences, School of Engineering and Applied Science, School of Education, and Graduate school also gave brief presentations. For more information, see http://www.colorado.edu/csl/2012_Symposium.html.

Plans are under way for the fifth annual STEM education symposium to be held on September 23, 2013. Invited guests will include donors, VIPs, and key stakeholders throughout the state and the university.

2.B.ii. The First CSL-hosted NSF Grants

The Center for STEM Learning serves as a campus administrative resource to host national projects in STEM education, especially those that have a campus-wide (or broader) emphasis. Since the formation of the Center, three new NSF-funded grants have been housed within it and seven more grant proposals are in review.

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

Anne-Barrie Hunter (a fellow of the NSF i³ CSL) serves as PI for *Talking About Leaving Revisited: Exploring the Contribution of Teaching to Undergraduate Persistence in the Sciences*. This grant is based upon and builds from Elaine Seymour and Nancy Hewitt's study, *Talking About Leaving: Why Undergraduates Leave the Sciences* (1997). In essence, the new study will comprise of three steps: (1) a study of STEM field-switching patterns based on national and institutional data, (2) a switcher and non-switcher interview that replicates and extends the original research, and (3) a three-part study of instructors teaching foundational STEM courses using course observation, instructor interviews and student focus groups, and online surveys of students in those classes.

The goal of this research is to develop a theoretically driven model built upon previous work and research that will discern persistence and switching patterns in STEM fields. This work will provide an updated portrait of factors shaping why undergraduates switch majors. It is also intended to improve quality, access, and persistence to graduation in STEM undergraduate education, which will have national and global impacts, both economically and environmentally.

2.B.ii.b. STEM Talking and Photo-Origami Outreach

Elisabeth Stade, CSL fellow from the Department of Mathematics in the College of Arts and Sciences, is conducting research for two grants hosted in the Center for STEM Learning. *STEM Talking* examines the mathematical content and course requirements for pre-service teachers at the University of Colorado. Researchers and project staff review best practices and existing requirements at other Colorado institutions providing pre-service teacher education and collect data from the existing "Spirit and Uses of Mathematics" courses offered at CU-Boulder. Ongoing research will identify challenges with such courses and evaluate the effectiveness of recommended changes to the curriculum.

Ms. Stade's second project, Photo-Origami Outreach, is an NSF-funded EFRI grant. As the community outreach component of this grant, they have worked closely with the CU Science Discovery program and the Boulder Valley School District to create classes, educational experiences, and teacher professional development around research in polymer science. In the first year, they supported the development of 3-D printer partnerships with the Ryan Elementary STEAM program. Photo-Origami has also created and conducted a CU Science Discovery polymer science class, "Bounce and Tangle." During Summer 2013, the project is running a teacher professional development course GRTE 5030 Photo Origami and Polymer Science that will provide research experiences for teachers. This ongoing outreach effort will continue to develop a variety of activities and professional development experiences for local teachers and students.

2.B.iii. SEI/CSL End of Year Event

On May 7, 2013, the NSF i³ Center for STEM Learning (CSL) partnered with the Science Education Initiative (SEI) to host an end-of-year event to celebrate the year's successes in STEM education at the University of Colorado Boulder. This event featured a total of four keynote speakers: NSF i³ collaborating researchers, Anne-Barrie Hunter with Ethnography & Evaluation Research and Anne-Marie Hoskinson, Andrew Martin, and Nichole Barger with the Department of Ecology & Evolutionary Biology. Ms. Hunter spoke about undergraduate persistence in STEM majors. Drs. Hoskinson, Martin and Barger gave recommendations on how to implement a flipped classroom. In addition to these speakers, the end of year event featured breakfast, a networking session, lunch, and a poster session with approximately 30 posters from programs affiliated with the SEI and the NSF i³. Roughly 150 members of the CU-Boulder community participated in this end of year event.

2.B.iv. Participation in NSF i³ research site visit

In May, 2012, the CU-Boulder CSL was visited by NSF i³ system evaluators and researchers: Joe Merlino, President of The 21st Century Partnership for STEM Education, Joy Frechtling, Vice President of Westat and Associate Director of Westat's Education Studies Group, and Karen Stephenson, President of Netform. During their two-day visit, they met with CU-Boulder's provost, the dean of the Graduate School, the director of the Office of Communications, the director of the Office of Government Relations, the CSL Project Management Team, several recipients of the Chancellor's Award for Excellence in STEM Education, and DBER community members. They also participated in the SEI/iSTEM End-of-Year Event. We are awaiting their report.

The NSF i³ project continues to work with these researchers and anticipates having an additional site-visit in fall 2013. Research on the establishment of the CU campus network and the impact of that network is continuously being evaluated by the NSF i³ project.

2.C. Enhanced use of technology

Over the last year, the CSL has shared resources electronically.

2.C.i. Website

A new website was established to maintain and update the NSF i³ effort as the new center was launched. The website coordinates work internally at CU-Boulder and shares information and resources with the public at large. The website is available at: <http://www.colorado.edu/csl>.

2.C.ii. Streaming videos

The weekly DBER and PER meetings are now being captured and streamed online. Thirty-seven DBER videos and 26 PER videos from the weekly meetings are now posted. These videos feature both local researchers and internationally renowned visitors. More information can be found at: <http://sites.google.com/site/custemeducationalvideos/home>.

2.C.iii Robust database of participants

We continue to maintain a database system for supporting the NSF i³ community and constituent programs. Our web efforts allow us to track participants, quickly send out surveys, collect information, electronically track applications, and provide for collaborative space.

2.C.iv. Communication efforts

As discussed below, the Office of University Communications is leading an effort to promote STEM education as a central theme of the University of Colorado Boulder. New media (blogs, twitter, and web2.0 tools) are playing an increasing role in this communications effort. Last year, CU-Boulder established and filled the position of vice chancellor for strategic relations to coordinate communications, alumni relations, government relations, and fund-raising. This vice chancellor serves on CSL's Executive Board. A list of all press the Center for STEM Learning has received in the past year is available in 7.G. CSL Press.

2.C.v. Advising CU Technology Taskforce

In 2012 the University of Colorado established the Taskforce on Teaching with New Technologies. The taskforce serves to advise the University president and each of the campus chancellors. The CU CSL project team advises on this Taskforce and serves as a campus and system-wide point of contact in STEM education. In addition to providing links to campus uses of technologies in service of education (e.g., clickers, social media, interactive media, etc.), members of the CSL project team meets periodically with the University system's external consultant (Goldstein and Associates) to advise on the current and future landscape of technology use in service of education.

2.C.vi. Support and Study of Massively Open Online Courses

In 2013, the University of Colorado signed a contract with Coursera to offer courses through their learning platform. In fall 2013, CU Boulder will be hosting four new MOOCs (Massive Open Online Courses) to engage and study the impact of learning in this online environment. Two of the four courses are in the STEM educational environment (electrical engineering and physics). The physics MOOC will be the source of a study supported in part by the Center for STEM Learning and the NSF i³ seeded efforts in technology.

3. Diversity, equity, and access

Below are some of the NSF i³ project's diversity and access efforts which intersect with and/or supplement existing programs on campus:

3.A. Office of Diversity Equity and Community Engagement (ODECE)

CU-Boulder has established a vice chancellor-level position focusing on diversity and access. The CSL directors are the STEM education consultants to that office. More information is available at <http://www.colorado.edu/odece/>.

3.B. Colorado Diversity Initiative (CDI)

This program, which gives the highest priority to encouraging and supporting diversity, works to improve access to STEM learning and is a strong collaborator with the NSF i³ effort. This year the program introduced the Colorado Advantage Graduate Preview Weekend for college seniors and recent graduates interested in pursuing a STEM doctoral degree at the University of Colorado Boulder. More information is available at <http://www.colorado.edu/GraduateSchool/DiversityInitiative/>.

3.C. Partnerships in 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. In 2012-13, partnering with NSF i³, PISEC Director, Katie Hinko, has secured two grants to continue PISEC programming – a University of Colorado Outreach Award, and a College of Arts and Sciences Diversity Award. More information about PISEC is available at <http://www.colorado.edu/physics/PISEC/index.html>.

3.D. Minority Bridge Program

The CU-Boulder physics department continues to coordinate with the American Physical Society as they partner with institutions committed to doubling the number of black and Hispanic PhDs in physics across the United States (other institutions include Harvard, Princeton, Stanford, MIT, and the University of California). The role of the CU physics department continues to evolve and the CSL continues to consult and advise on the approach to STEM education and access.

3.E. Latin American Center for Arts, Science, and Education (CLACE)

A community based program, 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. The University of Colorado Boulder currently collaborates with CLACE in a variety of ways, including collaborative funding, and linking CU-Boulder prospective STEM teachers with opportunities to work with CLACE students.

3.F. Noyce

The NSF i³ partners with the two Noyce programs: the Noyce pre-certification program at CU-Boulder and the Streamline to Mastery program for practicing teachers. Each Noyce community focuses on working in underrepresented/underserved populations. These Noyce scholars are featured by the NSF i³ by presenting at DBER and hosting poster presentations at our annual symposia. The CU-Noyce efforts continue to expand opportunities and establish new models for recruitment, certification, induction and support of STEM teachers. The latest models are focused on establishing collaborative learning teams (Communities of Practice). More at: <http://noyce.colorado.edu>

3.G. CU Science Discovery

This program is partnering with the NSF i³ to create opportunities for underserved students in their staple afterschool/summer camp programs. In particular, the NSF i³ is supporting the integration of Science Discovery into a more central practice/role at the university.

3.H. Boulder Area STEM Education Coalition (BASEC)

BASEC (see <http://boulderareastem.org>) focuses on diversity, equity, and access for children in STEM. The NSF i³ has helped shape this effort, which helps to link CU-Boulder with the Boulder County community. In partnership with BASEC, the NSF i³ has supported career fairs for youth, campus visits, and networking among the dozens of community-based programs focusing on STEM.

Since July 2012, BASEC has held three quarterly meetings to discuss STEM events, workshops, community building, etc. These events were held on September 13, 2012, and January 10 and April 10, 2013 at the Thorne Nature Center, JILA Auditorium (CU-Boulder), and NCAR respectively. Each meeting included nearly 50 attendees.

On Memorial Day weekend, May 25-27, 2013, BASEC in partnership with the CU Center for STEM learning (NSF i³) sponsored a booth at the Boulder Creek Festival. The festival hosted over 100,000 people in downtown Boulder. The CSL/BASEC booth offered fun and interactive science activities for kids and adults, as well as provided information about different STEM education programs in and around the region. The Creek Festival is an annual event with 2013 being the third year to include STEM

learning information.

3.I. Women in Electrical, Computer & Energy Engineering Group

The NSF i³ continues to support the Women in Engineering program on campus. The group strives to create a community atmosphere among Engineering students providing role models, support and promoting professional and technical development. The ongoing meetings are intended to help build a community and cohort between electrical engineering undergraduate and graduate women. The group was founded by a faculty member, who is also advised by NSF i³ co-PI, Noah Finkelstein, and has recently been awarded a University of Colorado Outreach Award to expand the group's efforts. The project has now expanded to include broader STEM educational speakers and to connect the program to other efforts on campus through the Center for STEM Learning.

3.J. Chancellor's Awards for Excellence in STEM Education

The Chancellor's Awards support faculty and student engagement in innovative research on student learning and implementation of research-based STEM education programs and initiatives and also serve as a mechanism to seed and support work in Diversity and Access at CU.



For example, Ian Her Many Horses was given a graduate award for his research on curriculum support for elementary students from non-dominant communities. The focus of his project is to study the needs of elementary school students in order to design and implement games and simulations. The students are placed in small groups and work with prospective elementary teachers to design these games and simulations in both 2- and 3-dimensional environments. Ian is using his Chancellor's Award funding to assess the significance of small group work to accomplish problem-solving tasks. He will use that information to develop support materials to enhance the students' development of computational thinking skills.

4. Dissemination and public policy

Efforts to disseminate findings and support educational policy run throughout each of the three major areas of the NSF i³: course transformation, discipline-based education research, and professional development for teachers.

Much of our focus on dissemination and networking has been on the programmatic level:

- The NSF i³ has supported the dissemination of the LA Program (see **Error! Reference source not found.**) model of educational transformation. In the past

year, in addition to the three major workshops described earlier, the NSF i³ directors have made over a dozen presentations at state and national venues regarding the STEM learning effort. Currently more than three-dozen institutions are replicating this successful program that has been shown to positively impact student learning, increase the number and quality of certified teachers, and enhance institutional commitment to education.

- As described above, the DBER seminars (see 2.A.ii. Discipline Based Education Research) are now streaming on the web and have hosted more than a dozen participants from outside of CU-Boulder.
- The NSF i³ has continued partnering with researchers at Western Michigan in the design and population of a website dedicated to collecting research-based models of educational transformation in undergraduate STEM (see STEMreform.org). Owing to lack of community uptake, this 3-year funded website is no longer funded or hosted. We have archives of these resources.
- The NSF i³ has been an instrumental partner in creating a state-supported regional coalition for STEM education—the Boulder Area STEM Education Coalition (BASEC). This coalition includes over 300 members, has been endorsed by all of the Boulder county commissioners, and has received support from the University of Colorado Boulder, Google Inc., Ball Aerospace, NCAR/UCAR, and a host of other regionally based efforts. More on BASEC can be found at: <http://boulderareastem.org>.
- The NSF i³ effort at CU-Boulder is a key program that is part of the Colorado STEM Network. This statewide network is seeking to establish a statewide coordinated effort around STEM education. Co-PI, Noah Finkelstein, has recently joined the Governor’s Taskforce on STEM education.
- The CU Center for STEM Learning is working to establish a formal partnership with the STEMx effort in Colorado, run by our sister-center XSci. The STEMx network is a multi-state STEM network intended to “share, analyze and disseminate quality STEM education tools to transform education, expand the number of STEM teachers, increase student achievement in STEM and grow tomorrow’s innovators.” More at: <http://www.stemx.us> and <http://www.xsci.org>
- CU-Boulder and the NSF i³ effort have been essential partners in the new Sloan/APLU effort to create a national network among STEM education centers. Our goal is to foster communication and interaction among STEM Education Centers and to help enhance their capacity to support effective undergraduate science, technology, engineering, and mathematics education. The project began May 2013. More at: <http://www.aplu.org/page.aspx?pid=2734>
- Members of CU government relations and the CSL Project Management Team have coordinated efforts to discuss and promote STEM education policy with members of the U.S. Congress (Senators Udall and Bennet, and Congressman Polis), their staff, and staff of U.S. House Science and Technology Committee (Sokolov).

Parallel efforts have been made to raise awareness about STEM education and the NSF i³ efforts at CU-Boulder:

- A Swedish documentary crew shot a film about CU-Boulder's STEM Education initiatives that featured the NSF i³ program and our progress towards creating a center. This film crew visited for the week in April 2012. The film is available at <http://urplay.se/Produkter/175595-Jakten-pa-det-demokratiska-klassrummet-University-of-Colorado>
- This year the CU-Boulder NSF i³ has been featured at national meetings of the Association of Public and Land-grant Universities' Science and Mathematics Teacher Imperative, the American Institute of Physics, the American Association of Physics Teachers, and the American Physical Society's Physics Teacher Education Coalition.
- Executive Board member Phil DiStefano currently chairs the Executive Board of the Association of Public and Land-grant Universities' Science and Mathematics Teacher Imperative. The CU-Boulder NSF i³ efforts serve as key examples of engaging research universities in educational transformation.
- The NSF i³ PMT has given a wide variety of addresses on educational policy including:
 - September 2012: PMT member Noah Finkelstein was invited to give an address at Tufts University, showcasing the relevance of DBER for institutional transformation.
 - November 2012: PMT member Noah Finkelstein attended the annual colloquium at Florida State University. During the colloquium, he advised project management members on developing a STEM education research group.
 - November 2012: The University of Washington-Seattle hosted the National Visiting Committee. Noah Finkelstein attended on behalf of CU-Boulder.
 - January 2013: The Mathematical Association of America held its annual meeting in San Diego, CA. PMT members Noah Finkelstein and Eric Stade attended the meeting to offer their input on mathematics education research; they showcased how discipline based educational research and a center for STEM learning can promote institutional integration and change.
 - February 2013: PMT member Noah Finkelstein was invited to attend a colloquium hosted by UC Davis to discuss and assess the quality and importance of online learning. Accessibility to the resources offered by UC Davis has been a critical component to improving student interest in STEM fields of study. This trip expanded a long-standing partnership with UC Davis.
 - April 2013: PMT member Noah Finkelstein was invited to participate in a panel discussion at the Experienced Faculty Workshop in Washington, D.C. Hosted by the American Physical Society, the workshop provided veteran professors with new (and more) resources for their students.

- June 2013: PMT member Eric Stade attended the STEM Solutions Summit in Austin, Texas. This summit pinpointed the critical need for integrated centers in transforming the first two years of STEM education
- June 2013: PMT Member Noah Finkelstein attended an AAU / Sloan sponsored meeting of roughly 30 Foundations (including NSF) to identify key avenues for institutionally transforming the first two years of STEM education.
- June 2013: PMT member Mike Klymkowsky (with Ernst Hafen) organized a two-day symposium on the use of students' educational data to improve education at the ETH Zurich, Switzerland
- The NSF i³ initiative has hosted a variety of policy makers including:
 - US Congressman Jared Polis
 - Scott Green, Engineering Site Director, Google Boulder
 - Peter Lorenzen, Vice President, Senior Colorado State and Boulder Location Executive, IBM Corp.
 - Kacy Redd, Associate Director for Science and Mathematics Education Policy, APLU
 - Bradley McLain, Co-Director of Xsci, University of Colorado Denver
 - Eric Brewé, Director, Florida International University STEM Center
 - Kerry Glenn, STEM Coordinator, Northglenn High School, Adams County District 12
 - Colorado State Representative Dickey Lee Hullinghorst
 - Boulder County Commissioner, Deb Gardner
 - Peter Boon, University of Utrecht, and Freudenthal Institute for mathematics education transformation

The NSF i³ has produced a series of materials that describe our efforts. We have produced a brochure and a one-page summary of the project. Additionally, the NSF i³ has developed one-page summaries of many of the key constituent programs. Currently, there are one-page summaries of eight programs including: the NSF i³, DBER, PER@C, PhET, the LA Program, and SEI. The Office of University Communication has offered to produce more of these one-page summaries and at this time, we have created a full suite of 20 summaries within the past year. Additionally, the CSL/NSF i³ effort has partnered with University Communications in a variety of press releases (see Section 7.G. CSL Press for a complete list).

The NSF i³ continues to collaborate with University Communications, Government Relations, Media Relations, News Services, the College of Arts and Sciences, the School of Education, the College of Engineering and Applied Sciences, the CU Foundation, and STEM education program leaders around branding and communications. As a result, there have been over a dozen articles in the past year about CU-Boulder STEM education, many of which are posted at <http://www.colorado.edu/news/series/stem-education>.

4.A. Scientific presentations/publications

The NSF i³ has supported 11 affiliate publications this year, and over 175 in total. See 7.I. Partial listing of publications by the NSF I³ affiliates for a list of publications from the last year.

5. University structures: Towards a center for STEM education

In the past year, the NSF i³ directors met regularly to manage programming in order to accomplish our mission and reach our goals.

In addition to weekly meetings of the NSF i³ directors, members of the team have been meeting with the key personnel at the university, such as deans, the provost, and the chancellor to lay the groundwork and build community consensus around this center.

The final center proposal, including by-laws (see 7.C. CU-Boulder Center for STEM Learning (CSL) by-laws) and an organizational chart (see 7.B. CU-Boulder Center for STEM Learning (CSL) organizational chart) was accepted Dec 11, 2012, after review by the chancellor, provost, associated deans, and legal council. For the full text of the proposed center, see 7.A. Proposal to establish the CU-Boulder Center for STEM Learning (CSL).

Currently the Center's Executive Board includes:

- Chair: Chancellor Phil DiStefano, NSF i³ PI
- Provost Russell Moore
- Vice Chancellor for Strategic Relations Frances Draper
- Dean of the Graduate School John Stevenson
- Dean of Arts and Sciences Steven Leigh
- Dean of Education Lorrie Shepard
- Dean of Engineering & Applied Sciences Rob Davis

The current directors of the center are:

- Paul Chinowsky, Mortenson Professor of Sustainable Development, School of Engineering and Applied Sciences.
- Noah Finkelstein, Department of Physics
- Valerie Otero, School of Education and co-Director of the LA, CU Teach, and Noyce programs

In addition to the directors, the Project Management Team consists of:

- Stan Deetz, director of the Peace and Conflict Studies Program
- Michael Klymkowsky, Department of MCD Biology and co-director CU Teach
- Daria Kotys-Shwartz, Department of Mechanical Engineering and director of the Center for Industrial Partnerships
- Robert Parson, Department of Chemistry and Biochemistry and JILA Fellow
- Diane Sieber, Associate Dean of the College of Engineering & Applied Sciences

We are in the midst of securing an external advisory board and have strong interest from national leaders in STEM education, organizational change, social & behavioral sciences, business, and policy.

6. Evaluation

The NSF i³ at CU-Boulder has been conducting three levels of evaluation:

- Providing measures of positive outcomes of increased educational capacity for constituent programs,
- Measuring the integration of constituent programs, and
- Assessing the institutional capacity and commitment to establishing a STEM Education center.

These evaluations are being conducted internally under the direction of the NSF i³ directors and externally through external evaluator, Dr. Rachel Scherr. In late 2012, Rachel Scherr evaluated the progress of the CSL (see 7.K. 2012 External Evaluation Report). This report has summarized key successes (the formation of the center), and formative next steps (externalizing role/ purpose of a center for key stake-holders). We are currently acting on the recommendations of the evaluation.

After nearly five years, the NSF i³ is meeting its goals of establishing a center, integrating programs, and promoting and creating opportunities for individual efforts in STEM education.

6.A. Component efforts

Key programs are successful and benefit from the NSF i³. For example:

- The NSF i³ has supported roughly 50 individuals directly through the Chancellor's Awards for Excellence in STEM Education (see 2.A.i. Chancellor's Awards for Excellence in STEM Education).
- The LA Program (see **Error! Reference source not found.**) has become a key model for teacher preparation, course transformation, and institutional change. As described above, we are now impacting roughly 10,000 students/year, hiring 200+ LAs/year, have dramatically increased the learning gains of students in large-enrollment classes, and have nearly tripled the number of students going into teaching in hard-to-staff subjects (such as chemistry and physics).
- DBER (see 2.A.ii. Discipline Based Education Research) and PER@C (see 2.A.iv.b. Physics Education Research Group at Colorado) groups hold meetings attended by more than 20 faculty and students per week, create a culture of scholarly work around educational transformation, and produce dozens of papers and presentations.
- The College of Engineering & Applied Sciences is establishing a parallel center, the Center for Engineering Education and Research Assessment, and is collaborating with the LA Program, CU Teach, and other Center affiliates.

6.B. Integration efforts

The NSF i³ has, through concerted programming and communication efforts, created opportunities for integration, and has built a more robust network of programs.

6.B.i. Creating time and space for integration

Much of the NSF i³'s programming is designed to facilitate cross-program communications. This includes the annual symposia, the SEI/CSL End-of-Year Event, PER@C and DBER group meetings, meetings with University Communications and resultant materials, our website, <http://www.colorado.edu/csl/>, and email communications sent to our collaborators across campus.

In the last year, more than 300 different people have participated in an NSF i³-sponsored event.

In year one of this grant we conducted a “baseline” survey of the network among programs. This cross-campus survey resulted in a dataset identifying which programs were connected, in what ways, and how often interaction occurred (see 7.J. STEM Program Interaction Map as an example).

Just over a year ago (year 3) we conducted a mid-program follow-up (expanding on the original survey at the advice of our external evaluator) and already had compelling indications that more programs are involved and are more integrated with each other since our initial survey.

Next year, in the last year of the program we anticipate conducting a final survey of program integration, which will parallel the efforts of year one and three. This survey will also parallel the external NSF i³ effort (Merlino, Frechtling, & Stephenson) that is reviewing the impacts of CU-Boulder CSL.

6.C. Creating a center structure

As described in Section 5. University structures: Towards a center for STEM education, the center proposal was submitted and approved. One essential form of evaluation of this NSF i³ project was whether we were able to establish a functioning and sustained center. With the launch of the center, we anticipate meeting that goal. In addition to creating the campus center and establishing by-laws, we have also developed what we hope to be a sustainable infrastructure for the center. In particular, we have identified roles for participants in this center and expanded from the NSF i³ Project Management Team. The organizational chart for the center (see 7.B. CU-Boulder Center for STEM Learning (CSL) organizational chart) highlights the broad array of buy-in, partnership, and roles that have been established. We are in the midst of securing funding, both from internal CU-Boulder sources and from extramural sources. These include a successful proposal submitted to the Association of American Universities' STEM Education Initiative as a Project Site (one of eight selected national), and current proposals that have been submitted to the NSF's Widening Implementation &

Demonstration of Evidence-Based Reforms (WIDER). We are simultaneously working with the University of Colorado Foundation (the development office) to secure private and philanthropic donations.

7. Appendices

7.A. Proposal to establish the CU-Boulder Center for STEM Learning (CSL)

1. Statement of general purpose of the unit

1.A. Background to the proposed creation of the center

The proposed center is an outcome of the award of NSF Grant “I³: Towards a Center for STEM (Science, Technology, Engineering and Mathematics) Education.” In 2008, Chancellor DiStefano was awarded this NSF grant responding to the National Academies' *Rising Above the Gathering Storm* report, which calls for four avenues of action to support U.S. science, technology, engineering and mathematics (STEM) competitiveness for the coming century; these are, in priority order, to: “focus on actions in K–12 education (10,000 Teachers, 10 Million Minds), research (Sowing the Seeds), higher education (Best and Brightest), and economic policy (Incentives for Innovation).” The principal investigators of this grant felt that CU-Boulder was particularly well poised to take direct and immediate action on these issues through developing and integrating three currently existing lines of NSF supported work: (1) undergraduate and graduate course transformation, (2) undergraduate and graduate teacher preparation, and (3) discipline-based education research among faculty, students, and post-doctoral scholars. The purpose of the NSF grant is to create a STEM education center that will: (a) integrate the three lines of inquiry and development described above, (b) retain the status and rigor offered through science and engineering departmental identity, (c) expand the reach of thriving STEM education community to include more departments and participants, and (d) establish CU-Boulder as a national hub of STEM education.

1.B The purpose (mission) of the CU-Boulder Center for STEM Learning (CSL) is:

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.C. Our vision for achieving this mission is:

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.

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.D. Disciplines typically involved

Historically, university-level STEM educational efforts have been carried out largely in disciplinary isolation. This center will build on the strengths of this disciplinary focus by establishing an interdisciplinary, collaborative effort among university and community stakeholders and coordinating mechanisms for communication and coordination among CU-Boulder's pre-existing disciplinary- and interdisciplinary-efforts. At least 40 programs, involving more than 50 faculty, and 20 centers/ departments from the College of Arts & Sciences, the College of Engineering & Applied Science, and the School of Education are currently involved in STEM education research and educational transformation. These include but are not limited to: Aerospace Engineering, Applied Mathematics, Astrophysical & Planetary Sciences, Atmospheric & Oceanic Sciences, Chemistry & Biochemistry, Chemical and Biological Engineering, Civil, Environmental and Architectural Engineering, Communication, Computer Science, Electrical, Computer, & Energy Engineering, Continuing Education and Professional Studies, Ethnography & Evaluation Research, Geology, Integrative Physiology, Mathematics, Mechanical Engineering, Molecular, Cellular, & Developmental Biology, Outreach and Engagement, Physics, Psychology, the Institute of Cognitive Science, and the School of Education.

1.E. Areas of research and service

We improve STEM education by building a robust network of affiliated programs that address three integrated lines of inquiry:

1. Educational transformation: We support work to improve student understanding of content, to develop student understanding of the nature of STEM and of learning STEM, and to increase student interest in STEM and STEM education through the implementation of research-based curricula that emphasize student engagement and the use of validated measures of student learning. We emphasize that establishing and assessing learning goals, as well as adapting educational practices to achieve these goals, are key to transforming educational environments. We work to transform undergraduate and graduate courses, as well as K12 and informal educational opportunities.
2. STEM education research: Our efforts promote STEM education research as the central tool in improving the quality, efficacy, and inclusiveness of STEM education. We foster collaboration between researchers across campus, and we conduct research that creates new materials, resources, and models for STEM education, directed at improving student learning and access to STEM.
3. K20 teacher recruitment, preparation, and professional development: Center efforts and affiliated programs promote content mastery by recruiting and preparing K12 teachers from within the STEM departments and promoting appropriate disciplinary-based courses in education. Additionally, we support

the professional development of graduate students, postdocs, and faculty broadly and as educators in particular.

1.F. Proposed Activities

General activities may include:

- Formally coordinate our three related lines of inquiry: (1) educational transformation (particularly course, departmental, and institutional transformation in higher education), (2) education research within and across STEM fields and departments, and (3) K20 teacher recruitment, preparation, and professional development.
- Serve as an additional intellectual and academic home for faculty, researchers, staff, and students from the various schools, departments, institutes, centers, and programs invested in STEM education transformation and research.
- Nucleate, sustain, and advocate for programs that reach audiences not historically represented in STEM: all programs participating in the CU-Boulder Center for STEM Learning will be encouraged to address diversity and support students, staff and faculty from under-represented populations.
- Create opportunities, personnel support, and events for communication among existing programs and support cross-programmatic planning, grant writing, and project development.
- Stabilize, sustain, and externalize the CSL model for university-level STEM education, allowing other institutions to adopt, adapt, and build upon our efforts.
- Promote research and faculty, graduate, and postdoc development in STEM education through funding, mentoring, and communication.
- Develop, advocate, and support the incorporation of useful learning and program assessment tools within and across STEM departments.

Specific programmatic activities may include:

- Institutionalize and expand the Colorado Learning Assistant Program.
- Make Chancellor's Awards for Excellence in STEM Education to graduate students: matching funds will be awarded to support students who engage in graduate-level education research and educational reform programs within the STEM disciplines.
- Make Chancellor's Awards for Excellence in STEM Education to faculty: to support faculty who engage in discipline-based educational research.
- Develop a cyber infrastructure and a web-based STEM education portal to link programs and disseminate results.
- Conduct evaluation of the center and support evaluation of STEM education efforts across campus.
- Support and institutionalize an annual symposium on STEM education
- Develop workshops, and a seminar/group meeting series that spans the STEM education transformation and research community at CU-Boulder.
- Establish a visiting speakers program and invite scholars from across the

country to share findings and visit CU-Boulder.

- Host workshops for the STEM community at CU-Boulder that target key areas of interest.
- Support and develop regional and national STEM education networks and events.
- Serve in an advisory role to the state of Colorado on STEM education initiatives, legislation, and funding priorities.
- Streamline fundraising and communications efforts for the center and its affiliated programs by working with the University of Colorado Foundation, the Office of Government Relations, and the office of University Communications.

2. Statement of congruence with role and mission of parent organizations

2.A CU-Boulder

2.A.i. Mission

The Boulder campus of the University of Colorado shall be a comprehensive graduate research university with selective admissions standards. The Boulder campus of the University of Colorado shall offer a comprehensive array of undergraduate, masters, and doctoral degree programs.

2.A.ii. Vision

The University of Colorado at Boulder will become a leading model of the "new flagship university" of the 21st century—by redefining learning and discovery in a global context and setting new standards in education, research, scholarship, and creative work that will benefit Colorado and the world.

First, the university environment will be intellectually inspiring, academically challenging, welcoming, supportive, and conducive to positive personal growth.

Second, CU-Boulder will become a dynamic global force for nurturing ideas and the uses of knowledge.

Third, the university will be a place that exemplifies diversity, intercultural understanding, and community engagement.

Fourth, CU-Boulder will help promote Colorado as a global crossroads of ideas and discovery.

Fifth, the university will provide students with a foundation of knowledge that will help them reach their full potential.

Sixth, CU-Boulder will be an agile organization supported by effective leadership, financial and operational models, and infrastructure.

2.A.iii. Statement of congruence

The Center for STEM Learning directly addresses the university's mission and vision. We will be "redefining learning and discovery in a global context and setting

new standards in education, research, scholarship, and creative work that will benefit Colorado and the world.” The center will be focused on broadening a STEM education and research community on campus, improving STEM education through innovative, research-based/multidisciplinary courses and programs, recruiting top-tier math, science, and engineering students as future K-20 STEM educators, and addressing local, state, and national calls for reform through policy work. These efforts will enable CU-Boulder to deliver an unrivaled university experience, and pursue knowledge in service to Colorado, the nation, and the world. The Center for STEM Learning will establish CU-Boulder among local, national, and international educators as a global leader in STEM education.

2.B. The Graduate School

2.B.i. Mission

The mission of the Graduate School is to facilitate and enhance the educational experiences and opportunities for all graduate students and to encourage excellence in research, creative and scholarly work.

- [from *Graduate School Rules*, 2001 edition, retrieved from www.colorado.edu/GraduateSchool/policies/_docs/GraduateSchoolRules.pdf, Jun 2012.]

2.B.ii. Statement of congruence

“Enhancing educational experience” and “excellence in research, creative and scholarly work” are included in the Graduate School mission. These are core efforts of the CSL, which will support the Graduate School mission by funding graduate students, postdocs, and faculty research, and by supporting and growing the existing interdisciplinary community that promotes academic rigor, fosters mentoring, and provides professional development. The CSL will support, promote, and create a network among key affiliate programs, such as the Colorado Learning Assistant Program, which addresses the mission. At its core, the CSL will develop and support the emerging fields of discipline-based education research (DBER) within CU-Boulder and nationally. DBER is naturally congruent with the graduate school mission. Structurally, because the graduate school constituency spans the associated colleges, schools, and institutes throughout the University, it is a natural fit and venue for coordinating CSL programs designed to span these constituent units. Finally, should the CSL grow into an institute in the future, the Graduate School would be the home, providing temporal and structural congruence from this proposed center.

3. Description: institutional capability for implementing unit

The institutional capacity for establishing the CU-Boulder Center for STEM Learning lies within the existing structures at the university – primarily the disciplinary departments, centers, institutes, and colleges, which house the faculty, researchers, and graduate students in STEM education. That is, while faculty, postdocs, and graduate students will be members of, contribute to, and receive support from the CSL, they will maintain their dominant affiliation with their

disciplinary departments, institutes, centers, and colleges (education, physics, chemistry, biology, math, geology, engineering, etc.). Similarly, program affiliates (e.g. CU Teach and Science Discovery) will remain autonomous, but may receive support from the center. The Graduate School will have appropriate facilities for administrative staff supporting by this project, and will provide meeting space and institutional / fiscal infrastructure.

While maintaining a separate identity, the Learning Assistant Program will be housed within the CSL. The resources and management structure of that program will also be incorporated in the CSL.

4. Description of administrative structure of the unit and reporting relationships

(See Organizational Chart: 7.B. CU-Boulder Center for STEM Learning (CSL) organizational chart)

The CU-Boulder Center for STEM Learning will be housed within the Graduate School. Overall policy direction and responsibility for ensuring that the center is operated in a manner consistent with what was outlined in the NSF proposal will rest with the Executive Board. CU-Boulder chancellor and provost (or their designated appointees) will sit on the Executive Board with the deans of the Graduate School, the School of Education, the College of Engineering and Applied Science, and the College of Arts and Sciences (or their designated appointees). Chancellor DiStefano, Dean Gleeson, Dean Shepard, and Associate Dean Argrow currently serve as co-PIs on the NSF i³ award prompting the creation of the CSL. The executive director and Project Management Team will report to the dean of the Graduate School. In addition to the executive director, the Project Management Team includes the managing directors and the associate directors. The executive director will serve as fiscal officer, oversee the overall operations, supervise the managing directors, associate directors and administrative staff, and serve as chair of the Project Management Team, which includes the executive director, the associate directors, and the managing directors. Additionally, the executive director will be responsible conducting research on the CSL model and its impacts.

The associate directors will work closely with the executive director and managing directors to oversee daily operations of the center and coordinate with the Executive Board. Each associate director will be the lead and day-to-day supervisor of one of the three major focuses of the center. The associate director of course transformation will be the coordinator of efforts associated with transformation-focused Chancellor's Awards, CSL materials development efforts, center web infrastructure and outreach, and assessment resources. The associate director of research will be the coordinator of efforts associated with research-focused Chancellor's Awards, the Discipline Based Education Research seminar series, the development of assessments and evaluations of CSL course transformation efforts,

and visiting speakers. The associate director of faculty development will coordinate workshops on course transformation and research methods, organize the annual symposium, arrange mentoring teams, coordinate appropriate tutorials, and link the CSL with K12 recruitment, preparation, induction, and mentoring programs.

The managing directors will serve as liaisons to CU-Boulder institutes and to each of the affiliated schools and colleges. There must be at least one managing director from the College of Arts and Sciences, the College of Engineering and Applied Sciences, and the School of Education. Initially the center will also include managing directors focused on institute relations, and on center evaluation and transformation.

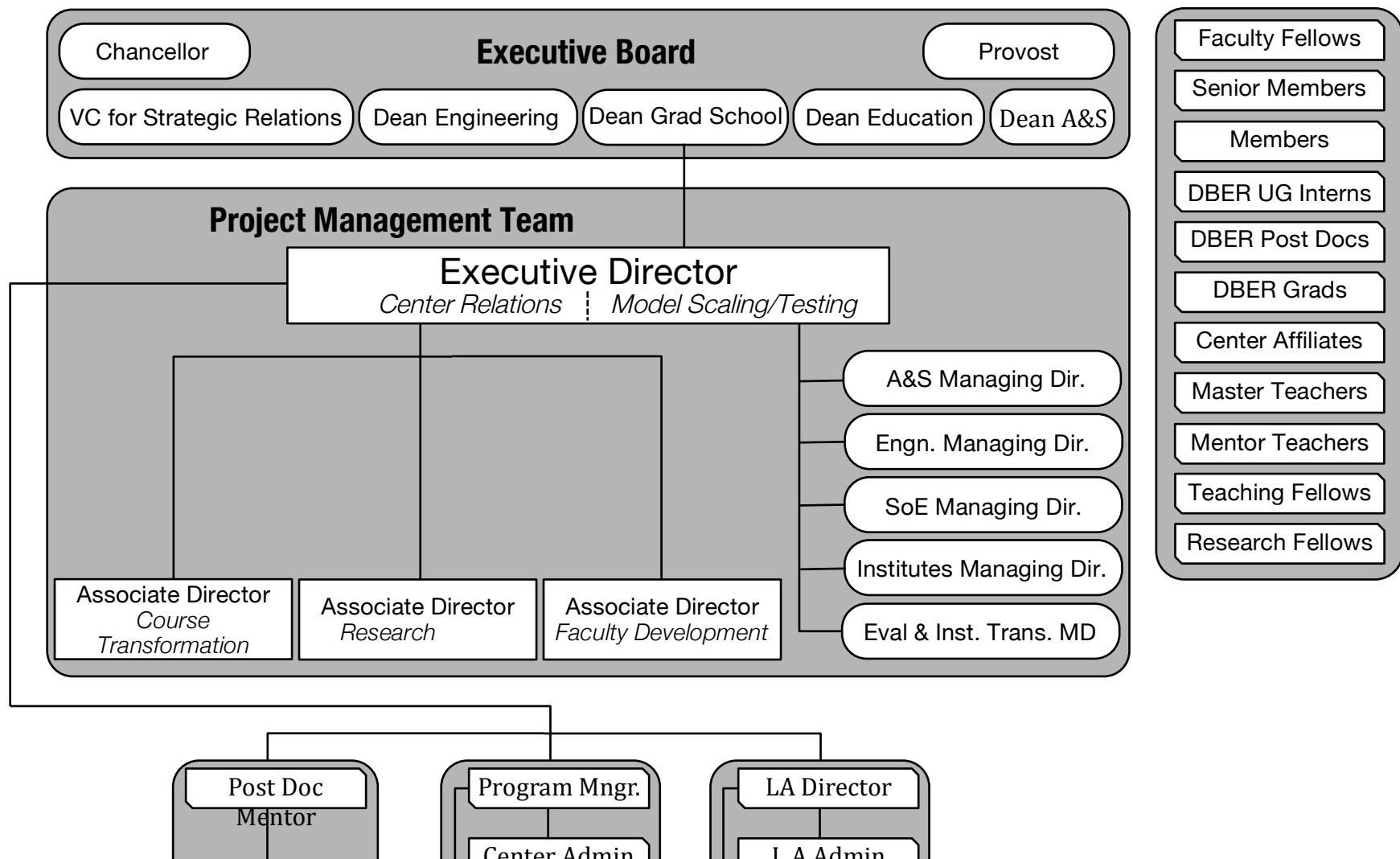
Fellows will provide consultation to the executive director and project management team on center matters and will make recommendations regarding the goals of the center. The roles of senior members, members and affiliates are described in the Bylaws.

Center administrative staff will include a project director, who will run daily operations of the center, including keeping the financial books and supervising the center administrator and IT manager.

On a regular basis (not less than every third year), the center will contract with both internal and external evaluators, who will coordinate with the Executive Board to assess the effectiveness of the center and affiliated programs and review annual progress.

5. By-Laws of the Center (See 7.C. CU-Boulder Center for STEM Learning (CSL) by-laws)

7.B. CU-Boulder Center for STEM Learning (CSL) organizational chart



7.C. CU-Boulder Center for STEM Learning (CSL) by-laws

1. Statement of purpose

1.A. The purpose (mission) of the CU-Boulder Center for STEM Learning (CSL) is:

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

1.B. Our vision for achieving this mission is:

- i. To maintain an infrastructure of institutional support in order to transform STEM education, support education research within STEM fields and departments, and to promote K20 faculty recruitment, preparation, and professional development.
- ii. To facilitate change in STEM education by integrating an interdisciplinary approach, recruiting scholars, promoting, sustaining, and evaluating existing reform efforts, supporting programs, advocating for diversity and access, influencing relevant policy, and communicating with the public.

1.C. We improve STEM education through three integrated lines of inquiry:

- i. Educational transformation: We support work to improve student understanding of STEM content, develop student understanding of the nature of STEM and of learning, and to increase student interest in STEM through the implementation of reform-based curricula that emphasize student-engagement and the use of valid measures of student learning. We emphasize that establishing and assessing goals, as well as adapting educational practices to achieve these goals, is transforming educational environments. We work to transform undergraduate and graduate courses, as well as K12 and informal educational opportunities.
- ii. STEM education research: Our efforts in STEM education research serve as a tool in improving the quality, efficacy, and inclusiveness of STEM education through collaboration between researchers across campus, and we conduct research that creates new materials, resources, and models for STEM education, directly improving student learning and access to STEM.
- iii. K20 teacher recruitment, preparation, and professional development: We promote content mastery by supporting affiliate programs (particularly CU Boulder) to recruit and preparing K12 teachers from within the STEM departments. Our programs and education courses build on student understanding of teaching in STEM. Additionally, we support the professional development of students broadly and educators in particular.

2. Membership procedures, rights, privileges and responsibilities

2.A. Fellows

- i. Both academic and research faculty of the University of Colorado Boulder are eligible to become fellows and serve without compensation. Fellows may serve as principal investigators on research administered through the center and the center's staff will provide services in the administration of such research grants. Fellows will review and approve the Direct Administration-Indirect Cost Recovery rate for standard grants on a biennial basis. Fellows will provide consultation to the executive director on center matters and will make recommendations regarding the goals of the center.

- ii. Meetings of the fellows will normally be held at least quarterly at the call of the executive director. Meetings may also be called by written or electronic request of three or more fellows to the executive director. All fellows must be notified at least one day in advance of a fellows meeting.
Only fellows of the Center for STEM Learning may vote. Unless specified elsewhere in these bylaws, the members of the Project Management Team may vote on any question brought before the fellows. Fellows may submit votes electronically to the project director up to three hours in advance of a meeting.
A quorum shall consist of a simple majority of center fellows. Fellows physically present at the meeting, attending via video or teleconferencing, or who have submitted votes electronically in advance of a meeting will count towards a quorum. Whether a quorum exists shall be determined at the time the meeting is called to order.
A majority of those present at meetings and those voting by email will be sufficient to decide a question, except as other provisions of these bylaws require a two-thirds majority of all fellows.
Center activities will be announced and policy issues discussed via e-mail, to the greatest extent possible, in order to minimize the number of meetings.

- iii. Election of fellows will be from those STEM education scholars at CU Boulder who show a strong interest and a long-term commitment to active participation in the CSL. Potential new fellows will normally be nominated by a CSL fellow. Election will be by at least a two-thirds majority vote by written or electronic ballot of all fellows. The term of the initial fellows will be for 2 years. The term of subsequent appointments will be for four years, and fellows may be re-elected to additional terms. Termination of a fellow's appointment at CU-Boulder will automatically result in termination of the appointment as fellow. A fellow serves without compensation, at the pleasure of the Dean of the Graduate School, and may also be terminated by two-thirds majority vote of all active fellows.
A fellow off-campus for more than six months will be expected to remain in contact with the center via electronic mail, or may be declared inactive and ineligible for voting. An inactive fellow may be returned to active status upon return to the Boulder campus.

2.B. Senior Members

- i. Senior membership in the CSL is open to all employees of the University of Colorado Boulder who participate in the center's activities and have made a long-term

commitment to the CSL. It is ordinarily expected that senior members will hold a doctorate and will have been a member, as defined below, in the CSL for two years after receiving a doctorate.

- ii. Election will be by at least a two-thirds majority vote by written or electronic ballot of all fellows. The title of senior member is conferred for fixed periods of time, not to exceed three years, and is renewable. Termination of an appointment by CU-Boulder will automatically result in termination of the title of senior member. A senior member serves without compensation and at the pleasure of the Dean of the Graduate School, and the appointment may also be revoked by two-thirds majority vote of all active fellows.
- iii. Senior members serving as principal investigators on grant proposals will normally be expected to name the center as the unit that will administer the grant, and the center's staff will provide services in the administration of such grants. Senior members may submit center proposals on their own, without a sponsoring fellow.

2.C. Members

- i. Membership in the CSL is automatically conferred upon those employees who occupy CSL space and/or are supported as CU-Boulder employees by grants administered by the CSL. Members are authorized to use the resources of the CSL, subject to the approval of the Project Management Team, and are encouraged to submit scientific papers with the CSL by-line.

2.D. Affiliates

- i. The CSL may extend temporary membership privileges to additional persons under the title of CSL Affiliate. An affiliate must be nominated by one or more sponsoring fellows of the CSL. Appointment is subject to the approval of a majority of CSL fellows. Appointment as a CSL affiliate does not construe employment by the University of Colorado Boulder, and, of itself, will not result in remuneration to the affiliate. The sponsor must present evidence that the affiliate is actively engaged in research with a track-record of success, and/or distinguished in conducting or promoting research-based education practice. Reappointment may be approved by a majority vote of the fellows of the CSL. Affiliates serve without compensation and at the pleasure of the Dean of the Graduate School, and may be terminated at any time by a two-thirds majority vote of the fellows of the CSL.
- ii. The sponsoring fellow will act as principal investigator for funding proposals submitted through the CSL, involving the affiliate as co-investigator. An affiliate is accorded all the privileges of the general membership of the CSL, including the use of all facilities. As available, a limited amount of office space will be set aside especially for the shared use of affiliates in order to encourage their presence on campus.

3. Governance

3.A. Executive Board

- i. The CU-Boulder chancellor, provost, and vice chancellor of strategic relations, and deans of the Graduate school, the School of Education, the College of Arts and Sciences, and the College of Engineering and Applied Sciences, or their appointees will sit on the Executive Board. The Executive Board will serve as the primary policy-making body of the center. This board will approve appointments to the Project Management Team, including the executive director, who will report to this board, the associate directors, and the managing directors. The Executive Board will meet at least annually.

3.B. Project Management Team (PMT)

- ii. The PMT will consist of a minimum of three managing directors, three associate directors, and the executive director of the CSL, who will serve as chair.
- iii. The PMT will develop an annual budget for the center, which must then be approved by a majority of the fellows and Dean of the Graduate School. The PMT will be responsible for conducting the day-to-day operations of the CSL, subject to the policies of the Executive Board, Dean of the Graduate School and fellows. It will be responsible for conducting center elections and will act as the nominating committee. Fellows may request that the PMT address particular issues by contacting the executive director. Where appropriate, the PMT will make recommendations to the university administration on the acquisition and use of facilities and the faculty and supporting staff needed for the effective operation of the center.
- iv. Meetings of the PMT will normally be held at least once every month at the call of the executive director. The project manager and project administrator are expected to attend all PMT meetings. Meetings may also be called by written request of two or more PMT members to the executive director. All PMT members must be notified at least one day in advance of a meeting. Half of all PMT members will constitute a quorum. Except where specified elsewhere in the by-laws, a simple majority of all PMT members present will decide a question.

3.C. Executive Director

The executive director may receive compensation, as determined by the Dean of the Graduate School. S/he serves as fiscal officer, oversees the overall operations, and supervises the associate directors, managing directors and administrative and research staff. The executive director, along with the associate directors and managing directors, will be responsible for carrying out policies established by the Executive Board, dean of the Graduate School and fellows. The executive director will sign off all proposals routed through the center. The executive director will be a voting member and will serve as chair of the PMT. Additionally, the executive director will be responsible conducting research on the CSL model and its impacts.

- i. The regular term of office for the executive director is two years. The selection of the executive director will normally occur the spring term prior to appointment. The PMT will be responsible for facilitating the selection and will act as the nominating committee. Nominations must be approved by two-thirds of all active, voting fellows, then by the Executive Board. All active fellows are eligible for nomination. Past executive directors are eligible for re-election. The executive director serves at the pleasure of the Dean of the Graduate School, and may be removed from office by a petition signed by two-thirds of all active fellows.

3.D. Associate Directors

- i. Associate directors will serve to oversee each of the main themes of the center: course transformation, STEM education research, and faculty development. Associate directors may receive compensation, as determined by the Dean of the Graduate School.
- ii. The regular term of office of associate directors is two years. They are eligible for re-election. The selection of the directors will normally occur the spring term prior to appointment. The PMT will be responsible for facilitating the selection and will act as the nominating committee. Nominations must be approved by two-thirds of all active fellows, then by the Executive Board. All active fellows are eligible for nomination. Past associate directors are eligible for re-election. The associate directors serve at the pleasure of the Dean of the Graduate School, and may be removed from office by a petition signed by two-thirds of all active fellows.
- iii. At the discretion of the executive director, an associate director will become acting director if the executive director is to be absent from the center for more than one week.
- iv. The associate directors will work closely with the executive director and managing directors to oversee daily operations of the center and coordinate with the Executive Board.

3.E. Acting Director

- i. If all associate directors are absent simultaneously with the executive director for more than one week, the executive director will designate an acting director. If the acting director is to serve for a period of time of one month or more, the designation of acting director must receive the approval of the fellows, who may choose to hold an election to select an acting director.

3.F. Managing Directors

- i. Managing directors will advise and assist the executive director. They will serve as liaisons to each of the affiliated schools, colleges and institutes, and coordinate documentation of institutional transformation. They may receive compensation, as determined by the Dean of the Graduate School.

- ii. The regular term of office of managing directors is two years. The selection of managing directors will normally occur the spring term prior to appointment. The PMT will be responsible for facilitating the selection and will act as the nominating committee. Nominations must be approved by two-thirds of all active, voting fellows, then by the Executive Board. All active fellows are eligible for nomination. Past managing directors are eligible for re-election. The managing directors serve at the pleasure of the Dean of the Graduate School, and may be removed from office by a petition signed by two-thirds of all active fellows. There must be at least one managing director from the College of Arts and Sciences, the College of Engineering and Applied Sciences, and the School of Education.
- iii. The executive director may appoint active CSL members or fellows to be managing directors to replace members who are absent from Boulder for more than one month. Such appointments automatically end upon the return of the regularly elected managing director. A managing director may recommend his or her own temporary replacement by written notice to the executive director.

3.G. Committees

- i. Ad hoc and standing committees may be established from among the fellows, senior members, and members. All appointments to CSL committees will be made by the executive director, subject to the advice and majority vote of the fellows, for terms not to exceed one year. Appointments to committees may be renewed with the consent of the fellows.

4. Provisions for changing by-laws

- i. The by-laws of the Center for STEM Learning may be amended with the approval of the Dean of the Graduate School, and after consultation with the executive director. Proposed changes to these bylaws must be submitted to and approved by a two-thirds majority vote of all active, voting fellows, provided that a written (electronic or otherwise) copy of the amendment is provided to all fellows at least 30 days prior to the vote.

5. Compliance with Regent and University Laws and Policies

- i. The CSL will comply with all applicable laws, regulations and policies of the Regents of the University of Colorado and the University of Colorado Boulder.

7.D. List of affiliated programs

| Short Name | Program | Contact | Position | Phone | Email | Website |
|------------|--|------------------------|------------------------------|----------------|---------------------------------|---|
| CMTL | A Community of Mathematics Teachers and Learners | Eric Stade | Professor | (303) 492-4989 | Eric.Stade@colorado.edu | http://outreach.colorado.edu/programs/details/id/78 |
| | Aliance for Technology, Learning, and Society | Jill Van Matre | Assistant Director | (303) 735-1454 | Jill.VanMatre@colorado.edu | http://www.colorado.edu/ATLAS/ |
| | Aliance for Technology, Learning, and Society | John Bennett | Director | (303) 735-6153 | John.Bennett@colorado.edu | http://www.colorado.edu/ATLAS/ |
| | Alternative Breaks | Anna Domenico | Director | (303) 492-7632 | volunteer@colorado.edu | http://www.colorado.edu/vrc/altbreaks/index.html |
| | Alumni Association of CU-Boulder | Jennifer Cassidy Moxon | Events & Outreach Chair | (303) 492-8484 | ucbalumni@colorado.edu | http://www.cualum.org/services/contact-us/ |
| | Assessing the Effects of Natural Gas on Water Quality in Garfield County | Joseph Ryan | Program Contact | (303) 492-0772 | joseph.ryan@colorado.edu | http://outreach.colorado.edu/programs/details/id/87 |
| | Astronomy Day at CU | Doug Duncan | Director | (303) 735-6141 | dduncan@colorado.edu | http://cosmos.colorado.edu/sbo/public/astroday.html |
| | AVID Tutoring | Victoria Hand | Program Contact | (303) 492-7738 | victoria.hand@colorado.edu | http://outreach.colorado.edu/programs/details/id/179 |
| | Baker Residential Academic Program | Stephanie Keith | Baker Hall Director | (303) 492-3188 | Bakerrap@colorado.edu | http://bakerrap.colorado.edu |
| | BeSocratic | David Nesbitt | Director | (303) 492-5011 | djnadmin@jila.colorado.edu | http://www.colorado.edu/physics/Web/wizards/cu_wizards.html |
| | BeSocratic | Mike Klymkowsky | Director | (303) 492-8508 | Michael.Klymkowsky@Colorado.edu | http://www.colorado.edu/physics/Web/wizards/cu_wizards.html |
| BSI | Biological Sciences Initiative | Lisa Romero de Mendoza | Associate Director | (303) 492-8230 | romero@colorado.edu | http://www.colorado.edu/Outreach/BSI/ |
| BSI | Biological Sciences Initiative | Julie Graf | Director | (303) 492-8230 | julie.graf@colorado.edu | http://www.colorado.edu/Outreach/BSI/ |
| | Broadening Participation | | Director, Student Engagement | | | |

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| | Center for Energy and Environmental Security | Lakshman Guruswamy, Ph.D. | Director | | cees@colorado.edu | http://cees.colorado.edu/ |
| CIRTL | Center for Integration of Research, Teaching, and Learning | Laura Border | Network Leader (for CU-Boulder) | (608) 263-0630 | info@cirtl.net | http://www.cirtl.net/ |
| | Center for the American West | Patty Limerick | Faculty Director and Chair of the Board | (303) 492-4879 | patricia.limerick@colorado.edu | http://centerwest.org/ |
| CIRES | CIRES Education and Outreach | Susan Buhr | Director | (303) 492-1143 | sbuhr@cires.colorado.edu | http://cires.colorado.edu/education/outreach/index.html |
| | Colorado Bioneers | Sarah Dawn Haynes | | (303) 492-8308 | bioneers@colorado.edu | http://ecenter.colorado.edu/bioneers |
| | Colorado Center for Biorefining & Biofuels | Frannie Ray-Earle | Center Coordinator | (303) 492-7736 | c2b2@colorado.edu | http://www.c2b2web.org/ |
| CDI | Colorado Diversity Initiative | Bob Boswell | Co-Director | (303) 492-8565 | Robert.Boswell@colorado.edu | http://www.colorado.edu/GraduateSchool/DiversityInitiative/index.html |
| CDI | Colorado Diversity Initiative | Mark Hernandez | Co-Director | (303) 492-5991 | Mark.Hernandez@colorado.edu | http://www.colorado.edu/GraduateSchool/DiversityInitiative/index.html |
| CU LA Program | Colorado Learning Assistant Program | Valerie Otero | Director | (303) 492-7403 | Valerie.Otero@Colorado.edu | http://stem.colorado.edu/la-program |
| | Colorado Math Circle | Silvia Chang | Director | (303) 494-1097 | mathcircle@coloradomath.org | http://www.coloradomath.org/ |
| | Colorado Momentum | Mary Nelson | PI | (303) 492-4273 | Mary.Nelson@Colorado.EDU | |
| | Colorado Space Grant Consortium | Bernadette Garcia | Associate Director | (303) 492-3141 | bgarcia@colorado.edu | http://spacegrant.colorado.edu/index.php/outreach |
| | Colorado Space Science Teacher's Summit | Erin Wood | Educational Coordinator | (303) 735-0692 | erin.wood@lasp.colorado.edu | http://lasp.colorado.edu/education/teacherssummit/index.html |
| COSI IGERT | Computational Optical Sensory Imaging Integrative Graduate Education and Research Traineeship | Rafael Piestun | Director | (303) 735-0894 | Rafael.Piestun@Colorado.EDU | http://cosi.colorado.edu/index.html |
| | Conference on World Affairs | Maura Clare | Director of Public Affairs | (303) 492-2525 | cwa@colorado.edu | http://www.colorado.edu/cwa/ |
| | Continuing Education- ACCESS Program | Carol Drake | Program Director | (303) 492-3963 | carol.drake@colorado.edu | http://conted.colorado.edu/programs/access/ |
| | CU in the Community- Learn about climate | Sophie Roudane | Program Coordinator | (303) 492-4471 | sophia.roudane@colorado.edu | http://learnmoreaboutclimate.colorado.edu/ |

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| | CU on the Weekend | | | (303) 492-9881 | weekend@colorado.edu | http://conted.colorado.edu/programs/cu-on-the-weekend/ |
| | CU Science and Technology Policy Program | Mark Williams | Professor | (303) 492-8830 | Markw@snobear.colorado.edu | |
| | CU Science Discovery | Stacey Forsyth | Director | (303) 492-4839 | Stacey.Forsyth@colorado.edu | http://www.colorado.edu/ScienceDiscovery/ |
| CUTeach | CUTeach | Mike Klymkowsky | Co-Director | (303) 492-8508 | Michael.Klymkowsky@Colorado.edu | http://stem.colorado.edu/cu-teach |
| CUTeach | CUTeach | Valerie Otero | Co-Director | (303) 492-7403 | Valerie.Otero@Colorado.edu | http://stem.colorado.edu/cu-teach |
| | Digital CUrrents | Anthea Johnson Rooen | ATLAS Director of Outreach | (303) 735-0797 | anthea.johnson@colorado.edu | |
| | Digital Library for Earth System Education | Tamara Sumner | Associate Professor | (303) 735-4469 | sumner@colorado.edu | http://dlsciences.org/ |
| DBER | Discipline Based Education Research | Mike Klymkowsky | Director | (303) 492-8508 | Michael.Klymkowsky@Colorado.edu | http://www.colorado.edu/theNSF13/DBER.html |
| eCSite | eCSite | Clayton Lewis | PI | (303) 492-6657 | Clayton.Lewis@Colorado.EDU | |
| eCSite | eCSite | Jessica Feld | Project Coordinator | (303) 735-6566 | Jessica.Feld@Colorado.EDU | |
| | El Pueblo Magico | Kris Gutierrez | Professor | (303) 492-8450 | kris.gutierrez@colorado.edu | |
| | Energy Certificate Programs | Paul Komor | Energy Education Director | (303) 492-7805 | komor@colorado.edu | http://rasei.colorado.edu/index.php?id=122&page=Education |
| | Energy Justice: Combating Global Warming in Peru | Nicholas Doman | Director | (303) 735-0181 | guruswam@colorado.edu | |
| | Ethnic Astronomy | John Stocke | Professor | (303) 492-1521 | stocke@casa.colorado.edu | http://fiske.colorado.edu/ |
| E&ER | Ethnography and Evaluation Research | Anne-Barrie Hunter | Co-Director | (303) 735-0887 | Anne-barrie.Hunter@Colorado.EDU | http://www.colorado.edu/eer/ |
| E&ER | Ethnography and Evaluation Research | Sandra Laursen | Co-Director | (303) 735-2942 | Sandra.Laursen@Colorado.EDU | http://www.colorado.edu/eer/ |
| FTEP | Faculty Teaching Excellence Program | Mary Ann Shea | Director | (303) 492-1049 | maryann.shea@colorado.edu | http://www.colorado.edu/ftep/ |
| Planetarium | Fiske Planetarium and Science Center | Doug Duncan | Director | (303) 735-6141 | dduncan@colorado.edu | http://fiske.colorado.edu/ |
| | Friday Night Stargazing at Sommers | Keith Gleason | Manager, Sommers-Bausch Observ. | (303) 492-6732 | keithg@cosmos.colorado.edu | http://cosmos.colorado.edu/sbo/public/openhouse.html |
| | From Top to Bottom | Ryan Vachon | Program Coordinator | (303) 324-0383 | ryan.vachon@colorado.edu | |

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| | Front Range Pika Project | Chris Ray | Contact | (303) 489-8863 | cray@colorado.edu | http://www.citsci.org/cwis438/Browse/Project/Project_Info.php?ProjectID=275&WebSiteID=7 |
| | Girls at the Museum Exploring Science | Cathy Regan | Education Coordinator | (303) 492-4843 | cathy.regan@colorado.edu | |
| | GK12 Project EXTREMES | Lesley Smith | Program Director | (303) 735-1750 | lesley.smith@colorado.edu | http://cires.colorado.edu/education/outreach/exteremes/index.html |
| GTP | Graduate Teacher Program | Laura Border | Director | (303) 492-4902 | gtp@colorado.edu | http://www.colorado.edu/gtp/ |
| | High School Success Institute | Janet Yowell | K-12 Engineering Education Coordinator | (303) 492-5230 | janet.yowell@colorado.edu | http://itll.colorado.edu/ |
| ITL | Integrated Teaching and Learning Program & Laboratory | Derek Reamon | Co-Director | (303) 735-0484 | Derek.Reamon@Colorado.edu | http://itll.colorado.edu/ |
| ITL | Integrated Teaching and Learning Program & Laboratory | Jacquelyn Sullivan | Co-Director | (303) 492-8303 | Jacquelyn.Sullivan@Colorado.edu | http://itll.colorado.edu/ |
| IDREAMS | Integrative Design-based Reform-oriented Educational Approach for Motivating Students | Alexander Repenning | Project Investigator | (303) 492-1349 | Alexander.Repenning@Colorado.EDU | |
| LASP | LASP Education and Outreach | Dan Baker | Director | (303) 492-0591 | Dan.Baker@lasp.colorado.edu | http://lasp.colorado.edu/education/community/K-12/ |
| | Making Global Local | Erin Furtak | Assistant Professor of Curriculum and Instruction | (303) 492-4242 | erin.furtak@colorado.edu | http://learnmoreaboutclimate.colorado.edu/for-educators |
| | Materials Science from CU-Boulder | Hester Nadel | Program Director | (303) 492-8640 | sfcu@colorado.edu | http://cmrc.colorado.edu/outreach/classroomprograms1.html |
| | Mercury Contamination in Southwest Colorado | Joseph Ryan | Professor | (303) 492-0772 | joseph.ryan@colorado.edu | |
| MASP | Miramontes Arts and Sciences Program | Linnea Avallone | Director | (303) 492-8229 | Linnea.Avallone@Colorado.EDU | http://www.colorado.edu/masp/ |
| | Mortenson Center in Engineering for Developing Communities | Bernard Amadei | Director | (303) 492-7734 | Amadei@colorado.edu | http://ceae.colorado.edu/mc-edc/ |
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| NCWIT | National Center for Women and IT | Lucy Sanders | CEO and Co-Founder | | | http://www.ncwit.org/ |
| | National Education Policy Center | Bethy Leonardi | Research Assistant | (720) 939-4713 | bethyleonardi@gmail.com | http://nepc.colorado.edu/ |
| | Neuroscience Undergraduate Program | Donald Cooper | Director Neuroscience Undergrad Program | (303) 335-0248 | dcooper@colorado.edu | http://neurocloud.org/teaching/ |
| NOYCE | NOYCE Foundation | Ron Ottinger | Executive Director | (650) 856-2600 | nfo@noycefdn.org | http://www.noycefdn.org/index.php |
| | Observatory Field Trips for Schools | Keith Gleason | Manager, Sommers-Bausch Observ. | (303) 492-6732 | keithg@cosmos.colorado.edu | http://cosmos.colorado.edu/sbo/public/openhouse.html |
| | Ozone & Snow | Shelly Sommer | Contact | (303) 492-1867 | Shelly.sommer@colorado.edu | http://instaar.colorado.edu/outreach/ozone-and-snow/ |
| PISEC | Partnerships for Informal Science Education in the Community | Katie Hinko | Director | (303) 492-7815 | | http://www.colorado.edu/physics/PISEC/ |
| PER | Physics Education Research @ Colorado | Noah Finkelstein | PI | (303) 735-6082 | finkelsn@Colorado.EDU | http://www.colorado.edu/physics/EducationIssues/index.htm |
| PhET | PhET Interactive Simulations | Kathy Perkins | Co-Director | (303) 492-6714 | katherine.perkins@colorado.edu | http://phet.colorado.edu/index.php |
| PTLC | President's Teaching and Learning Collaborative | Mary Ann Shea | Director | (303) 492-1049 | Maryann.shea@colorado.edu | http://www.colorado.edu/ptsp/ptlc/ |
| PTSP | President's Teaching Scholars Program | Mary Ann Shea | Director | (303) 492-1049 | maryann.shea@colorado.edu | http://www.colorado.edu/ptsp/index.html |
| | Problem-Solving Cycle | Jennifer Jacobs | Research Associate | (303) 492-9565 | jennifer.jacobs@colorado.edu | http://psc.stanford.edu/ |
| | Professional Learning as Leadership | Erin Furtak | Assistant Professor of Curriculum and Instruction | (303) 492-4242 | erin.furtak@colorado.edu | |
| | Renewable & Sustainable Energy Institute | Margie Bopp | Administrative Assistant | (303) 492-0284 | margie.bopp@colorado.edu | http://rasei.colorado.edu/ |
| | Saturday Physics Program | Carole Capsalis | Program Coordinator | (303) 735-5993 | Carole.capsalis@colorado.edu | http://www.colorado.edu/physics/Web/Saturday/index.html |
| SEI | Science Education Initiative | Kathy Perkins | Director | (303) 492-6714 | katherine.perkins@colorado.edu | http://www.colorado.edu/sei/ |
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| | Special Celestial Event Observing | Keith Gleason | Manager, Sommers-Bausch Observatory | (303) 492-6732 | keithg@cosmos.colorado.edu | http://cosmos.colorado.edu/sbo/public/openhouse.html |
| | STEMsation | Victoria Hand | Assistant Professor | (303) 492-7738 | victoria.hand@colorado.edu | |
| | Sustainable Practices Program | Kelly Simmons | Program Manager | (303) 492-7438 | kelly@bouldersustainability.org | http://ecenter.colorado.edu/education/sustainable-practices |
| | Teach Engineering Digital Library Collection | Jacquelyn Sullivan | | (303) 492-7222 | Jacquelyn.Sullivan@Colorado.edu | http://teachengineering.org/ |
| | Teaching NPS Interpretive Staff | Karl Mueller | Professor | (303) 552-7067 | karl.nueller@colorado.edu | http://structure.colorado.edu/~structure/teaching_GEOL4712/index.htm |
| | TEAMS Program | Deborah Fink | Planning and Promotions Librarian | (303) 492-8302 | deborah.fink@colorado.edu | http://ucblibraries.colorado.edu/news/index.htm |
| Herbst | The Herbst Program of Humanities for Engineers | Diane Sieber | Director | (303) 492-6399 | Diane.Sieber@colorado.edu | http://engineering.colorado.edu/herbst/ |
| | University Libraries | Ami Nacu-Schmidt | | (303) 735-3102 | ami@cires.colorado.edu | http://sciencepolicy.colorado.edu/stcert/ |
| | University of Colorado Museum of Natural History | Patrick Kociolek | Director | (303) 492-6297 | cumuseum@colorado.edu | http://cumuseum.colorado.edu/index.html |
| | Water Resources Outreach to the Four-Corners Area | Anna Domenico | Director | (303) 492-7632 | volunteer@colorado.edu | http://www.colorado.edu/vrc/altbreaks/index.html |
| | | | | | | |

7.E. Chancellor's Awards for Excellence in STEM Education

Current Faculty Scholars:

Barbara Demmig-Adams, William Adams, and Sara Wise, College of Arts & Sciences - Ecology & Evolutionary Biology *Assessing the Impact of Early, Individualized Faculty and TA Interventions for At-Risk Students*

The "achievement gap" affecting retention and graduation rates of minority and first-generation college students is as well-described, pervasive, and persistent in educational institutions across the United States as it is difficult to ameliorate (Winerman 2011). While many large-scale programs have been designed to attack the achievement gap, and some show promise (e.g. Haak et al. 2011), only a few controlled studies exist that offer evidence of effective techniques, using specific instructional and psychological interventions. For example, at the K-12 level, collaborative inquiry-oriented approaches to science instruction have been shown to close the achievement gap more effectively than traditional lecturing (Wilson et al., 2011). Short, self-affirming written exercises have recently been shown to significantly narrow the achievement gap for both middle school minority students and college females (Cohen et al. 2009 Miyake et al. 2010).

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.

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.

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.

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, and 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 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, 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.

Past Faculty 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

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

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.

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

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.

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

The Sky's the Limit: An Unmanned Aircraft Laboratory Model The 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.

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

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

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.

Tiffany Ito, College of Arts & Sciences - Psychology

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.

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 disciplines, 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 H. 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

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 a 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

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).

Current Graduate Scholars:

Susanna Kohler, College of Arts & Sciences - Astrophysical & Planetary Sciences
Advisor: Seth Hornstein

Can we train scientists to communicate effectively with the public?

Kyuhan Koh, College of Engineering & Applied Science - Computer Science

Advisor: Alex

Repenning Computing Computational Thinking: Towards the Automatic Recognition of Computational Thinking in Real Time

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

Ben Van Dusen, School of Education

Advisor: Valerie Otero

Boundary Objects that Mediate Students' Motivation and Identity Toward Physics

Past Graduate Scholars:

Lindsay Anderson, College of Arts & Sciences - Psychology

Advisor: 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

Advisor: 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

Advisor: Michael Main

Tablet Teaching Pilot Program

Corrie Colvin Williams, College of Architecture & Planning

Advisor: 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

Advisors: 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

Advisor: Valerie Otero

What types of curriculum support do elementary students need to successfully develop computational thinking practices within 2D and 3D environments?

Lauren Kost-Smith, College of Arts & Sciences – Physics

Advisor: Steven Pollock

Investigating the Gender Gap in Undergraduate Physics Courses

Krista Marshall, School of Education

Advisors: 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

Advisor: 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

Advisor: Michael Eisenberg

Learning Computer Science the Craftopolis Way

Calvin Pohawpatchoko, College of Engineering & Applied Science – Computer Science

Advisor: Clayton Lewis

An Old Method New Again - Rethinking Nation Building in a Digital Age: Piloting Cognitive Apprenticeship in Indigenous Nation Building

Ian Renga, School of Education

Advisor: Jennie Whitcomb & Erin Furtak

A Study of STEM Teacher Candidates' Learning in a Course Facilitating Collaborative Inquiry into Teaching Practice

Sarah Roberts, School of Education

Advisor: Erin Furtak

Reforming Undergraduate Biology Teaching Through Formative Assessment

Michael Ross, School of Education

Advisor: Valerie Otero

Transforming the Classroom Power Structure to Impact Physics Learning

Benjamin Spike, College of Arts & Sciences – Physics

Advisor: 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
Advisor: Linnea Avallone
Undergraduate Students' Climate Change Conceptions

Ben Van Dusen, School of Education
Advisor: 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

7.F. Outcomes of the Chancellor's Awards

| Name | Affiliation | Dept. | Title | Fund Period | # of Papers | # of Presentations | # of New Funding |
|------------------|-------------|-------|--|-------------|-------------|--------------------|------------------|
| David Webb | Advisor | EDUC | AY appointments to support a longitudinal study of the implementation and impact of Las on teaching in undergraduate mathematics | 2009-2010 | n/a | n/a | n/a |
| Doug Duncan | Advisor | APS | AY Year appointment to support student's difficulties with cosmology | 2009-2010 | 5 | 5 | n/a |
| Erin Furtak | Advisor | EDUC | Summer appointment to support reforming undergraduate biology teaching through formative assessment | 2009-2010 | n/a | n/a | n/a |
| Linnea Avallone | Advisor | ATOC | AY Appointment to Support Undergraduate Climate Change Curriculum Development and Validation | 2009-2010 | n/a | n/a | n/a |
| Michael Main | Advisor | CSCI | AY Year appointment to support a tablet teaching pilot program | 2009-2010 | n/a | n/a | n/a |
| Noah Finkelstein | Advisor | PHYS | AY Appointment to support an Examination of Conceptions of Teaching and Learning Physics in Graduate TAs and Undergraduate Las | 2009-2010 | n/a | n/a | n/a |
| Steven Pollock | Advisor | PHYS | AY Year appointment to support investigating the gender gap in undergraduate physics tutorials | 2009-2010 | n/a | n/a | n/a |
| Victoria Hand | Advisor | EDUC | AY appointments to support a longitudinal study of the implementation and impact of LAs on teaching in undergraduate mathematics | 2009-2010 | n/a | n/a | n/a |
| Clayton Lewis | Faculty | CSCI | Video Resources for Lower Division Computer Science Curriculum | 2009-2010 | n/a | n/a | n/a |
| Dirk Grunwald | Faculty | CSCI | Video Resources for Lower Division Computer Science Curriculum | 2009-2010 | n/a | n/a | n/a |
| Eric Frew | Faculty | ASEN | The Sky's the Limit: An Unmanned Aircraft Laboratory Model | 2009-2010 | n/a | n/a | n/a |
| Erin Furtak | Faculty | EDUC | Teaching and Learning Biology at CU: Course Evaluation and Revision Project | 2009-2010 | 1 | 1 | 2 |
| Ken Anderson | Faculty | CSCI | Video Resources for Lower Division Computer Science Curriculum | 2009-2010 | n/a | n/a | n/a |
| Steven Pollock | Faculty | PHYS | Development of Pre-Post Tests for Upper Division Electricity and Magnetism Tutorials | 2009-2010 | 1 | 1 | 1 |
| Benjamin Spike | Student | PHYS | AY Appointment to support an Examination of Conceptions of Teaching and Learning Physics in Graduate TAs and Undergraduate Las | 2009-2010 | n/a | n/a | n/a |
| Colin Wallace | Student | APS | AY Year appointment to support student's difficulties with cosmology | 2009-2010 | 5 | 5 | n/a |
| David Cheeseman | Student | CSCI | AY Year appointment to support a tablet teaching pilot program | 2009-2010 | n/a | n/a | n/a |
| Kim Trenbath | Student | ATOC | AY Appointment to Support Undergraduate Climate Change Curriculum Development and Validation | 2009-2010 | n/a | n/a | n/a |

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|----------------------|---------|------|--|-----------|-----|-----|-----|
| Louisa Harris | Student | EDUC | AY appointments to support a longitudinal study of the implementation and impact of Las on teaching in undergraduate mathematics | 2009-2010 | n/a | n/a | n/a |
| Ryan Grover | Student | EDUC | AY appointments to support a longitudinal study of the implementation and impact of Las on teaching in undergraduate mathematics | 2009-2010 | n/a | n/a | n/a |
| Sarah Roberts | Student | EDUC | Summer appointment to support reforming undergraduate biology teaching through formative assessment | 2009-2010 | n/a | n/a | n/a |
| Alice Healy | Advisor | PSYC | Understanding the Components of the iClicker System that Promote Learning, Retention, and Generalization of Classroom Knowledge | 2010-2011 | n/a | n/a | n/a |
| Doug Duncan | Advisor | APS | Understanding Students' Difficulties with Cosmology | 2010-2011 | n/a | n/a | n/a |
| Erin Furtak | Advisor | EDUC | What Works in Undergraduate Physics Education? A Research Synthesis | 2010-2011 | n/a | n/a | n/a |
| Frank Barnes | Advisor | ECEE | Developing an Adaptive Method for Teaching Mobile (Phones) Programming to Freshman Engineering Students | 2010-2011 | n/a | n/a | n/a |
| Melinda Piket-May | Advisor | ECEE | Developing an Adaptive Method for Teaching Mobile (Phones) Programming to Freshman Engineering Students | 2010-2011 | n/a | n/a | n/a |
| Charles Rogers | Faculty | PHYS | Learning Goals and Course Materials for Advanced Undergraduate Physics Laboratories | 2010-2011 | n/a | n/a | n/a |
| Heather Lewandowski | Faculty | PHYS | Learning Goals and Course Materials for Advanced Undergraduate Physics Laboratories | 2010-2011 | n/a | n/a | 1 |
| Jenny Knight | Faculty | MCDB | Development of a Capstone Concept Assessment to measure integrated content retention in biology | 2010-2011 | n/a | n/a | 1 |
| John Basey | Faculty | EBIO | Variation in Working Memory and the Optimal Design of STEM Labs | 2010-2011 | n/a | n/a | n/a |
| Virginia Ferguson | Faculty | MCEN | Assessing YOU'RE@CU: A New Program to Promote Diversity in Engineering | 2010-2011 | n/a | n/a | 1 |
| Colin Wallace | Student | APS | Understanding Students' Difficulties with Cosmology | 2010-2011 | n/a | n/a | n/a |
| Heidi Iverson | Student | EDUC | What Works in Undergraduate Physics Education? A Research Synthesis | 2010-2011 | n/a | n/a | n/a |
| Lindsay Anderson | Student | PSYC | Understanding the Components of the iClicker System that Promote Learning, Retention, and Generalization of Classroom Knowledge | 2010-2011 | n/a | n/a | n/a |
| Seyitriza Tigrek | Student | ECEE | Developing an Adaptive Method for Teaching Mobile (Phones) Programming to Freshman Engineering Students | 2010-2011 | n/a | n/a | n/a |
| Alexander Reppenning | Advisor | CSCI | Targeting the Technology Gender Gap: Making Computer Science Engaging and Accessible for All Students | 2011-2012 | n/a | n/a | n/a |
| Alice Healy | Advisor | PSYC | Understanding the Components of the iClicker System that Promote Learning, Retention, and Generalization of Classroom Knowledge | 2011-2012 | n/a | n/a | n/a |
| Angela Bielefeldt | Advisor | CVEN | An assessment for teaching methodologies for instilling social responsibility in undergraduate civil engineering students | 2011-2012 | n/a | n/a | n/a |
| David Webb | Advisor | EDUC | Targeting the Technology Gender Gap: Making Computer Science Engaging and Accessible for All Students | 2011-2012 | n/a | n/a | n/a |
| Linnea Avallone | Advisor | ATOC | Undergraduate Students' Climate Change Conceptions | 2011-2012 | n/a | n/a | n/a |

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|------------------------|---------|------|---|-----------|-----|-----|-----|
| Louise Chawla | Advisor | ARCH | Significant life experiences: exploring the lifelong influence of environmental and science education in program participants | 2011-2012 | n/a | n/a | n/a |
| Michael Eisenberg | Advisor | CSCI | Learning Computer Science the Craftopolis Way | 2011-2012 | n/a | n/a | n/a |
| Valerie Otero | Advisor | EDUC | Empowering Students through the Use of iPad Technology | 2011-2012 | n/a | n/a | n/a |
| Valerie Otero | Advisor | EDUC | Transforming the Classroom Power Structure to Impact Physics Learning | 2011-2012 | n/a | n/a | n/a |
| Garrett Nicodemus | Faculty | CHEN | Biologically-Focused Screencasts and ConcepTests for Chemical and Biological Engineering Courses | 2011-2012 | 1 | 5 | 1 |
| Heidi Bustamante | Faculty | IPHY | Evaluation of the Effectiveness and Success of Inquiry-Based Laboratories in IPHY | 2011-2012 | n/a | n/a | n/a |
| Janet Casagrand | Faculty | IPHY | Evaluation of the Effectiveness and Success of Inquiry-Based Laboratories in IPHY | 2011-2012 | n/a | n/a | n/a |
| John Falconer | Faculty | CHEN | Biologically-Focused Screencasts and ConcepTests for Chemical and Biological Engineering Courses | 2011-2012 | 1 | 5 | 1 |
| Kris Gutierrez | Faculty | EDUC | When Scientific and Everyday Knowledge Grow into One Another: Designing for Robust Science Learning for Students from Non-Dominant Communities | 2011-2012 | n/a | n/a | n/a |
| Teresa Foley | Faculty | IPHY | Evaluation of the Effectiveness and Success of Inquiry-Based Laboratories in IPHY | 2011-2012 | n/a | n/a | n/a |
| Tiffany Ito | Faculty | PSYC | A Classroom Intervention to Reduce the Gender Achievement Gap in College Science | 2011-2012 | n/a | n/a | 1 |
| Victoria Hand | Faculty | EDUC | Examination of shifts in content understanding and imagined trajectories for underrepresented high school students serving as mentors for Science Explorers | 2011-2012 | n/a | n/a | n/a |
| Ben Van Dusen | Student | EDUC | Empowering Students through the Use of iPad Technology | 2011-2012 | n/a | n/a | n/a |
| Corrie Colvin Williams | Student | ARCH | Significant life experiences: exploring the lifelong influence of environmental and science education in program participants | 2011-2012 | n/a | n/a | n/a |
| Jane Meyers | Student | CSCI | Learning Computer Science the Craftopolis Way | 2011-2012 | n/a | n/a | n/a |
| Kim Trenbath | Student | ATOC | Undergraduate Students' Climate Change Conceptions | 2011-2012 | n/a | n/a | n/a |
| Krista Marshall | Student | EDUC | Targeting the Technology Gender Gap: Making Computer Science Engaging and Accessible for All Students | 2011-2012 | n/a | n/a | n/a |
| Lindsay Anderson | Student | PSYC | Understanding the Components of the iClicker System that Promote Learning, Retention, and Generalization of Classroom Knowledge | 2011-2012 | n/a | n/a | n/a |
| Michael Ross | Student | EDUC | Transforming the Classroom Power Structure to Impact Physics Learning | 2011-2012 | n/a | n/a | n/a |
| Nathan Canney | Student | CVEN | An assessment for teaching methodologies for instilling social responsibility in undergraduate civil engineering students | 2011-2012 | n/a | n/a | n/a |
| Clayton Lewis | Advisor | CSCI | An Old Thing New Again - Rethinking Nation Building in a Digital Age: Piloting Cognitive Apprenticeship in Indigenous Nation Building | 2012-2013 | n/a | n/a | n/a |

| | | | | | | | |
|----------------------|---------|-------|---|--------------|-----|-----|-----|
| Diane McKnight | Advisor | ARCH | Enhancing Environmental Literacy and Interest in Polar Sciences for Primary School Children in the Boulder Valley School District and Beyond | 2012-2013 | n/a | n/a | n/a |
| Erin Furtak | Advisor | EDUC | A Study of STEM Teacher Candidates' Learning in a Course Facilitating Collaborative Inquiry into Teaching Practice | 2012-2013 | n/a | n/a | n/a |
| Jennie Whitcomb | Advisor | EDUC | A Study of STEM Teacher Candidates' Learning in a Course Facilitating Collaborative Inquiry into Teaching Practice | 2012-2013 | n/a | n/a | n/a |
| Valerie Otero | Advisor | EDUC | What types of curriculum support do elementary student need to successfully develop computational thinking practices within 2D and 3D environments? | 2012-2013 | n/a | n/a | n/a |
| Beth Stade | Faculty | MATH | STEM Talking: Aligning and Improving the Mathematical Education of Pre-Service Teachers | 2012-2013 | n/a | n/a | n/a |
| Brian Couch | Faculty | MCDB | Development of an observation protocol to measure Scientific Teaching | 2012-2013 | n/a | n/a | n/a |
| Jane Stout | Faculty | IPHY | Connecting with others versus doing science: Exploring how communal goals might explain the gender gap in STEM participation | 2012-2013 | n/a | 1 | n/a |
| John Gunther | Faculty | MUSIC | Enhancing the Pedagogy of Science, Math, and Technology through Music: Exploring Informal Science Education through the Arts | 2012-2013 | n/a | n/a | n/a |
| Alexandra Mass | Student | ARCH | Enhancing Environmental Literacy and Interest in Polar Sciences for Primary School Children in the Boulder Valley School District and Beyond | 2012-2013 | n/a | n/a | n/a |
| Calvin Pohawpatchoko | Student | CSCI | An Old Thing New Again - Rethinking Nation Building in a Digital Age: Piloting Cognitive Apprenticeship in Indigenous Nation Building | 2012-2013 | n/a | n/a | n/a |
| Ian Her Many Horses | Student | EDUC | What types of curriculum support do elementary student need to successfully develop computational thinking practices within 2D and 3D environments? | 2012-2013 | n/a | n/a | n/a |
| Ian Renga | Student | EDUC | A Study of STEM Teacher Candidates' Learning in a Course Facilitating Collaborative Inquiry into Teaching Practice | 2012-2013 | n/a | n/a | n/a |
| Alex Reppenng | Advisor | CSCI | Computing Computational Thinking: Towards the Automatic Recognition of Computational Thinking in Real Time | 2013-Present | n/a | n/a | n/a |
| Seth Hornstein | Advisor | APS | Can we train scientists to communicate effectively with the public? | 2013-Present | n/a | n/a | n/a |
| Tom Yeh | Advisor | CSCI | Developing User Interface and Peer Instruction: Assessing Results on Engagement, Retention, and Failure Rate for CSCI 1300 Introduction to Computer Programming | 2013-Present | n/a | n/a | n/a |
| Valerie Otero | Advisor | EDUC | Boundary Objects that Mediate Students' Motivation and Identity Toward Physics | 2013-Present | n/a | n/a | n/a |
| Barbara Demmig-Adams | Faculty | EBIO | Assessing the Impact of Early, Individualized Faculty and TA Interventions for At-Risk Students | 2013-Present | n/a | n/a | n/a |

| | | | | | | | |
|------------------|---------|------|---|--------------|-----|-----|-----|
| Ben Zwickl | Faculty | PHYS | A comparative study of different forms of assessment in laboratory Settings | 2013-Present | n/a | n/a | n/a |
| Chris Link | Faculty | IPHY | Transformation of the Cell Physiology Laboratories in Integrative Physiology | 2013-Present | n/a | n/a | n/a |
| Katie Hinko | Faculty | JILA | Characterizing the Development of University Students who Participate in Informal STEM Programming | 2013-Present | n/a | n/a | n/a |
| Molly Welsh | Faculty | IPHY | Transformation of the Cell Physiology Laboratories in Integrative Physiology | 2013-Present | n/a | n/a | n/a |
| Sara Wise | Faculty | EBIO | Assessing the Impact of Early, Individualized Faculty and TA Interventions for At-Risk Students | 2013-Present | n/a | n/a | n/a |
| Shaw Ketels | Faculty | PSYC | A New Approach to Teaching General Psychology at CU | 2013-Present | n/a | n/a | n/a |
| Teresa Foley | Faculty | IPHY | Transformation of the Cell Physiology Laboratories in Integrative Physiology | 2013-Present | n/a | n/a | n/a |
| William Adams | Faculty | EBIO | Assessing the Impact of Early, Individualized Faculty and TA Interventions for At-Risk Students | 2013-Present | n/a | n/a | n/a |
| Ben Van Dusen | Student | EDUC | Boundary Objects that Mediate Students' Motivation and Identity Towards Physics | 2013-Present | n/a | n/a | n/a |
| Jeffrey LaMarche | Student | CSCI | Developing User Interface and Peer Instruction: Assessing Results on Engagement, Retention, and Failure Rate for CSCI 1300 Introduction to Computer Programming | 2013-Present | n/a | n/a | n/a |
| Kyuhan Koh | Student | CSCI | Computing Computational Thinking: Towards the Automatic Recognition of Computational Thinking in Real Time | 2013-Present | n/a | n/a | n/a |
| Susanna Kohler | Student | APS | Can we train scientists to communicate effectively with the public? | 2013-Present | n/a | n/a | n/a |
| Totals | | | | | 14 | 21 | 8 |

| Name | Award Date | Title | NSF Award Program | Total Funding |
|---------------------|------------|---|-------------------|-----------------------|
| Erin Furtak | 6/1/2012 | Investigating Instructional Influences on the Productivity of Clicker Discussions | DUE | \$196,672.00 |
| Erin Furtak | 7/1/2010 | CAREER: Educative Learning Progressions as Tools for Teacher Development (ELEVATE) | DRL | \$559,201.00 |
| Heather Lewandowski | 5/1/2011 | Using a Research-Based Approach to Reform Upper-Division Laboratory Courses | DUE | \$199,747.00 |
| Jennifer Knight | 9/1/2011 | Collaborative Research: Automated Analysis of Constructed Response Concept Inventories to Reveal Student Thinking: Forging a National Network for Innovative Assessment Methods | DUE | \$84,529.00 |
| Virginia Ferguson | 2/1/2011 | CAREER: Reverse-Engineering the Bone-Cartilage Interface for Successful Joint Repair - Coupled with a New Program to Promote Diversity in Rehabilitative Bioengineering | CBET | \$445,024.00 |
| Garret Nicodemus | 2/1/2013 | Resources to Implement Flipped Chemical Engineering Classrooms | DUE | \$200,000.00 |
| John Falconer | 2/1/2013 | Resources to Implement Flipped Chemical Engineering Classrooms | DUE | \$200,000.00 |
| Tiffany Ito | 1/1/2013 | Research Initiation Grant: Improving Attitudes towards Engineering Via Aesthetics | EEC | \$150,000.00 |
| Total Funds: | | | | \$2,035,173.00 |

7.G. CSL Press

International recognition of CU STEM efforts continues to rise

In April 2012, a Swedish television producer visited CU-Boulder looking to feature its efforts in STEM Education in an episode of a program on education. The program, called UR Play, features stories and documentaries about education across all disciplines. The specific episode featuring CU nicely weaves together the stories, interviews, and classroom footage to form a wonderful representation of the goals we as a university are continuously striving to accomplish. For more information see: <http://urplay.se/Produkter/175595-Jakten-pa-det-demokratiska-klassrummet-University-of-Colorado>

AAU selects CU Boulder as STEM Initiative project site finalist

Recently, the University of Colorado Boulder submitted a concept paper to the Association of American Universities in support of its Undergraduate STEM Education Initiative. The AAU was determined to select STEM project sites to implement frameworks supporting undergraduate education. The AAU has completed its initial review which concluded that the University of Colorado Boulder would be one of eleven candidate institutions to serve as a potential project site. When the selection process is complete, eight institutions will serve as project sites for a three-year period. *Update:* The selection process ended in late June and CU-Boulder was chosen to be one of these sites.

Congratulations to the 2013-2014 Chancellor's Awardees!

April 1, 2013 marked the deadline for applications for the University of Colorado Boulder Chancellor's Award for Excellence in STEM Education. The awards support faculty and student engagement in innovative research on student learning and implementation of research-based STEM education programs and initiatives. Five faculty awards were given this year including two combined awards, which were given to: Barbara Demmig-Adams, William Adams, and Sara Wise; and Teresa Foley, Chris Link, and Molly Welsh. The other three faculty awardees are Katie Hinko, Shaw Ketels, and Ben Zwickl. The four graduate awards went to Susanna Kohler, Kyuhan Koh, Jeffrey LaMarche, and Ben Van Dusen. For brief synopses and information about the research projects the awards will support, visit the Chancellor's Scholars page: <http://www.colorado.edu/csl/scholars.html>.

CU Teach and LA Program recognition continues to rise

The CU Teach and LA Programs were recently featured on the CU Boulder news web page. The article highlights the specific goals and outcomes for each of the programs,

including their constant stride to encourage the best students to become secondary math and science teachers. Caleb Ulliman, a CU Teach student, tells how his experience as an LA led him to pursue a career in secondary science teaching--all with the support and encouragement of Julie Andrew and Kim Bunning, the program's master teachers. Read the full article at <http://www.colorado.edu/news/features/innovative-programs-transform-undergraduate-stem-courses>

Ben Van Dusen wins NCAR art program!

The National Center for Atmospheric Research selected Ben Van Dusen as the winner of the NCAR art program. He will be having a 2-month showing of his math and science inspired art from December 2013 to January 2014. Congratulations Ben! Ben's designs are available at his website: <http://circlelimitdesigns.com>.

APS honors Valerie Otero as Woman Physicist of the Month!

The American Physical Society has named CU-Boulder's Valerie Otero the Woman Physicist of the Month for April. She is recognized for her work in Physics Education Research and for holding positions as Principal Investigator for the CU-Teach and LA Programs housed in the School of Education. Nominees for this award have positively impacted other individuals' lives and careers. Each Woman Physicist of the Month will be featured on the APS website and recognized at a national APS meeting. More information is available on the award web page at <http://www.aps.org/programs/women/scholarships/womanmonth/2013.cfm>

Eric Stade honored by the Boulder Faculty Assembly

Congratulations Eric! The Boulder Faculty Assembly has announced the recipients of the 2013 BFA Excellence Awards. Eric Stade was recognized for Excellence in Service as a faculty member of the Department of Mathematics, and as a lead of the Libby Residential Academic Program. Each of the BFA Excellence awardees receives a \$3,000 cash prize funded by the Office of the Chancellor. Photographs of the ceremony and the reception will be available on the BFA website after May 1, 2013 at <http://www.colorado.edu/FacultyGovernance/awards/>.

Klymkowsky honored with OUSTA Award for outstanding science teaching

Every year the Society for College Science Teachers (SCST) awards the Undergraduate Science Teacher Award to a well-deserving recipient. For the 2012-2013 year, that recipient is Mike Klymkowsky. Recognition of deficiencies in student achievement have led to his developing of a new introductory chemistry program called Chemistry, Life, the Universe and Everything (CLUE). The OUSTA award honors his achievements in this project and in enhancing the science teaching profession. For more information on

the award go to <http://www.scst.org/grants/2013-ousta-winner> or see the article featured on the University of Colorado-Boulder's news page at: <http://www.colorado.edu/node/2739109>

BLOrk: Boulder Laptop Orchestra

The Boulder Laptop Orchestra began as a result of an encounter between Professor John Gunther and doctoral student, Charles Dietrich. Musicians and artists produce music using a laptop, a hemispherical speaker, and numerous controls, including video game accessories. The general concept has been adapted from Princeton's Laptop Orchestra (PLOrk), which began in 2006 and creates a music ensemble for both music and non-music majors. BLOrk is funded, in part, through John Gunther's Chancellor's Award for Excellence in STEM Education. For more information about BLOrk, please read the full article about the recent concert featured on the CU-Boulder website at: <http://www.colorado.edu/news/features/when-research-meets-music-bloork>

Boulder Laptop Orchestra Event, March 2nd!

The Boulder Laptop Orchestra (BLOrk) will have a performance on March 2 at 7:30 p.m. in the ATLAS theatre. The event is open to the public, and audiences are advised to arrive 15 minutes early. Seating is first-come, first-served. BLOrk will perform works by John Cage, Ornette Coleman, and Pauline Oliveros, as well as original works by ensemble members. The concert will also incorporate research from CU-Boulder doctoral students, Charles Dietrich (Computer Science – <http://colorado.edu/cs/>) and Chris Chronopoulos (Astrophysics - <http://aps.colorado.edu/>). Experience data that was originally emitted from the sun and then recorded, cleaned, raised to an octave and tonality that humans can easily hear and turned into sounds that can be played on a keyboard. Chris Chronopoulos made this portion of the concert possible. A 3D camera will track the movement of the hands and fingers of Charles Dietrich. Using Intel technology, the frequency and volume of sound changes with a wiggle and wave of his fingers, creating a new musical instrument.

BLOrk partners with leading artists in the fields of music, visual arts, and technology to showcase creative innovations in both art and technology. Among the tools that BLOrk uses in its shows: traditional acoustic instruments, iPads, laptops, software and hemispherical speakers that project sound in a way similar to that of acoustic instruments. BLOrk is the ensemble-in-residence of the ATLAS Institute's Center for Media, Art and Performance and is led by College of Music faculty, John Gunther and John Drumheller. This concert is made possible in part by funding from the Chancellor's Award for Excellence in STEM Education.

NSF grant funds 20-year-old STEM study update, CSL's first
The National Science Foundation has funded a five-year, \$4.3 million grant to revive and update a study on why undergraduates leave STEM disciplines to pursue other majors. The study, titled "Talking about Leaving Revisited", stems from and expands upon the 1990s study "Talking about Leaving: Why Undergraduates Leave the Sciences," and is one of the first studies to be run through the Center for STEM Learning. The role of the Center is to provide a solid network of support to link people and ideas in order to catalyze information gathering. Read the full article at <http://www.colorado.edu/news/releases/2013/02/26/43-million-grant-will-allow-cu-boulder-update-20-year-old-groundbreaking>

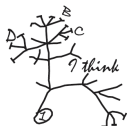
CSL announces a call for Chancellor's Award applications!
The Center for STEM Learning is now accepting Chancellor's Award applications for the 2013-2014 school year. Applications for faculty/staff and graduate awards will be due Monday, April 1, 2013. For more information see the Chancellor's Award page at <http://www.colorado.edu/csl/ChancellorAward.html>.

CU announces official launch of the Center for STEM Learning

December 20, 2012 marked the official launch of the Center for STEM Learning (CSL). CSL is housed within the Graduate School and is funded by the National Science Foundation and CU-Boulder. The Center for STEM Learning developed from Integrating STEM Education, an on-campus program that facilitated communication between STEM disciplines, students, and key members of the community. The purpose (mission) of the CU-Boulder Center for STEM Learning is to improve science, technology, engineering, and mathematics (STEM) learning at the University of Colorado Boulder, and to serve as a state, national, and international resource for such efforts. Our vision for achieving this mission is to maintain an infrastructure of institutional support in order to transform STEM education, support education research within STEM fields and departments, and promote K20 faculty recruitment, preparation, and professional development, and 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.

We are proud to announce the members of the center's executive board: Philip P. DiStefano (Chancellor), Russell Moore (Provost & Executive Vice Chancellor for Academic Affairs), Frances Draper (Vice Chancellor for Strategic Relations), Steven Leigh (Dean of the College of Arts & Sciences), Lorrie Shepard (Dean of the School of Education), Robert Davis (Dean of the College of Engineering & Applied Science), and John Stevenson (Dean of the Graduate School).

7.H. One-page handouts



Discipline-Based Education Research (DBER) seminar series



The Discipline-based Education Research (DBER) group began in 2004 as a forum through which faculty in science, technology, engineering, and mathematics (STEM) departments could engage in conversations about effective education. It is based on the premise that the various STEM disciplines face both common and distinct pedagogical challenges. These issues are critical to effective university teaching, but no mechanism existed for sharing successes and challenges across departments.

Through a weekly seminar series, guest speakers and members of the CU-Boulder STEM education research community present their ideas, observations, and conclusions relating to particular problems and issues associated with promoting effective learning in STEM disciplines. These seminars bring together faculty, researchers, program staff, and graduate students from roughly 45 different programs and departments across four schools/colleges.

Attending these seminars is a great way to get involved with the CU-Boulder STEM education researcher community. DBER also serves as a vehicle to make connections with STEM education experts from other institutions, who both attend and present seminars.

The DBER seminars also serve as a forum within which Chancellor's Award recipients describe the design of their projects, and their observations and conclusions. The DBER community has also taken on broader challenges, such as: examining the proposed Colorado state science standards for coherence and "teachability"; giving feedback to the National Academies about their *Framework for K-12 Science Education*; working with CU Teach in the design of Functions and Modeling and Research Methods courses (part of the STEM teacher certification program), as well as considering the conceptual coherence of foundation courses in various disciplines.

For additional information and to watch videos of past seminars, visit:
www.colorado.edu/csl/DBER



Recent DBER seminar topics:

- The role of technology in STEM education
- Faculty attitudes to pedagogical techniques
- The use of mentoring programs to aid student learning
- Experiential and informal STEM education
- Diversity and access to STEM education
- Automated analysis and assessment of student work
- Identification of conceptually difficult topics in specific STEM disciplines
- Improving the scientific thinking of students
- Course transformation through the use of Learning Assistants and pedagogically-based instruction
- Research-based transformation upper division physics lectures and labs
- Interdisciplinary approaches to STEM education
- Active STEM education classrooms

DBER is sponsored by the Center for STEM Learning (CSL) | www.colorado.edu/csl

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Center for STEM Learning
UNIVERSITY OF COLORADO BOULDER

**International leader in
transformative STEM
education research**

The purpose (mission) of the CU-Boulder Center for STEM Learning (CSL) is:

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

Our vision for achieving this mission is:

- To maintain an infrastructure of institutional support in order to transform STEM education, support education research within STEM fields and departments, and promote K20 faculty recruitment, preparation, and professional development.
- 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.

More than 75 Programs Involved

iSTEM brings together more than 75 programs in STEM education, representing tens of millions of dollars in grants at CU-Boulder, including:

- CU Teach – a nationally leading program bringing STEM students to teaching, offering a specialized secondary science and math teacher certification program for STEM majors.
- Learning Assistant / Noyce Programs – couple the transformation of undergraduate courses with the recruitment and preparation of future teachers in STEM.
- The Science Education Initiative - led by Nobel laureate, Carl Wieman, this initiative seeks to transform undergraduate education in 7 different departments on campus.
- Physics & Discipline-Based Education Research Groups (PER & DBER) - One of the largest and best recognized PER research groups in the nation. DBER spans more than 30 departments and programs, meets weekly to support faculty, staff & students in educational research.
- Integrated Teaching and Learning Program & Lab - a nationally-recognized, hands-on, engineering program for CU-Boulder Students and Faculty and K12 students and teachers.

Increasing National Recognition

- President Obama cites programs like CU Teach as national models for teacher preparation to address the challenges in teacher and workforce preparation.
- Chancellor Philip DiStefano was invited to the White House in honor of the university's commitment to STEM education.
- Bruce Alberts, editor-in-chief of *Science*, says, "I view the University of Colorado at Boulder as the national leader in driving improvements in STEM education..."
- Because CU is a national leader in teacher recruitment and preparation, CU hosted the Association for Public and Land-Grant Universities (APLU) Science and Math Teacher Improvement's inaugural conference

Executive Board

Phil DiStefano Chancellor
Russell Moore Provost, Exec VC for Academic Affairs
Frances Draper Assoc VC Strategic Relations
Steven Leigh Dean, College of Arts & Sciences
Lorrie Shepard Dean, School of Education
Robert Davis Dean, College of Engineering & Applied Science
John Stevenson Dean, Graduate School

www.colorado.edu/csl

Contact: csl@colorado.edu



The Center for STEM Learning is generously supported through the National Science Foundation's Innovation through Institutional Integration (I³) endeavor and by the University of Colorado Boulder.

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The CU-Boulder LA Model



<http://lamodel.colorado.edu>

The Learning Assistant (LA) Model is an experiential learning program of the University of Colorado Boulder.

Course Transformation: Undergraduate students are hired as Learning Assistants to help transform courses to be responsive to research on how students learn.

Over 45 math and science courses have been transformed using Learning Assistants.

Teacher Recruitment: Over 70 talented mathematics, science, and engineering majors have been recruited to become K-12 teachers through the Learning Assistant program.

Just under 20 are currently teaching in high needs school districts in subject such as physics and chemistry.

National Emulation Model

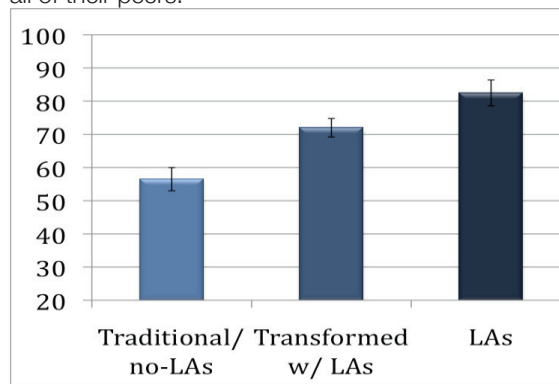
- Universities throughout the nation received significant funding to replicate the Colorado Learning Assistant model
- Addresses our Nation's critical shortage of highly qualified math and science teachers
- 21st century educational program, a signature program at CU-Boulder



High Impact -- Multi-disciplinary

- Aligned with several institutional priorities outlined in the University's strategic plan, Flagship 2030
- Approximately 240 mathematics, science, and engineering majors hired each year to serve as Learning Assistants in 12 departments
- Over 9000 students are impacted each year at a cost of under \$65 per student

Students Learn More: Students in courses transformed with Learning Assistants outperform those in traditional courses. Learning Assistants outperform all of their peers.



Pollock, S. Physical Review ST: PER (2010).

The Learning Assistant Model is affiliated with the Center for STEM Learning (CSL) | www.colorado.edu/csl

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Physics Education Research Group @ Colorado



Center for STEM Learning
UNIVERSITY OF COLORADO BOULDER



What is PER@C?

The Physics Education Research Group at Colorado (PER@C) is one of the largest research programs in PER in the nation. Our research group develops and studies: uses of technology in physics education, assessments (conceptual, epistemological, and belief oriented), theoretical models of students learning physics, social and contextual foundations of student learning, examination of successful educational reforms and replication studies of such reforms, and student problem-solving in physics. We sponsor educational reforms in pre-college to post-doctoral physics. The research group includes faculty, staff, and students from the Department of Physics and the School of Education.

PER@C Successes:

- Faculty, researchers, and post-docs make PER@C the largest PER group in the nation.
- With tens of millions in external funding, PER@C is one of the best-funded programs of its kind in the nation.
- PER@C is one of the most published PER groups in the nation, with papers appearing in *Science*, *Nature: Physics*, *Physics Today*, *American Journal of Physics*, and *Physical Review*.
- PER@C faculty lead corner-stone efforts in science education at CU-Boulder, including nationally recognized programs.
- **PER@C is leading the way in understanding how science is learned and transforming how science is taught.**

PER@C is generously supported by:

The American Physical Society, PhysTEC, the Science and Mathematics Teacher Imperative, the University of Colorado Boulder, the National Science Foundation, the American Association of Physics Teachers, the William and Flora Hewlett Foundation, and the American Institute of Physics.

For more information, visit:
per.colorado.edu

PER@C Highlights:

The PhET Interactive Simulations Project:

Developing, testing, and researching online simulations in physics, and now, chemistry, biology, geology and math.

Lower-division Course Transformation: Developing materials, implementing, evaluating and conducting research on transformation in Physics 1, 2 and 3.

Upper-division Course Transformation: Transforming junior Electricity and Magnetism, Quantum Mechanics, Classical Mechanics, Advanced Labs, and using PER-based tools in courses as advanced as the graduate level.

Assessments: The development of research-based instruments for evaluation of student learning including: attitudes and beliefs, quantum mechanics, and upper division E/M.

The Learning Assistant Program: Research on the nationally recognized effort that couples course transformation with teacher recruitment and preparation.

Theoretical Work: Developing theories of student learning in physics, including student use of representations, analogies, simulations; student development of epistemic and ontological commitments in physics; the development of future teachers, graduate students and faculty.

Areas of focus include **institutional change** in physics and science, **gender studies**, and **informal science education**.

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PhET Interactive Simulations



Center for STEM Learning
UNIVERSITY OF COLORADO BOULDER

PhET Interactive Simulations are a suite of free, research-based tools that improve the way that physics, chemistry, biology, earth science and math are taught and learned. These interactive tools enable students to make connections between real life phenomena and the underlying science which explains such phenomena. Our team of scientists, software engineers, and science educators use a research-based approach to create simulations that support student engagement with and understanding of scientific concepts. All simulations are free and easily downloadable or can be run live from the web.

Interactive & Engaging: PhET simulations animate what is invisible to the eye through the use of graphics and intuitive controls such as click-and-drag manipulation, sliders and radio buttons. In order to further encourage quantitative exploration, the simulations also offer measurement instruments including rulers, stop-watches, voltmeters and thermometers. As the user manipulates these interactive tools, responses are immediately animated thus effectively illustrating cause-and-effects relationships as well as multiple linked representations (motion of the objects, graphs, number readouts, etc...).

Research Based: To ensure educational effectiveness and usability, all of the simulations are extensively tested and evaluated. These tests include student interviews in addition to actual utilization of the simulations in a variety of settings, including lectures, group work, homework, and lab work. Our rating system indicates what level of testing has been completed on each simulation.

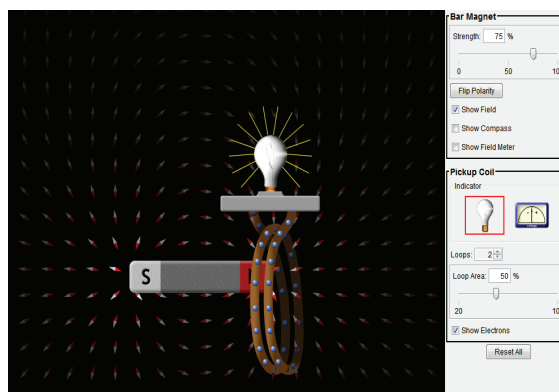
For more information or to use PhET Sims, visit:
<http://phet.colorado.edu>

PhET is generously supported by:

O'Donnell Foundation
Devoted to Excellence in Education



University of Colorado **Boulder**



PhET Sims: Reaching the World

- **120 total sims** available
- **Over 740 activities for teachers** using sims
- Available in **69 languages** and counting
- **22 million:** Number of sims run online in 2011

How do I get PhET Sims?

All simulations are completely free and can be accessed from the PhET website in three ways:

- Download individual sims
- Download the entire website
- Run them live from the web

PhET is affiliated with the Center for STEM Learning (CSL) | www.colorado.edu/csl

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CU's Science Education Initiative

Departments and Faculty Take Action to Improve Science Learning



Center for STEM Learning
UNIVERSITY OF COLORADO BOULDER

CU's Science Education Initiative (SEI) is a \$5 million investment by President Benson and Chancellor DiStefano to catalyze and support significant, sustainable improvements in undergraduate science education. Founded by Nobel Laureate Carl Wieman and currently directed by Kathy Perkins, the SEI 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;
- 3) Use instructional approaches guided by research on learning and data on student thinking and learning;
- 4) Disseminate and adopt what works.

SEI Supports

Departments

7 funded: IPHY, PHYS, APS
MDCB, GEOL, CHEM, EBIO

Faculty

>100 faculty use SEI-funded resources
<75 faculty modified their teaching

Students

Changes in >50 courses
Impacts >10,000 students/yr

Faculty partner with Science Teaching Fellows to Transform Courses

Develop consensus learning goals

- Faculty work together to articulate explicit learning goals for courses.
- Shift from topics to outcomes: "What students should be able to DO at the end of the course?"

What should students learn?

Use data to support & guide faculty efforts

Probe student thinking and learning with:

What are students learning?

- Student Interviews
- Observations
- Surveys
- Analysis of student work
- Conceptual pre/post assessments

Science Teaching Fellows (STFs) & Faculty

Develop or adapt approaches supported by research and aligned with learning goals

These are:

- Aligned with research on learning
- Actively engage students
- Guided by knowledge on student thinking.

Which instructional approaches improve student learning?

Faculty are...

- Communicating explicit learning goals
- Attending to motivation
- Making lecture interactive with concept tests, in-class activities, and classroom discussion
- Adding or modifying homework, labs, and recitations
- Conducting and publishing research on student learning

Reference: Transforming Science Education at Large Research Universities: A Case Study in Progress. By Carl Wieman, Katherine Perkins, and Sarah Gilbert, *Change Magazine*, 2010

For more information visit:
www.colorado.edu/sei

SEI is affiliated with the Center for STEM Learning (CSL) | www.colorado.edu/csl

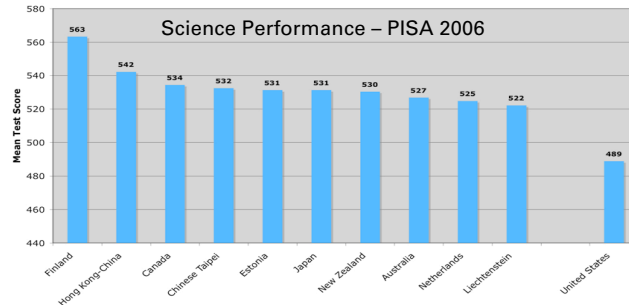
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**Investing in the Future for Colorado and the Nation
Science, Technology, Engineering, Mathematics (STEM) Education**
at the University of Colorado at Boulder
Noah Finkelstein and Valerie Otero

STEM Education: An Area of National Need

➤ ***We need investment in K12 education***

The U.S. ranked 21st out of 30 in science and 25th out of 30 in math achievement in a recent international survey of 15-year-old students (PISA 2006). On national assessments in science (NAEP 2005), only about 1/3rd of 8th grade students in Colorado rate as proficient, and 12th grade performance has dropped in the last 15 years. There remains a longstanding gap between majority and under-represented minority students.

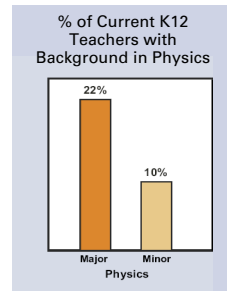


More information at: <http://www.oecd.org/dataoecd/15/13/39725224.pdf>, http://nationsreportcard.gov/science_2005/ and <http://www.whitehouse.gov/issues/education/educate-innovate>

➤ ***We need more K12 teachers in STEM***

- 2 out of 3 high school physics teachers are teaching out of field (hold neither a major nor a minor in physics).
- Retention of quality teachers is a major problem.
- Areas of national need include, math, physics, chemistry, molecular biology, and engineering.

More info at: <http://www.ptec.org> and <http://www.aeee.org/>

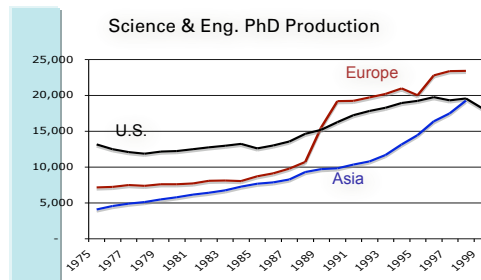


➤ ***We need investment in higher education & research:***

The US was recently surpassed by Europe and Asia in science & engineering PhD production.

Data from the National Science Foundation

More information at: <http://www.nsf.gov/statistics/seind02/c2/c2s4.htm#c2s4I2>



STEM Education: An Area of National Focus

The National Academy of Sciences’ 2006 National Research Council Report, *Rising Above the Gathering Storm*, recommends *four priorities* for investing in a competitive and secure country: 1) 10,000 teachers, 10 million minds (more STEM teachers in K12); 2) fundamental investment in science and engineering research; 3) supporting the best and brightest undergraduate and graduate students in STEM; and 4) incentives for innovation in business.

The U.S. America COMPETES Act (passed in 2007) writes this into law. Reauthorization is in process (in June 2010 it passes US House, HR: 5116).

More Information at: http://www.nap.edu/openbook.php?record_id=11463

CU’s Programs in STEM Education Directly Address the Calls for Action

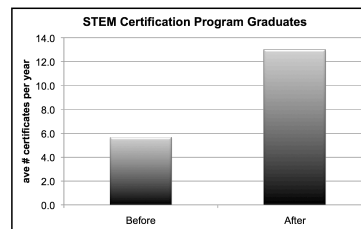
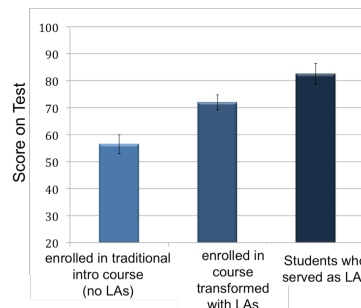
A critical lynchpin, perhaps the critical lynchpin in our educational system is higher education. It is where STEM disciplines are defined and practiced; it is where teachers are educated and return for professional development; it is where materials, assessments, and standards for the broader system are produced; it is where leading research on student learning occurs. **However, higher education is all too often overlooked in national discussions about STEM education.**

➤ A Sample of the Results at University of Colorado at Boulder

Through programs such as the Colorado Learning Assistant (LA) Model, the Science Education Initiative, and CU Teach, we are addressing the national challenges

- **Our students learn more**
 - For example, CU physics students learn two to three times more than the national average for students in traditionally taught courses.
- **We are recruiting more and better teachers into K12 STEM education**
 - We’ve more than doubled the number of STEM teachers in our programs
 - We’ve more than tripled the number of STEM teachers in areas of high need (math, physics, mol. biology, etc.)
- **We have a broad coalition of faculty** from STEM disciplines and the School of Education
 - More than 50 faculty from 14 disciplines participate
 - Among the faculty are multiple Nobel laureates, National Academy members, and department chairs

Student Achievement in physics is supported by LAs



➤ These results make CU unique and a model for other universities across the country.

More information on these efforts at:

<http://www.colorado.edu/istem> (the integrating STEM education effort)

<http://stem.colorado.edu/> (the Learning Assistant Program at Colorado)

Advancing Colorado and the Nation Science, Technology, Engineering, Mathematics (STEM) Education

Center for STEM Learning
University of Colorado Boulder
<http://www.colorado.edu/istem>

A national Center for STEM Learning: Redefining the future of higher education; Producing leading resources and models; and, Building capacity across the country.

The mission of the Center for STEM Learning (CSL) at University of Colorado Boulder is 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 in STEM education. We achieve this mission through: the creation of an infrastructure of institutional support to transform STEM education; the support of education research within and across STEM fields and departments; and K20 faculty recruitment, preparation, and professional development. CSL facilitates 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.

This Center includes an Executive Board consisting of the University Chancellor, Provost, and Deans of the Graduate School, Arts and Sciences, Engineering and Applied Sciences, and Education. As such, the Center is a campus-wide initiative spanning 4 colleges and bringing together faculty, staff and students from 14 departments actively involved in STEM education transformation and research.

CSL addresses Critical Areas of State and National Need

CSL improves STEM education at the undergraduate level, prepares STEM teachers of the future, and rigorously evaluates STEM teaching approaches, practices and methods.

- ***We need investment in K20 education:*** The U.S. ranks 21st out of 30 in science and 25th out of 30 in math achievement in international surveys of 15-year-old students (PISA 2006). On national assessments in science (NAEP 2005), only about 1/3rd of 8th grade students in Colorado rated as proficient, and our 12th graders have gotten worse since 1996. Simultaneously, a longstanding gap remains between majority and underrepresented minority students. More: http://nationsreportcard.gov/science_2005/, <http://www.whitehouse.gov/issues/education/educate-innovate>
- ***We need more K12 teachers in STEM:*** In 2009, only 46% of teachers who taught physics held a major or a minor in physics or physics education. Retention of quality teachers is also a major problem. Areas of national need include, math, physics, chemistry, molecular biology, and engineering. More at: <http://www.ptec.org> and <http://www.aeee.org> and http://www.nap.edu/openbook.php?record_id=11463
- ***We need investment in higher education & research:*** In 2008, about 5 million university degrees were awarded in science and engineering worldwide. Chinese students earned about 23%, Europeans earned about 19%, and U.S. students earned about 10% of these degrees. In 2007, China overtook the U.S. as the world leader in the number of doctoral degrees awarded in the natural sciences and engineering. The PCAST report, *Engage to Excel*, calls for 1 million more STEM majors in the next decade, and cites the first two years of college as the key. More: <http://www.nsf.gov/statistics/seind12/c2/c2h.htm> and http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf

A national Center for STEM Learning, redefining the future of higher education, producing leading resources and models, and building capacity across the country.

CU Boulder is a recognized national leader in STEM education, positioned to succeed.

Higher education is a, perhaps *the*, critical linchpin in our educational system. In addition to providing undergraduate and graduate education, higher education is where STEM disciplines are defined and practiced; it is the destination of students in our pre-college system; it is where teachers are educated and return for professional development; it is where we produce materials, assessments, and standards for the broader system; it is where leading research on student learning occurs. **In the last decade, CU has created the infrastructure to succeed in making essential contributions to transforming STEM education.** We are a research university involving those who generate STEM knowledge, as well as those deeply involved in studies of diversity, equity, and access. CU brings a long history of both attention to, and leadership in, STEM education. **Cited as an exemplary program by APLU and AAU, we provide models and practices that make CU an essential higher education component in national efforts in STEM education.**

University of Colorado Boulder brings a breadth of integrated resources.

- More than 50 active faculty members collaboratively transforming STEM education;
- Working across 14 different departments and programs (physics, chem., math, bio., engineering);
- Spanning Colleges of Arts & Sciences, Engineering and Applied Sciences, and Education;
- Linking undergraduates, graduates, postdocs, faculty, administrators;
- Spanning programs for children, family, teachers, non-profits, and schools across Colorado;
- Led by the University Chancellor, Provost, Sr. administrators, and internationally renowned faculty;
- CU-Boulder has developed nationally replicated programs in educational transformation.

University of Colorado Boulder brings a depth of resources.

- CU has decades of experience with dedicated initiatives to transforming K-20 STEM education.
- We host faculty and scholars from disciplinary departments and the School of Education who conduct foundational research (published in leading journals, e.g. *Science*) for educational transformation.
- More than a dozen graduate PhDs in STEM education *within disciplines* focusing on student learning.
- One of the largest discipline-based education research communities, working *within and across STEM fields*, addressing longstanding and new challenges in inter-disciplinary work (e.g. health and energy).
- Featuring the largest physics education research group in the country.

A Trusted Partner, Promoted in National Networks in STEM Education.

As higher education deeply engages in STEM education transformation, two critical components are being aligned – work within disciplinary societies and work by university systems. We are helping align these efforts:

- CU Boulder provides model programs, advising and building capacity for national disciplinary societies (e.g. American Physical Society, Am. Chemical Society, Am. Soc. for Engineering Education)
- CU supports, shapes, develops and disseminates efforts through professional societies of universities (Assoc. of American Universities - AAU, and the Assoc. of Public & Land-grant Universities APLU)

More information at:

<http://www.colorado.edu/istem> (the Integrating STEM education effort building a national Center)
<http://laprogram.colorado.edu> (the Learning Assistant Program at Colorado)
<http://cuteach.colorado.edu/> (a leading national model in teacher preparation and support)

Contacts:

Prof. Noah Finkelstein, Physics, Dir. Integrating STEM Education: Noah.Finkelstein@colorado.edu
 Prof. Valerie Otero, Education, Dir. Learning Assistant Program & CU Teach. Valerie.Otero@colorado.edu



Center for STEM Learning

UNIVERSITY OF COLORADO BOULDER

CU-Boulder's collaborative STEM education efforts are advancing K20 STEM education by transforming the way we teach, discover, and share knowledge.

Responsive Education

Our students participate in **groundbreaking**, research-based STEM education programs and initiatives that **produce proven advances**.

For example, CU-Boulder physics students consistently **outscore their peers by a factor of 2-3**.



We deliver an unrivaled STEM education experience to more than 10,000 students per year.

Teaching as Profession

"Strengthening STEM education is vital... we need to recruit and train math and science teachers to support our nation's students."

-President Barack Obama

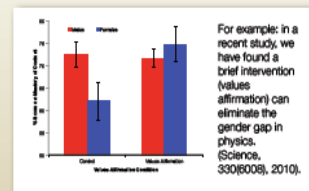


Since 2005, CU-Boulder has certified **216** discipline-trained STEM students to **teach science and math in Colorado**.

We are recruiting more and better students to address the need for effective K20 STEM educators.

World Leading Research

Our research on student learning has been **published in leading journals**.



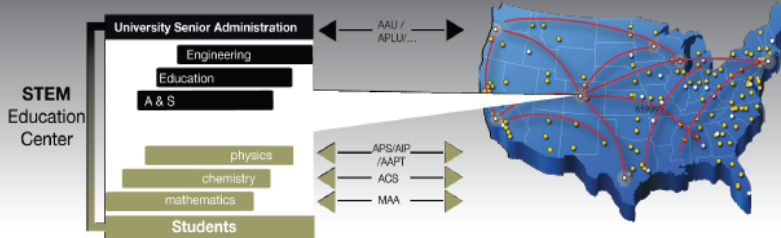
Our programs are replicated by institutions around the country.

More than 50 faculty, including **multiple Nobel laureates** are actively **engaged in STEM education research**.

CU-Boulder is internationally recognized for its leadership in STEM education.

Centers: a University and National Resource

Centers serve as critical links between administration and departmental & faculty practices, and catalyze university engagement



- A national network:**
- National resource
 - Support existing centers
 - Catalyze new centers
 - Link universities
 - Coordinate national voice

Executive Board: Philip DiStefano, Russell Moore, Frances Draper, Steven Leigh, Lorie Shepard, Robert Davis, John Stevenson
 Project Management Team: Paul Chinowsky, Stan Deetz, Noah Finkelstein, Mike Kymkowski, Daria Kotys-Schwartz, Valerie Otero, Robert Parson, Diane Sieber, Eric Stade

CSL@colorado.edu www.colorado.edu/csl (303) 492-6963

7.I. Partial listing of publications by the NSF I³ affiliates

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

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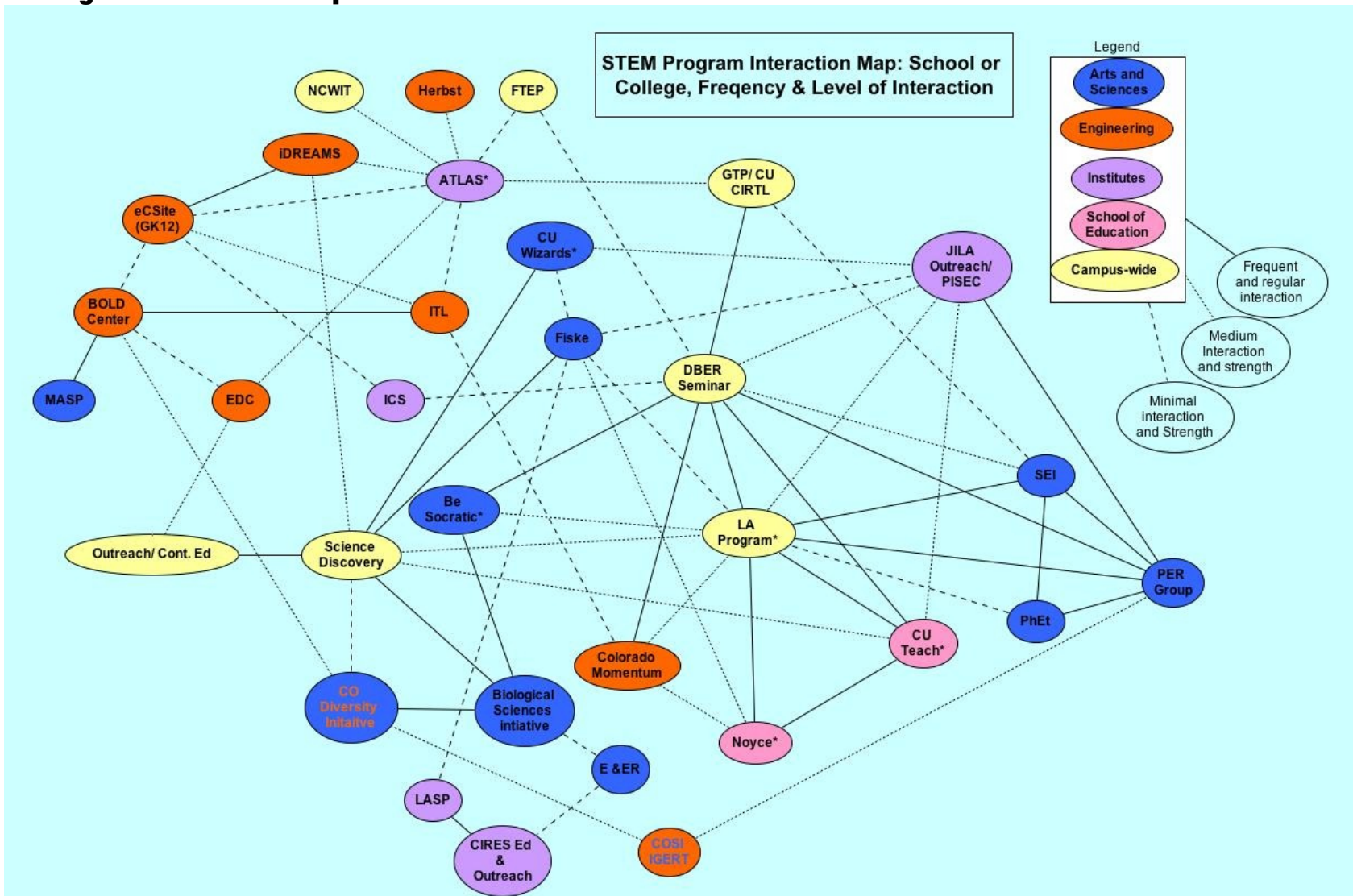
Van Dusen, B. & Otero, V. (2012). Influencing Students' Relationships With Physics Through Culturally Relevant Tools. *Proc. 2012 Physics Education Research Conference*. AIP

Zwickl, B., N. Finkelstein, and H. J. Lewandowski, "Development and Validation of the Colorado Attitudes about Science Survey for Experimental Physics," *Proceedings of the Physics Education Research Conference*, 1413, p 442-445 (2013).

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Zwickl, B., N. Finkelstein, and H. J. Lewandowski, "Transforming the advanced lab: Part I - Learning goals," *Proceedings of the Physics Education Research Conference*, 1413, 391-394 (2012).

7.J. STEM Program Interaction Map



7.K. 2012 External Evaluation Report

Integrating STEM External Evaluation Report

Prepared for: I-STEM Leadership Team, University of Colorado – Boulder
Prepared by: Rachel Scherr, External Evaluator

November 6, 2012

Goals of evaluation

This is the fourth evaluation for this project. The main goal of evaluation for this year is to help the Project Management Team (PMT) understand how best to move forward with the establishment of a Center for STEM Learning (CSL).

Personnel interviewed

Noah Finkelstein and Kate Kidder coordinated evaluator interviews with the following I-STEM stakeholders (alphabetical):

| Interviewee | Position, Department/Program | Activities |
|----------------------|--|---|
| Paule Beale | Professor and Chair, Physics | Support Physics course transformation |
| Stan Deetz | Director, Center for the Study of Conflict, Collaboration, and Creative Governance | PMT |
| Mike Dubson | Senior Instructor and Assoc. Chair, Physics | Support Physics LA program and course transformation |
| Noah Finkelstein | Professor, Physics | Co-PI and Project Management Team (PMT) |
| Kate Kidder | Project Manager | Project Manager |
| Mike Klymkowsky | Professor, Biology | Co-direct CU Teach |
| Daria Kotys-Schwartz | Instructor, Engineering | PMT |
| Mary Kraus | Associate Dean for Natural Sciences | |
| Laurie Langdon | Co-Director, Learning Assistant Program | Co-direct campus-wide LA program |
| John Leslie | Assistant Director of Strategy and Branding | Communications |
| Margot Neufeld | Director of Development for the School of Education | Development |
| Valerie Otero | Assoc. Professor, Education | PMT, co-direct CU Teach, direct campus-wide LA program, direct Noyce programs |
| Robert Parson | Assoc. Professor, Joint Institutes for Laboratory Astrophysics | PMT |
| Kathy Perkins | Assoc. Professor, Physics | Direct CU Science Education Initiative (SEI) & PhET Simulations |

| Interviewee | Position, Department/Program | Activities |
|-----------------|---|------------------------------------|
| Steve Pollock | Professor, Physics | Direct Physics LA program |
| Diane Sieber | Assoc. Dean for Education, Engineering | PMT |
| Jackie Sullivan | Assoc. Dean, Engineering | Create Engineering Education track |
| Ben Webster | Director of External and Government Relations | Government relations |

Center for STEM Learning (CSL)

The proposal to establish the CU-Boulder Center for STEM Learning (CSL) is under consideration and is expected to be approved shortly. The purpose of the CSL is to improve STEM education at CU-Boulder by creating and maintaining infrastructure to support STEM education. Currently, the CSL is funded (by NSF and CU) to conduct activities such as developing cyberinfrastructure to link STEM education programs, supporting and institutionalizing an annual symposium on STEM education, and making awards to faculty and graduate students to support engagement in STEM education research. When future funding is secured, the CSL anticipates greatly expanded support for STEM education research, including faculty lines, postdocs, teaching fellows, and graduate and undergraduate fellowships. The first application for such funding (through NSF's WIDER/EAGER initiatives) was unfortunately unsuccessful.

The CSL is intended to be an agent of change on the CU campus, seeking to enhance the priority that departments and programs place on STEM education, support STEM education research, and promote evidence-based STEM education practices. Faculty lines shared between the CSL and the disciplinary departments are likely to be an extremely important feature of the CSL as well as the most difficult to negotiate. Discussions with key stakeholders in Physics, Astronomy, Chemistry, Engineering, and Education have produced an initial plan, though negotiations are not yet officially under way.

Project Management Team (PMT)

The Project Management Team (PMT) includes representatives from several STEM disciplines as well as directors of key STEM education programs on campus, including the Learning Assistant (LA) Program and CU Teach. Finkelstein is a strong leader who gets things done. Participation on the PMT brings formerly isolated university STEM education efforts into contact with one another and provides a means for synergistic faculty relationships across the disciplines. Interviews with several members of the PMT indicate a shared sense of purpose and excitement as far as promoting a culture and practices of STEM learning on campus. Several members of the PMT look forward eagerly to the CSL becoming a networking and communication hub for STEM education research. Others anticipate the CSL's advocacy in helping departments appropriately evaluate faculty conducting STEM education research. In these ways, the PMT is a successful and functional col-

laboration towards getting the CSL established, and towards promoting STEM education on campus even before the CSL is operative.

The PMT is also experiencing some difficulties common to large collaborations with passionate, strongly committed leaders. Though Finkelstein invites full collaboration, he also takes independent action, which can result in decisions being made without the full deliberation of the PMT. This is both a significant benefit to the project and a potential risk to the PMT's working relationships and sense of common purpose. Otero, another primary leader of the CSL effort, is first and foremost concerned with protecting the quality and sustainability of the LA Program; perceiving that the LA program might be made vulnerable, rather than strengthened, by inclusion in the CSL, she elected to retain the LA Program in the School of Education. The mutual trust and partnership of a powerful leadership team has been a major asset for this project in the past, and deserves a high priority as the establishment of the CSL moves forward. The Director of the Center for the Study of Conflict, Collaboration, and Creative Governance, Stan Deetz, has been added to the PMT and serves a valuable role in helping the PMT function productively. Deetz's credentials include the design of interaction processes for multi-party decision making at the University of Colorado and beyond (for clients including IBM, Lucent, and AT&T).

University Relations

College of Arts and Sciences

At the Dean level, where improvement of STEM education is a high priority, the CSL concept enjoys broad support, representing a kind of institutional sustainability that laudable projects such as the former Science Education Initiative (SEI) have lacked. Associate Dean Mary Kraus has observed a positive shift in the culture of STEM education on campus: for the first time in her thirty years on the CU campus, undergraduate teaching is something that you can "knock into another faculty member on campus and discuss." The respect and recognition gained by Finkelstein and Otero is another sign of the value placed on STEM education. The I-STEM Symposium is an excellent means of communication for administrators such as Deans, who appreciate a focused special occasion as a means of staying informed.

The PMT has agreed to delay communicating about the CSL to the departments until the terms are settled and all parties have agreed on a unified message.

Communications and External Relations

The Assistant Director of Strategy and Branding (John Leslie) and the Director of External and Government Relations (Ben Webster) are well informed about the establishment of the CSL and will move forward with communications when the project has clearly defined its message. Leslie suggests that the CSL may benefit from existing communications infrastructure such as a campus calendar that can filter events by STEM tags, and notes the congruence of the CSL with the Flagship 2030 initiative, in which CU commits to redefining learning and discovery in a global context and setting new standards in education, research, scholarship, and creative work. Webster is concerned about the possibility of the CSL Director being a faculty member

from within a discipline, who would have obligations to his or her department, and supports a model in which a major investment from the university supports a CSL director dedicated entirely to CSL work.

Development

The expansion of the CSL into a powerful campus entity depends on securing financial support. CU development officers, responding to priorities set at the Dean level, are not yet prioritizing the CSL in their fundraising efforts.

Recommendations

- Consider increasing Deetz's independent communication with all PMT members so that Deetz may be understood as a neutral facilitator.
- Continue to institutionalize formal structures for PMT meetings such as decision making by anonymous vote.
- Create and communicate a strategic plan that assists Development and Communications in prioritizing CSL activities.
- Address the concerns that attend the possible appointment of a disciplinary faculty member as CSL director.
- Identify the benefit of the CSL to disciplinary departments. At the appropriate time, create a unified message for communicating this benefit to all departments.
- Continue to pursue funding for CSL expansion.