Integrating STEM Education

UNIVERSITY OF COLORADO BOULDER

I^3: Towards a Center for STEM Education

Award Number: DRL 0833364

Annual Report Year 4

Executive summary of success for year 4

In it's forth year, the University of Colorado Boulder's NSF I³ effort, *Towards a Center for STEM Education*, has made great strides.

As of Jun 27, we have submitted paperwork to CU-Boulder university administration to establish a center, the **CU-Boulder Center for STEM Learning** (CSL).
The creation of a sustained center is the primary objective of this NSF I³ grant.
We anticipate formal approval and launch of this center in the fall 2012.

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 to transform STEM education; the support of education research within and across STEM fields and departments; and K20 teacher recruitment, preparation, and professional development.

In addition to establishing this center, we've been building infrastructure to develop and sustain it through such programmatic efforts as building community and establishing networks among programs, committing to diversity, excellence, and access, disseminating our findings and consulting with public policy makers, and conducting formative evaluation.

CU-Boulder NSF I³ highlights include:

- Supporting more than 150 active CU-Boulder faculty, staff, and graduate students who are collaboratively transforming STEM education;
- Working across 14 different departments and programs (physics, chemistry, mathematics, biology, engineering, etc.);
- Linking and seeding efforts that span the Colleges of Arts & Sciences, Engineering and Applied Sciences, the School of Education, and the Graduate School;
- Connecting undergraduates, graduates, postdocs, faculty, and administrators;
- Explicitly supporting 35+ research projects and programs, and building a community of scholars in STEM education that spans more than 45 programs and departments;
- Gaining national support for renowned programs at CU-Boulder including the Colorado Learning Assistant Program, the Science Education Initiative, CU Teach, Science Discovery, and more;
- Building one of the largest discipline-based education research communities *within and across STEM fields*, to address longstanding and new challenges in inter-disciplinary work (e.g. health and energy);
    - Hosting faculty and scholars from disciplinary departments and the School of Education who conduct foundational research (published in

Science, Nature, etc.) that provide resources for educational transformation;
    - Publishing Hundred of papers about STEM education, with at least 70 in the past year alone;
    - Graduating more than a dozen PhD students *within disciplines* who have focused on student learning;
    - Fostering new PhD lines in STEM education research in at least four departments;
    - Supporting the largest physics education research group in the country;
    - Directly supporting (through NSF I^3 seed funding) of more than 15 faculty and 20 graduate students in STEM education research.
- Building a cohesive organization among more than 45 different programs on campus focusing on STEM education. These programs impact roughly 10,000 undergraduates per year and thousands of pre-college children through our community partnerships;
- Hosting community building events, such as annual symposia (supported by Colorado's Lt. Governor), mini-symposia, workshops, and programmatic events through the year;
- Emphasizing, supporting, and enhancing diversity, equity and access, for CU-Boulder and the STEM community through programming, research, and individual support;
- Supporting sister-efforts across the nation, advising and providing models for more than three-dozen colleges and universities across the nation seeking to transform STEM education and /or create centers for STEM education;
- Collaborating with national organizations including: the AAU STEM Education Initiative, the APLU Science and Mathematics Teacher Imperative, the American Physical Society, the American Chemical Society, and the Society for the Advancement of Biology Education.

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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) efforts in undergraduate and graduate course transformation, particularly at the undergraduate and graduate levels, (2) programs in undergraduate and graduate teacher preparation for K12 and college, and (3) 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 five year 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 submitted for approval on June 27th. For the full text of this proposal, 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 33 research projects and programs, and built a community of scholars in STEM education that spans more than 45 programs and

departments. In the last year this community has produced 50 publications on STEM education research and reform. The NSF I³ has supported the inclusion of a scholarly approach to educational practice that is spreading throughout our campus and institutions that are replicating our educational models.

1.D. Broader Impacts

Funding from the NSF I³ has built a cohesive organization among more than 45 different programs on campus focusing on STEM education. These programs impact roughly 10,000 undergraduates per year 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 will 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 minorities, women, and students from historically under-represented 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, supporting, and running programs

The NSF I³ supports individual programs that span a broad section of campus (such as the Colorado Learning Assistant Program, 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 list of programs, see 7.D. List of affiliated programs.

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

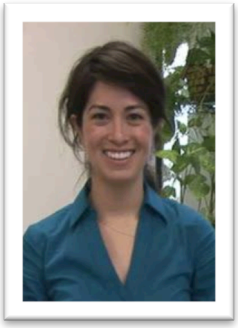
A key and innovative component of the NSF I³ is the Chancellor's Awards for Excellence in STEM Education program. These mini-awards provide funding to faculty (up to $10,000) and graduate students (25% research assistant appointments) who excel in discipline-based education research and/or promoting education within their department through course transformation. These awards have supported and encouraged STEM education research at CU-Boulder.

For faculty, the award money can support course release, summer salary, or research costs associated with STEM education projects. Funds can 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.

In the first four years of this project, the NSF I³ has funded 14 faculty awards (see 7.E. Chancellor's Awards for Excellence in STEM Education). The 2011-2012 Chancellor's fellows are currently wrapping up their projects and submitting final reports (see 7.F. Outcomes of the Chancellor's Awards).

For one of the current Chancellor's Award projects, Dr. Jane Stout from the Department of Psychology in the College of Arts and Sciences is assessing 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. Dr. Stout proposes 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. She is conducting two field studies that will test these suppositions in order to glean a stronger understanding of when and why gender disparities occur in STEM disciplines, and hopes this work will 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.

Eighteen graduate awards have been made over the past four 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 for to encourage their disciplinary departments to engage in course transformation and disciplinary-based education research.



The award given to Dr. Kimberly Trenbath for her project, *Undergraduate Climate Change Curriculum Development and Validation*, was particularly effective. Kim is the first ever University of Colorado Boulder graduate to be awarded a doctorate in atmospheric science education. The materials she has produced have been instrumental in the revision of two courses in introductory atmospheric studies at CU-Boulder. Kim is currently considering faculty positions for fall 2012.

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

2.A.ii. The LA Program

The Learning Assistant (LA) Program is a flagship program of the NSF I³. 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 LA Program made 104 undergraduate appointments in Fall 2011 and 106 appointments for Spring 2012. These appointments spanned 11 departments within two colleges (Arts & Sciences and Education). The program expanded into two new departments (Atmospheric & Oceanic Sciences; Ecology & Evolutionary Biology) as well as two educational psychology courses in the School of Education. In Fall 2012, 115 LAs will be hired, and Mechanical Engineering will participate in the program.

We continue to collect data, documenting the positive impact of LA-supported courses that feature interactive, research-based practices. We are in the midst of transitioning the LA Program to institutional rather than grant-funded support. Currently, departments, deans, and the provost all contribute to the LA Program. Information about the LA Program is available at: http://laprogram.colorado.edu/.

2.A.iii. Discipline Based Education Research

In year four, the Discipline Based Education Research (DBER) seminars built on the success of the first three years, holding 35 seminars since June 2011. These seminars brought together faculty and graduate students from roughly 45 different programs and departments and across four schools/colleges. The average attendance was more than 20 people, and spanned more than 80 faculty, graduate students, and staff from the university. These meetings continue to be effective at creating community among STEM education researchers on campus. DBER is also serving as a vehicle to make connections with STEM education experts from other institutions and has already hosted faculty from the American Physical Society, Arizona State Polytechnic, Clemson University, Florida International University, Indiana University, Massachusetts Institute of Technology, Rochester Institute of Technology, Seattle Pacific University, Stanford University, The University of California Berkeley, the University of Copenhagen, the University of Maine, the University of Nebraska, the University of New Hampshire, the University of North Dakota, the University of Texas at Austin, and the University of

Wisconsin–Madison. 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.iv. 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.v. Additional collaborative STEM education projects

Over the last year, the NSF I³ has supported and a collaborated with a variety of interdisciplinary efforts in science, technology, engineering, and math education, including:

2.A.v.a. CU Teach

The CU Teach program, a key affiliate program of the NSF I³ effort at CU-Boulder, has continued 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.v.b. Teaching and learning science courses

Two new courses in disciplinary-specific teaching have run (*Teaching and Learning Physics* and *Teaching and Learning Biology*). Chemistry is assembling a parallel course to offer in the 2012-2013 academic year.

2.A.v.c. Creating an engineering teacher certification track

Discussions are underway between key faculty/administrators in the College of Engineering and Applied Science, CU Teach, and the School of Education to identify what features a teacher certification program in engineering would include. With the support of Battelle Foundation, a working team, including members of the NSF I³ Project Management Team, is designing the *Engineering for Society* track that will

provide an avenue for students to earn both a teacher certification and an engineering degree. We anticipate a full program proposal by summer 2013.

2.A.v.d. Partnerships with other NSF centers and grants at CU-Boulder
The NSF I³ offers consulting, 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.v.e. Partnerships with other NSF centers nationally
The CU-Boulder NSF I³ project is serving to develop STEM education centers across the nation and a national network of these centers. Members of the PMT have been in consultation with newly developing centers in Texas, and at Florida International University, Central Florida University, and other institutions to help support their development. Furthermore, efforts are under way (under the supervision of the Association of Public and Land-grant Universities) to create a network of the more than one hundred STEM education centers across the country. Members of the PMT are consulting on this project and the CU-Boulder Center for STEM Learning seeks to serve as a hub of this national network.

2.B. Hosting events

The NSF I³ 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 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 Third Annual Symposium was held October 10, 2011 and was attended by more than 160 people, representing more than 55 departments, programs, and partners. Attendees included the CU-Boulder chancellor and provost, the vice chancellor for research, six deans, two state representatives, several donors, the vice president of Ball Aerospace, and faculty, staff, and students from across five academic colleges/schools.

The program began with a poster session showcasing 20 programs, which provided networking opportunities among our STEM education constituents. Colorado Lieutenant Governor Joe Garcia sent an introductory statement to be read at the beginning of a brief presentation. An award ceremony recognized recipients of the Chancellor's Award for Excellence in STEM Education. Howard Gobstein, executive vice president of research for the Association of Public and Land Grant Universities provided the keynote address for the event. The chancellor, provost, and deans of the College of Arts and Sciences, School of Engineering and Applied Science, School of

Education, and Graduate school also spoke briefly. For more information, see http://www.colorado.edu/istem/2011_Symposium.html.

Plans are under way for a fourth annual STEM education symposium to be held on September 30th and October 1st, 2012. We will invite participation from donors, VIPs, and key stakeholders throughout the state and the university, and plan to announce the establishment of our center at the event.

2.B.ii. Green Schoolyards Panel Discussion

The NSF I³ partnered with the College of Architecture and Planning to co-sponsor a panel discussion about green schoolyards on March 1, 2012. The panel, moderated by Louise Chawla, Professor of Architecture and Planning, and Eric Stade, Professor of Mathematics and NSF I³ PMT member, was about research that evaluates schoolyard habitats and gardens for their impact on student learning about science, the environment, and other subjects across the curriculum as well as student health, happiness, and well being. The panelists were Emily Stanley Ph.D., Kelly Keena, Ph.D., and Illene Pevec, Ph.D.

2.B.iii. NSF Reverse Site Visit for the Institutional Innovation through Integration (I³) Program

On March 26, 2012, project directors, Noah Finkelstein and Robert Parson, and external evaluator, Dr. Rachel Scherr, presented at the National Science Foundation's Reverse Site Visit for the Institutional Innovation through Integration (I³) program. The slides presented at this event are posted at http://per.colorado.edu/temp/CU_i3_RSV.pptx. In addition to summarizing the state of the project and prospects for the future, a discussion with external reviewers gave rise to three lines of additional current pursuits:

1. Externalizing the depth and breadth of our efforts, and making explicit the benefits of our efforts.
2. Writing up a narrative of how the STEM education community at CU-Boulder is being build and how it has worked.
3. Reaching out to the two-year college system once the center is established, especially in the interest programmatic diversity.

2.B.iv. SEI/iSTEM End of Year Event

On May 9, 2012, the NSF I³ (iSTEM) program partnered with the Science Education Initiative (SEI) to host an end-of-year event and celebrate the year's successes in STEM education at the University of Colorado Boulder. This event featured two keynote speakers: one from the NSF I³ Project Management Team, Derek Reamon, and an NSF I³ supported Chancellor Awardee, Heather Lewandowski. Dr. Reamon spoke about a partner program, Integrated Teaching and Learning program, Dr. Lewandowski spoke about upper division laboratory transformation in physics. In addition these speakers, the end of year event featured a networking session, lunch, and a poster session with roughly 50 posters from programs affiliated with the SEI and the NSF I³.

2.B.v. Participation in I³ research site visit

On May 9 and 10, 2012, the CU-Boulder NSF I³ was visited by NSF I³ system evaluators/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, we arranged for them to meet 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 NSF I³ Project Management Team, several recipients of the Chancellor's Award for Excellence in STEM Education, DBER community members. They also participated in the SEI/iSTEM End-of-Year Event. We are awaiting their report.

2.C. Enhanced use of technology

Over the last year, the NSF I³ has shared our resources electronically.

2.C.i. Website

A website is maintained to coordinate work internally at CU-Boulder and to share information and resources with the public. The website is available at: http://www.colorado.edu/istem.

2.C.ii. Streaming videos

Our weekly DBER and PER meetings are now being captured and streamed online. Thirty-seven DBER videos and 26 PER videos from our weekly meetings are now posted. These videos feature both local researchers and internationally renowned visitors. More info 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. Recently, 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 has recently agreed to serve on the CSL's Executive Board.

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 NSF I³ directors are the STEM education consultants to this office. More information is available at http://www.colorado.edu/odece/.

3.B. Colorado Diversity Initiative (CDI)

This program, which works to improve diversity and access in STEM, is a strong collaborator with the NSF I³ effort, particularly for undergraduate and graduate scholarships. 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. 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 is partnering with the American Physical Society to be one of eight institutions committed to doubling the number of black and Hispanic PhDs in physics in the United States (other institutions include Harvard, Princeton, Stanford, MIT, and the University of California).

3.E. National Society of Black Physicists and Hispanic Physicists

Each year CU-Boulder sends a delegation of 10 students to the joint annual meetings of the National Society of Black Physicists and Hispanic. A grass roots STEMS seminar grew from this community to support local students developing scientific community, and practice at providing scientific presentations. While the NSBP/NSHP meeting has not run since 2010, the students at CU-Boulder who have participated in the past created and sent a delegation to the Puerto Rico Interdisciplinary Scientific Meeting (PRISM). This delegation of one-half dozen students raised awareness about CU-Boulder, supported minority students at CU-Boulder, and created strong ties with the Puerto Rican scientific community. Noah Finkelstein has already been invited to give a follow-up addresses for the Puerto Rican LSAMP community. This community is currently seeking other programmatic offerings, such as SACNAS.

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 being featured by the NSF I³ by presenting at DBER and

hosting poster presentations at our annual symposia.

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)

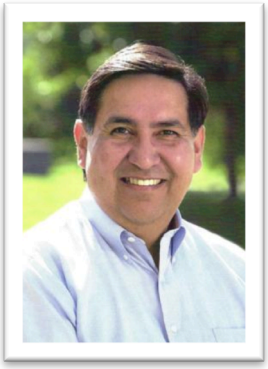
BASEC (see http://boulderareastem.org) focuses on diversity, equity, and access for children in STEM. The NSF I³ has helped shape and create this effort, which helps to link CU-Boulder with the Boulder County community. In partnership with BASEC, the NSF I³ has supported career fairs for youth, campus visits, and networking among the dozens of community-based programs focusing on STEM. In the past year BASEC has grown to over 300 members.

3.I. Women in engineering

The NSF I³ has supported a meeting of women in engineering on campus that is serving as the educational cornerstone of one of our faculty members, who is applying for an NSF CAREER award. This weekly meeting helps to build a community and cohort between electrical engineering undergraduate and graduate women. This faculty member, who is also advised by NSF I³ co-PI, Noah Finkelstein, has recently been awarded a University of Colorado Outreach Award to expand these efforts.

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

The Chancellor's Awards also serve as a mechanism to seed and support work in Diversity and Access at CU.



For example, Calvin Pohawpatchoko was given a graduate award for his work with Cognitive Apprenticeship methods, in which he brings computer technology and computational thinking experiences into Native Communities, and teaches Indigenous youth to build interfaces, webpages, and even computers. In particular, Calvin is using his Chancellor's Award funding to study elements of Indigenous culture and historic socio-culture context within the Cognitive Apprenticeship model and to look at how this model promotes technology fluency and influences post-secondary educational decisions and visions of Native youth.

3.K. Native Grad

The NSF I³ partnered the with Native Grad, a program that provided support to 22 Native American undergraduates, five of whom earned a degree in STEM fields.

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 teacher professional development.

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

- The NSF I³ has supported the dissemination of the LA Program (see 2.A.ii. The LA Program) model of educational transformation. In the past year, in addition to the three major workshops described above, the NSF I³ directors have made over a dozen presentations at state and national venues regarding this effort. Currently more than three-dozen institutions are replicating this successful program that positively impacts student learning, the number and quality of certified teachers, and institutional commitment to education.
- As described above, the DBER seminars (see 2.A.iii. 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).
- The NSF I³ has been an instrumental partner in creating a state-supported regional center for STEM education: the Boulder Area STEM Education Coalition (BASEC). This coalition includes over 300 members, has been endorsed by all of the county commissioners, and 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.

Parallel efforts have been made to raise awareness about STEM education and the NSF I³ efforts at CU-Boulder:

- On April 22, 2012, the Association of Public and Land-grant Universities, hosted its leadership collaborative of the Science and Mathematics Teacher Imperative in order to address the coming Next Generation Science Standards. The CU-Boulder NSF I³ cohosted this event, and PI, Phil DiStefano, opened the event with a keynote address.
- A Danish 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. The film is still in post-production.

- 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.
- PI Phil DiStefano currently chairs the Executive Board of the Association of Public and Land-grant Universities' Science and Mathematics Teacher Imperative.
- The NSF I³ PMT has given a wide variety of addresses on educational policy including:
    - February 2012: Co-PIs, Noah Finkelstein and Valerie Otero, gave an invited talk, "STEM Education, Research Universities and the Future of Colorado" at the Colorado General Assembly, Hearings of the Joint Education Committee, Senate and House of Representatives.
    - February 2012: Co-PI, Noah Finkelstein, was invited to give a keynote address and lead workshops at the 7th Annual Success in the Classroom: Sharing Practices that Work conference, hosted by the University of New Mexico.
    - February 2012: In January CU-Boulder was invited to be a partner in 100Kin10, a growing movement to respond to the national imperative to recruit, prepare, and support 100,000 STEM teachers over the coming 10 years. In February, co-PI, Noah Finkelstein, attended the first 100Kin10 Partner Summit in Washington, D.C.
    - March 2012: Co-PI, Noah Finkelstein, was invited to Florida International University (the largest Hispanic-serving institution in STEM education), to consult on their development of an institute for STEM education. Since this trip, where he advised FIU's president, vice president of research, foundation head, and government relations head, the university has established their institute (see http://sish.fiu.edu/initiatives/stem-transformation-institute/), which will serve as a sister center to the CU-Boulder Center for STEM Learning.
    - May 2012: Chancellor DiStefano met with NSF director, Subra Suresh, to discuss research universities and some key pillars of investment and continued research. He featured, as one of these key pillars, STEM education and the development of infrastructure for STEM Education transformation and research (such as STEM education centers).
    - May 2012: Co-PI, Noah Finkelstein, and PMT member, Eric Stade, attended the First National Conference of Centers for Science and Mathematics Education at the University of Utah. CU-Boulder was one of centers from across the country that was invited to participate.
    - May, 2012: Co-PI, Noah Finkelstein, gave an invited talk, "The Colorado Learning Assistant Program," at the Conference on Using Student-Generated Content and Peer Support to Enhance Student Engagement and Learning at the University of Manchester, Manchester, UK.

- June 2012: CU-Boulder Chancellor Phil DiStefano and Provost Russell Moore visited DC during the week of June 25th to participate in the Association of Public and Land-grant Universities' convocation celebrating the 150th anniversary of the Morrill Act, which established the land grant university system. During this visit, Chancellor DiStefano met with Zakiya Smith, President Obama's Senior Education Policy Advisor at the White House, to discuss college costs, efficiency, and STEM education. Provost Moore also met with David Bergeron, the Deputy Assistant Secretary for Post-Secondary Education, and senior professional staff from the Senate Commerce, Science, and Transportation Committee and the House Science, Space, and Technology Committee to discuss many of the same topics.
- June 2012: Co-PI, Noah Finkelstein, and PMT member, Mike Klymkowsky, gave invited presentations at the 2nd Conference on Transforming Research in Undergraduate STEM Education in Saint Paul, MN, a conference to promote the integration of research on undergraduate science and mathematics education
- June 2012: Co-PI, Noah Finkelstein, gave an invited talk, "Building on a Scholarship in Physics Education for Course and Program Transformation," at the APS Building Thriving Undergrad Physics Programs Conference, in Washington DC.

- The NSF I³ initiative has hosted a variety of policy makers including:
  - US Congressman Jared Polis
  - Bruce Alberts, American Association for the Advancement of Science (AAAS)
  - The lieutenant governor of Colorado, Joseph Garcia, Chairman of Colorado Commission on Higher Education
  - Shirley Malcom, AAAS
  - Colorado State Representative Dickey Lee Hullinghorst
  - Boulder County commissioners, Will Toor and Cindy Domenico
  - Boulder mayor, Susan Osborne

The NSF I³ has produced a series of simple 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 (see 7.G. One-page handouts). The Office of University Communication has offered to produce more of these one-page summaries. We anticipate creating a full suite of 25+ summaries in the coming year.

The NSF I³ continues to collaborate with the 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 roughly a dozen articles about CU-Boulder surrounding STEM education in the past year, many of which are posted at http://www.colorado.edu/news/series/stem-education. A communication and branding plan has been established from university officials. This joint communication effort is unique at CU-Boulder, and represents a pilot attempt to coordinate around many key areas of inquiry on campus.

4.A. Scientific presentations/publications

The NSF I³ has supported 50 publications. See 7.H. 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

Over the past year, the NSF I³ directors have been meeting bi-weekly to manage programming in order to accomplish our mission and reach our goals. One of the explicit five-year goals of this NSF I³ grant is to establish a center for STEM education at the University of Colorado Boulder.

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.

A 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 finalized on June 27, 2012, and is under review by the chancellor, provost, 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 Executive Board of the center includes:

- Chair: Chancellor Phil DiStefano, NSF I³ PI
- Provost Russ 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:

- Noah Finkelstein, Department of Physics
- Valerie Otero, School of Education and co-Director of the LA, CU Teach, and Noyce programs
- Diane Sieber, Associate Dean of the College of Engineering & Applied Sciences
- Daria Kotys-Shwartz, Department of Mechanical Engineering and director of the Center for Industrial Partnerships

- Derek Reamon, Department of Mechanical Engineering and co-director of the Integrated Teaching and Learning program
- Michael Klymkowsky, Department of MCD Biology and co-director CU Teach
- Robert Parson, Department of Chemistry and JILA fellow
- Stan Deetz, director of the Peace and Conflict Studies Program

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).

Four years into the project, 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 37 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 2.A.ii. The LA Program) 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.iii. Discipline Based Education Research) and PER@C (see 2.A.iv. 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 produced dozens of papers and presentations.
- The College of Engineering and Applied Sciences is establishing a parallel center, the Center for Engineering Education and Research Assessment, and is collaborating with the LA Program.

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 symposia, the iSTEM/SEI End-of-Year Event, PER@C and DBER group meetings, meetings with University Communications and resultant materials, our website, http://www.colorado.edu/istem/, and email communications sent to our collaborators across campus.

In the last year, at least 275 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.I. STEM Program Interaction Map as an example).

This past year we conducted a mid-program follow-up (expanding on the original survey at the advice of our external evaluator) and already have compelling indications that more programs are involved and are more integrated with each other since our initial survey. For example, our 2009 survey revealed that DBER, the LA Program, and PER were major hubs of interaction campus. Data from the mid-program follow-up shows that SEI, PhET, CIRTL, CU Teach, and the NSF I³ are now also key hubs of integration and connectivity. For a summary of these and other survey findings, see 7.J. 2011 Survey Analysis.

6.C. Creating a center structure

As described in 5. University structures: Towards a center for STEM education**,** the center proposal has been submitted. One essential form of evaluation of this NSF I³ project is whether we are able to establish a functioning center. We anticipate that we will. In addition to submitting the proposed framework for a center and establishing by-laws, we have also developed 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.

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 it's 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.

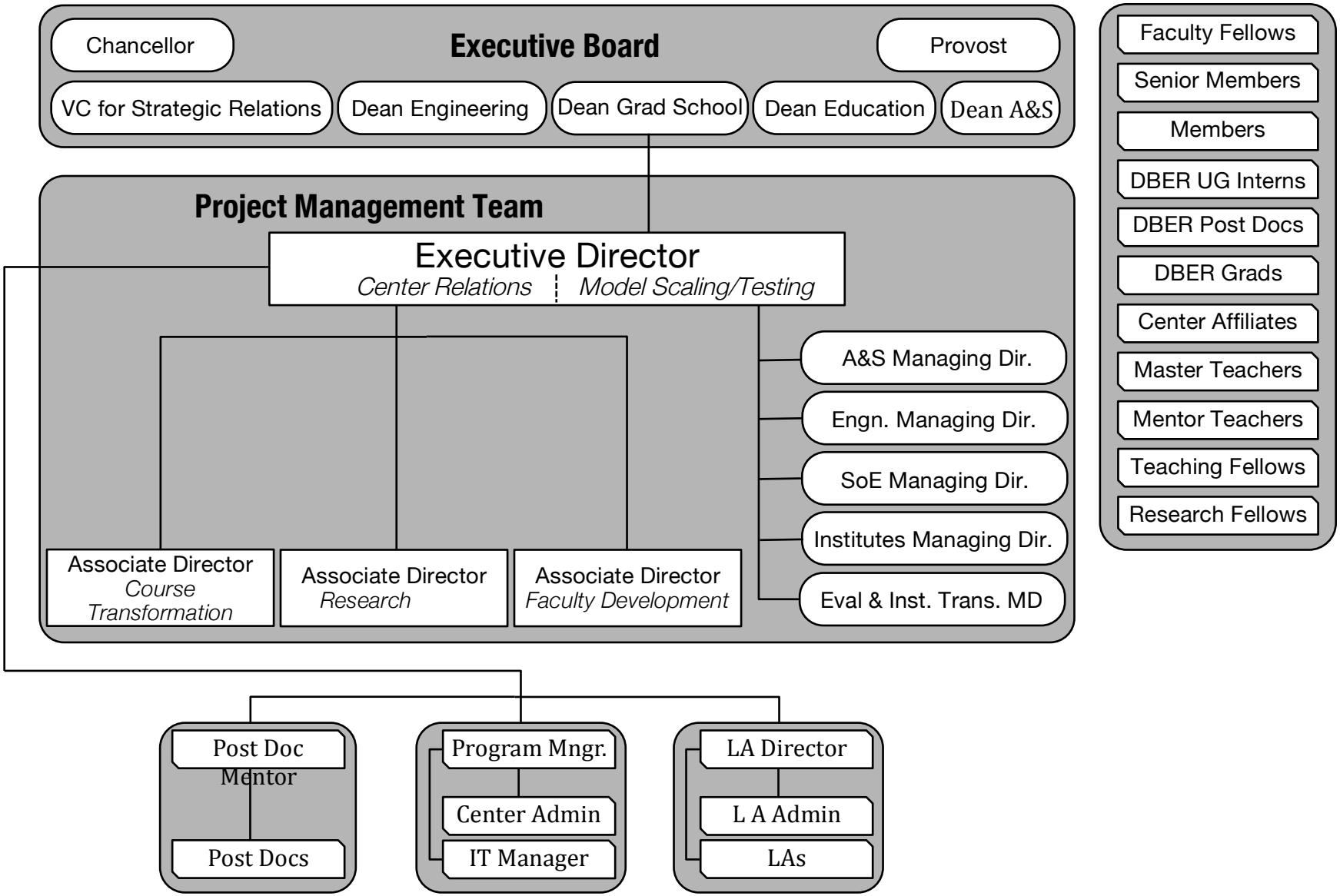
Fellows will provide consultation to the executive director and project management team on center matters and will make recommendations regarding the goals of the center. The roles of senior members, members and affiliates are described in the Bylaws.

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 promote K20 faculty recruitment, preparation, and professional development.

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

i. Educational transformation: We support work to improve student understanding of content, develop student understanding of the nature of STEM and of learning STEM, and to increase student interest in STEM 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, is key to 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 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.

iii. K20 teacher recruitment, preparation, and professional development: Center efforts promote content mastery by supporting affiliate programs (particularly CU Teach) to recruit and preparing K12 teachers from within the STEM departments. Our methods and education courses build on student understanding of teaching in STEM. Additionally, we support the professional development of students broadly and as 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 an it's 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 chose 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
	BeSocratic	David Nesbitt	Director	(303) 492-5011	djnadmin@jila.colorado.edu	http://www.colorado.edu/physics/Web/wizards/cuwizards.html
	BeSocratic	Mike Klymkowsky	Director	(303) 492-8508	Michael.Klymkowsky@Colorado.edu	http://www.colorado.edu/physics/Web/wizards/cuwizards.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/
BOLD Center	Broadening Opportunities through Leadership and Diversity	LaRuth McAfee	Director, Student Engagement & Community Building Programs	(303) 492-8809	laruth.mcafee@colorado.edu	http://engineering.colorado.edu/bold/index.html
	CARLA Lab	Barbara Wise	Contact	(303) 735-5226		http://carla.colorado.edu/

	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	Computationhal 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/
	Continiung 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/

	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 Wiliams	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/the NSF I3/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	
	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/extremes/index.html
GTP	Graduate Teacher Program	Laura Border	Director	(303) 492-4902	gtp@colorado.edu	http://www.colorado.edu/gtp/
GTO	Graduate Teacher Program	PJ Bennett	Interim Assistant Director		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	PI	(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://lcmrc.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	Angela Bielefeldt	Associate Director	(303) 492-8433	Angela.Bielefeldt@Colorado.EDU	http://ceae.colorado.edu/mc-edc/
	Mortenson Center in Engineering for Developing Communities	Bernard Amadei	Director	(303) 492-7734	Amadei@Colorado.EDU	http://ceae.colorado.edu/mc-edc/

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	Laurel Mayhew	Director	(303) 492-7815	Laurel.Mayhew@colorado.edu	http://spot.colorado.edu/~mayhew/PISEC/index.htm
PER	Physics Education Research @ Colorado	Noah Finkelstein	PI	(303) 735-6082	finkelsn@Colorado.EDU	http://www.colorado.edu/physics/EducationIssues/index.htm
	PhET	Carl Wieman	Chairman	(303) 492-6963	Carl.Wieman@Colorado.EDU	http://phet.colorado.edu/index.php
	PhET	Kathy Perkins	Co-Director	(303) 492-6714	katherine.perkins@colorado.edu	http://phet.colorado.edu/index.php
	PhET	Wendy Adams	Co-Director	(303) 492-6963	Wendy.Adams@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/
	Special Celestial Event Observing	Keith Gleason	Manager, Sommers-Bausch	(303) 492-6732	keithg@cosmos.colorado.edu	http://cosmos.colorado.edu/sbo/public/openhouse.html

			Observ.			
	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 Fellows:

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 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.

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 an set of teaching assistant resources and professional development to assist systemic continuity and effectiveness in the course. Mathematics is the language of STEM, science, technology, and engineering. Without the fundamental understanding of mathematics, students will struggle to have success in STEM related disciplines. Unfortunately, many elementary teachers are not only ill-prepared in mathematics, but also pass on poor attitudes and math stereotypes to their students. In 2010, a study published in the Proceedings of the National Academy of Science, made newspaper headlines showing that female elementary teachers who share their anxiety about math pass on that anxiety to their students and lower test scores. (Los Angeles Times, Jan. 26, 2010; Beilock, 2010). The need for effective pre-service mathematic content is well documented in "The Impact of Content Courses on Pre-service Elementary Teachers' Mathematical Content Knowledge" (Matthews, 2010).

Jane Stout, College of Arts & Sciences – Department of Psychology & Neuroscience

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).

Past Faculty Fellows:

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.

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

Erin Furtak, School of Education

Teaching and Learning Biology at CU: Course Evaluation and Revision ProjectThe 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.

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 biologyThe intent of this proposal is to begin developing a Capstone Molecular Biology Concept Assessment (Capstone MBCA) to evaluate how well graduating seniors in Molecular Cell and Developmental Biology (MCDB) can

integrate and apply concepts from all their coursework. Such an assessment tool will have widespread impact in supporting the transformation of undergraduate education and providing a resource to evaluate meaningful student learning. Some of the expected uses of this tool are: 1. To measure the level of conceptual learning in graduating biology majors, 2. To measure conceptual learning gains between beginning and end of final year of coursework, 3. To measure the level of content retention after graduation, 4. To help determine which different models of pedagogy can help to promote long-term content retention and integrative abilities. The Capstone MBCA can be used not only at CU, but at any college or university department that teaches genetics, molecular biology, and cell biology, across the nation and internationally. It may also be valuable to science educators in other disciples, as well as to science teachers at the secondary school level.

Heather Lewandowski and **Charles Rogers**, College of Arts & Sciences – Physics

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

Clayton 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.

Current Graduate Fellows:

Ian Her Many Horses, School of Education

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

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

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

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

Past Graduate Fellows:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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		AY Year appointment to support student's difficulites 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 CurriculumDevelopment 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	n/a
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 difficulites 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 CurriculumDevelopment and Validation	2009-2010	n/a	n/a	n/a
Lauren Kost-Smith	Student	PHYS	AY Year appointment to support investigating the gender gap in undergraduate physics tutorials	2009-2010	n/a	n/a	n/a
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
Linnea Avallone	Advisor	ATOC	Undergraduate Students' Climate Change Conceptions	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
Valerie Otero	Advisor	EDUC	Empowering Students through the Use of iPad Technology	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
Garrett Nicodemus	Faculty	CHEN	Biologically-Focused Screencasts and ConcepTests for Chemical and Biological Engineering Courses	2010-2011	1	5	n/a
Heather Lewandowski	Faculty	PHYS	Learning Goals and Course Materials for Advanced Undergraduate Physics Laboratories	2010-2011	n/a	n/a	n/a
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
John Falconer	Faculty	CHEN	Biologically-Focused Screencasts and ConcepTests for Chemical and Biological Engineering Courses	2010-2011	1	5	n/a
Kris Gutierrez	Faculty	EDUC	When Scientific and Everyday Knowledge Grow into One Another: Designing for Robust Science Learning for Students from Non-Dominant Commmunities	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	n/a
Ben Van Dusen	Student	EDUC	Empowering Students through the Use of iPad Technology	2010-2011	n/a	n/a	n/a
Colin Wallace	Student	APS	Understanding Students' Difficulties with Cosmology	2010-2011	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	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
Kim Trenbath	Student	ATOC	Undergraduate Students' Climate Change Conceptions	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
Clayton Lewis	Advisor	CSCI	An Old Thing New Again - Rethinking Nation Building in a Digital Age: Piloting Cognitive Apprenticeship in Indigenous Nation Building	2011-Present	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	2011-Present	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	2011-Present	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	2011-Present	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?	2011-Present	n/a	n/a	n/a
Beth Stade	Faculty	MATH	STEM Talking: Aligning and Improving the Mathematical Education of Pre-Service Teachers	2011-Present	n/a	n/a	n/a
Brian Couch	Faculty	MCDB	Development of an observation protocol to measure Scientific Teaching	2011-Present	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	2011-Present	n/a	n/a	n/a
John Gunther	Faculty	MUSIC	Enhancing the Pedagogy of Science, Math, and Technology though Music: Exploring Informal Science Education through the Arts	2011-Present	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	2011-Present	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	2011-Present	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?	2011-Present	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	2011-Present	n/a	n/a	n/a
					13	17	3

7.G. One-page handouts

Discipline-Based Education Research Group (DBER)

INTEGRATING STEM
Science, Technology, Engineering, and Math Education at Colorado

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, faculty and research students present their ideas, observations, and conclusions relating to particular problems and issues associated with promoting effective learning in STEM disciplines. Typically the group consists of faculty and students from a wide range of departments, including applied mathematics, astrophysics, chemistry & biochemistry, computer science, cognitive science, engineering, geology, mathematics, molecular, cellular & developmental biology, physics, and the school of education.

The DBER group meetings also serve as a forum within which iSTEM grant recipients describe the design of their projects, their observations and conclusions. DBER has also taken on broader challenges, such as: examining the proposed Colorado State Science Standards for coherence and "teachability"; 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 current topics and information visit:
www.colorado.edu/istem/DBER

Recent DBER seminar topics:

- Transforming upper division physics
- Learning through computer modeling
- Faculty attitudes to pedagogical techniques
- Learning through design in engineering
- Identification of conceptually difficult topics in specific STEM disciplines
- Approaches to integrating math and modeling into biology education
- An approach to improving the scientific thinking of students in an introductory class for non-science majors
- Course transformation through the use of learning assistants and pedagogically-based instruction

Committed to Excellence in STEM Education for Colorado | www.colorado.edu/istem

Integrating STEM Education is supported by the University of Colorado and the National Science Foundation through I3

References & Resources: Powell, K. 2003. Science Education: Spare me the lecture. Nature 425: 234-236
Klymkowky, M.W. & E.M. Furtak. 2009. Incoherent Science and Mathematics Education Undermines Biological Literacy.
http://coloradohigherednews.com/Pages/Archive.php?id=1460

INTEGRATING STEM
Science, Technology, Engineering, and Math Education at Colorado

International Leader in STEM Education

Integrating STEM Education (iSTEM) at CU Boulder works to improve STEM education through course transformation, discipline-based education research, and teacher recruitment and professional development.

We are establishing a **Center for STEM Education** at CU-Boulder to integrate an interdisciplinary community of scholars, promote and sustain existing efforts, sponsor new programs, advocate for diversity and access, influence policy, and raise needed funds.

More than 40 Programs Involved

iSTEM integrates over 40 programs in STEM education representing over $15 million 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 – couples 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 5 different departments on campus.
- NSF Grants in Physics, Chemistry, Biology, Math & Engineering to transform classes. These have been used to introduce student-centered research-based approaches in these classes.
- 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 10 departments, 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 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.
- PI/ 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..."

PI: Chancellor Phil DiStefano

Co-PIs: Provost Moore, Dean Gleeson, Dean Shepard, Assoc. Dean Argrow, Professor Finkelstein

Project Directors:
Noah Finkelstein (noah.finkelstein@colorado.edu)
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Project Administrator:
Kate Kidder (kate.kidder@colorado.edu)

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Committed to Educational Excellence for Colorado!

Integrating STEM Education is supported by the University of Colorado and the National Science Foundation through I³

The Learning Assistant (LA) Model

The LA Model is an experiential learning program of the University of Colorado at Boulder

Courses Transformed

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

Over 35 math and science courses have been transformed using Learning Assistants.

Teachers Recruited

Over 40 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

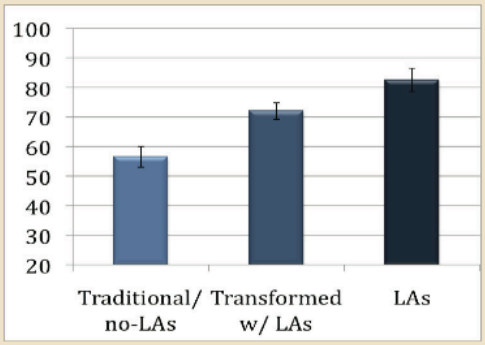
National Model

- 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

Multi-disciplinary — High Impact

- Aligned with several institutional priorities outlined in the University's strategic plan, Flagship 2030
- Approximately 160 mathematics, science, and engineering majors hired each year to serve as Learning Assistants in 8 departments
- Over 9000 students are impacted each year at a cost of under $50 per student

Students Learn More



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

Physics Education Research Group @ Colorado

INTEGRATING STEM
Science, Technology, Engineering, and Math Education at Colorado

What is PER@C?

The Physics Education Research Group at Colorado (PER@C) is one of the newest and 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 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.

PER@C Successes:

- Six faculty, including Nobel Laureate Carl Wieman, and six researchers and post-docs make PER@C the largest PER group in the nation
- With over $12 million in external funding, PER@C is one of the best-funded programs of it's 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, including nationally recognized programs

PER@C: *Leading the way in understanding how science is learned and transforming the teaching of science.*

per.colorado.edu
www.colorado.edu/istem

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 conducing research on transformation in Physics 1, 2 and 3.

Upper Division Course Transformation: Transforming junior Electricity and Magnetism & Quantum Mechanics, and use of 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.

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.**

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

PhET Interactive Simulations

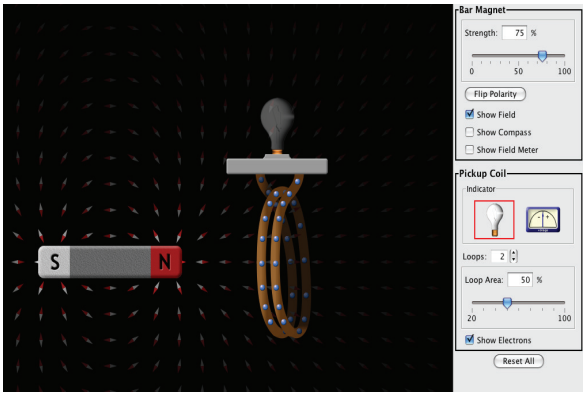
INTEGRATING STEM
Science, Technology, Engineering, and Math Education at Colorado

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 down-loadable 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:
www.phet.colorado.edu



PhET Sims: Reaching the World

- **84 total sims** available
- **Over 400 activities for teachers** using sims
- Available in **44 languages** and counting
- **8.4 million:** Number of sims run online in 2009

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 generously supported by:

THE WILLIAM AND FLORA HEWLETT FOUNDATION

NSF

Committed to Excellence in STEM Education for Colorado | www.colorado.edu/istem

CU's Science Education Initiative

Departments and Faculty Take Action to Improve Science Learning

INTEGRATING STEM
Science, Technology, Engineering, and Math Education at Colorado

CU's Science Education Initiative (SEI) is a 5-year, $5M investment by President Benson and Chancellor DiStefano to catalyze and support significant, sustainable improvements in undergraduate science education. Directed by Nobel Laureate Carl Wieman and 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	Faculty	Students
5 funded: IPHY, PHYS, MDCB, GEOL, CHEM	>100 faculty use SEI-funded resources <75 faculty modified thier teaching	Changes in >50 courses Impacts >10,000 students/yr

Faculty partner with Science Teaching Fellows to Transform Courses

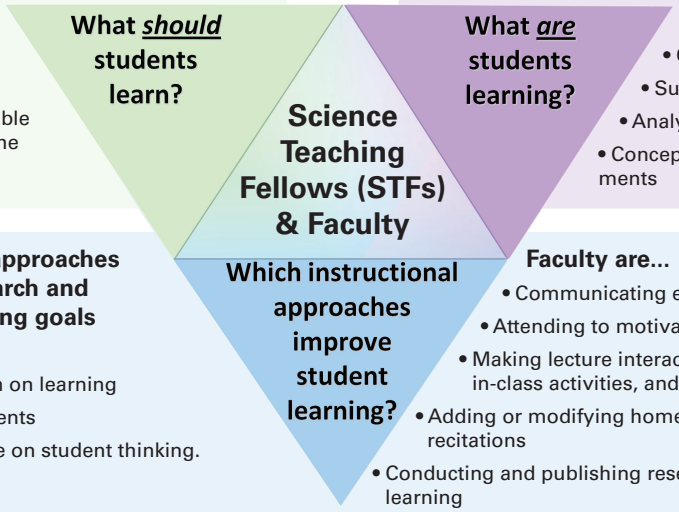
Develop consensus learning goals

- 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?"

Use data to support & guide faculty efforts

Probe student thinking and learning with:

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



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.

Faculty are...

- Communicating explicit learning goals
- Attending to motivation
- Making lecture interactive with concetp 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.

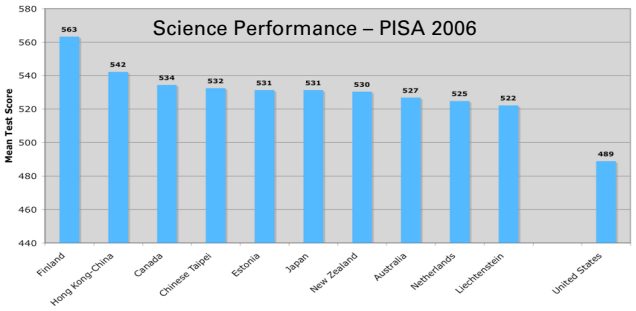
For more information visit:
www.colorado.edu/sei

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.

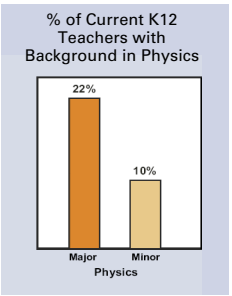


More information at: http://www.oecd.org/dataoecd/15/13/39725224.pdf, http://nationsreportcard.gov/science_2005/ and http://www.whitehouse.gov/issues/education/educate-innovate

➢ *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.aaee.org/

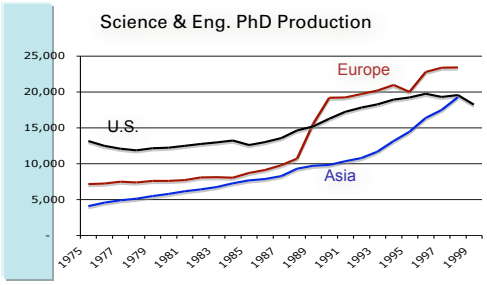


➢ *We need investment in higher education & research:*

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#c2s4l2



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.**

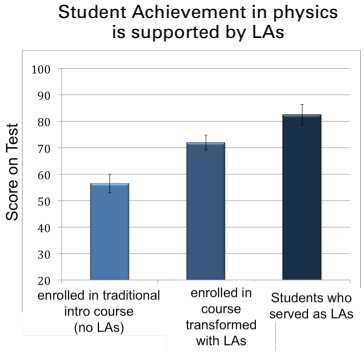
- *A Sample of the Results at University of Colorado at Boulder*

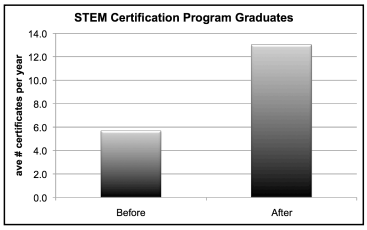
  Through programs such as the Colorado Learning Assistant (LA) Model, the Science Education Initiative, and CU Teach, we are addressing the national challenges

  - ***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





- *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.aaee.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)

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Prof. Valerie Otero, Education, Dir. Learning Assistant Program & CU Teach. Valerie.Otero@colorado.edu

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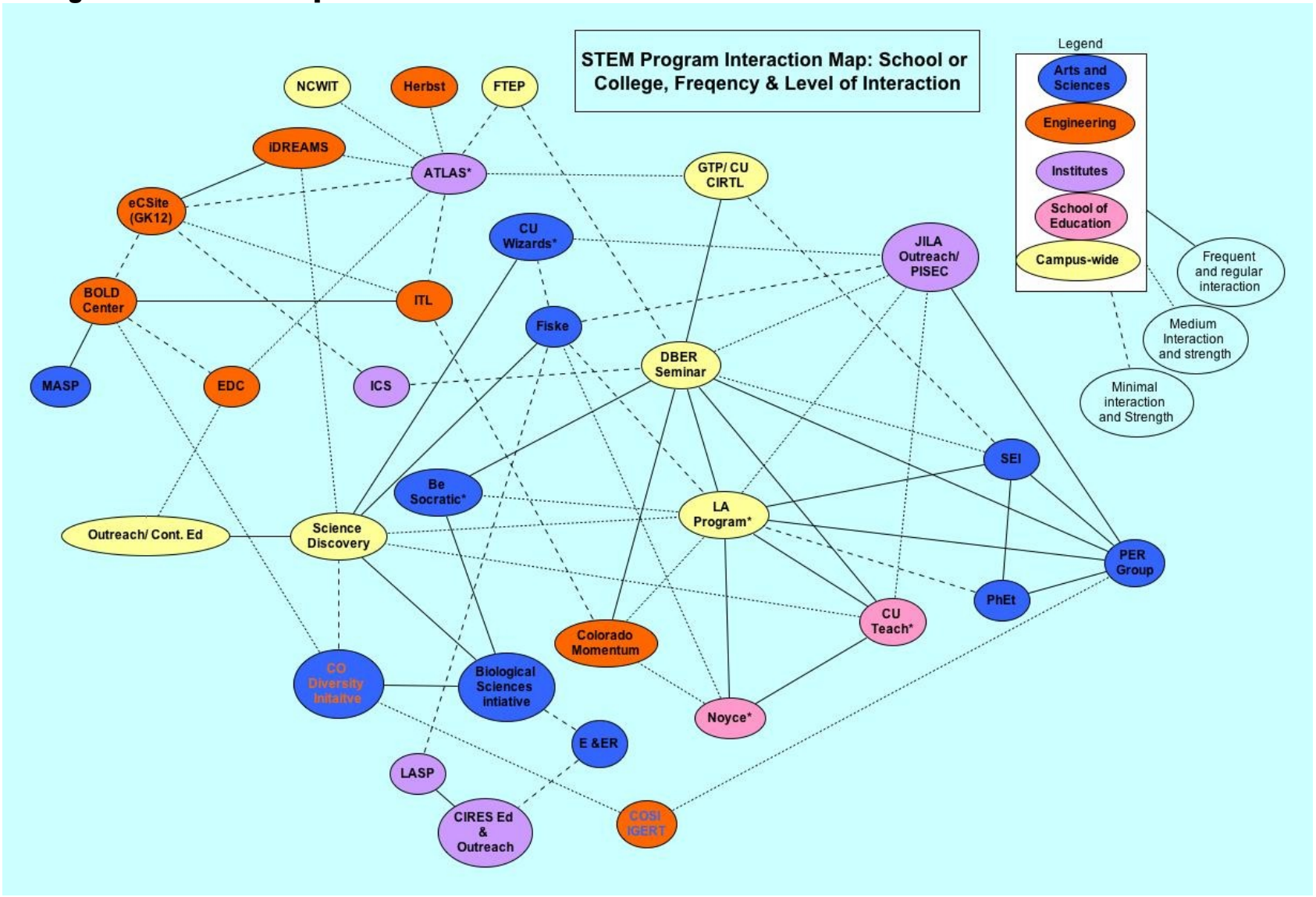
7.I. STEM Program Interaction Map

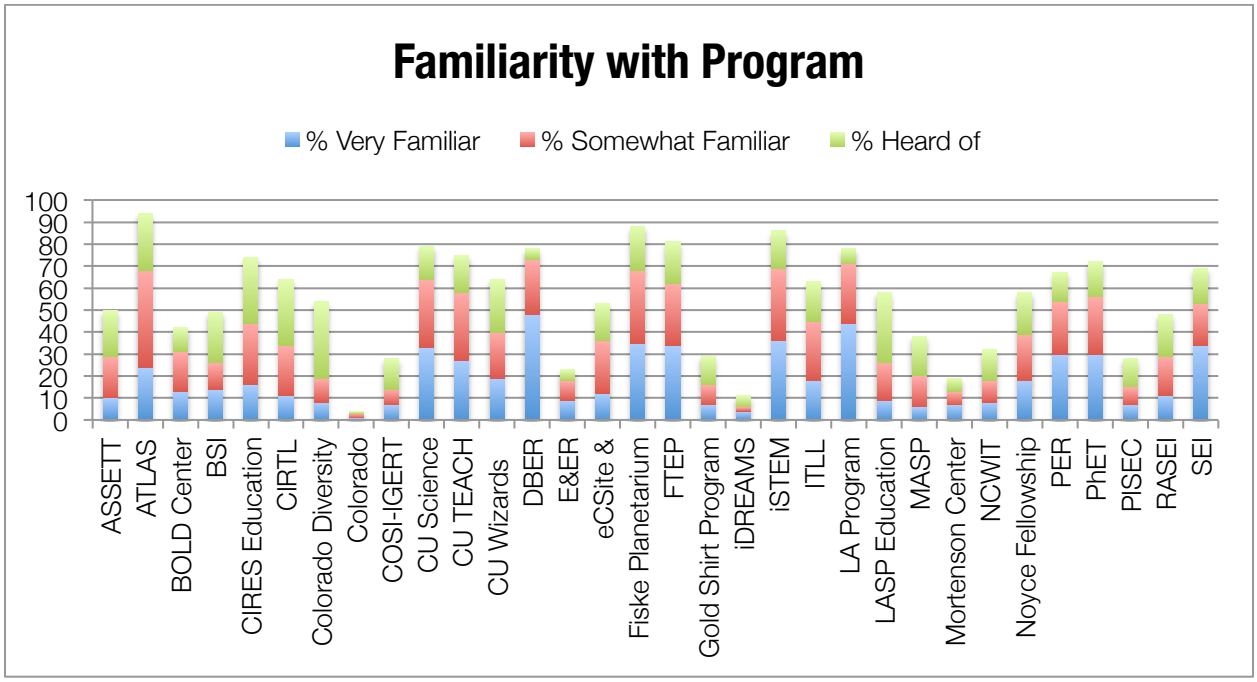


7.J. 2011 Survey Analysis

This analysis of the 2011 ISTEM Survey examine where the 135 respondents are now, compare the responses of the 22 people who also filled out both the last survey and this year's survey, and look at what respondents preferences are for foci of a new STEM education center. It incorporates suggestions made by external evaluator, Rachel Scherr.

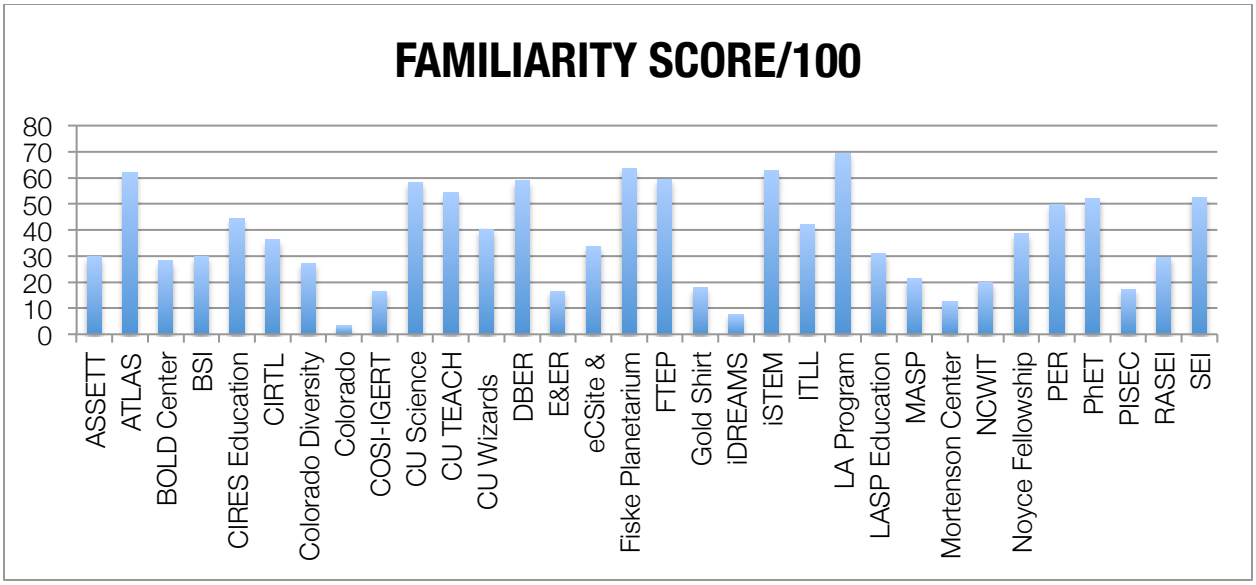
Familiarity with Program

We start by looking at Familiarity with STEM Programs at CU. In this chart we see the percent of respondents who are familiar with each of the STEM programs. We can see that for some programs like ATLAS, a lot of people are familiar to some degree but not many are very familiar. Other programs, like DBER, have a large percentage of those who are familiar being very familiar.



Strength of Familiarity

In this chart we see can get a picture of the strength of familiarity by weighting individuals who are familiar by how familiar they are.



NOTES:

- Program familiarity scores weighted by strength of response, and normalized to 100 with the following scale:
  - Very Familiar = 100
  - Heard of = 33
  - Somewhat Familiar = 67
  - Never Heard of = 0

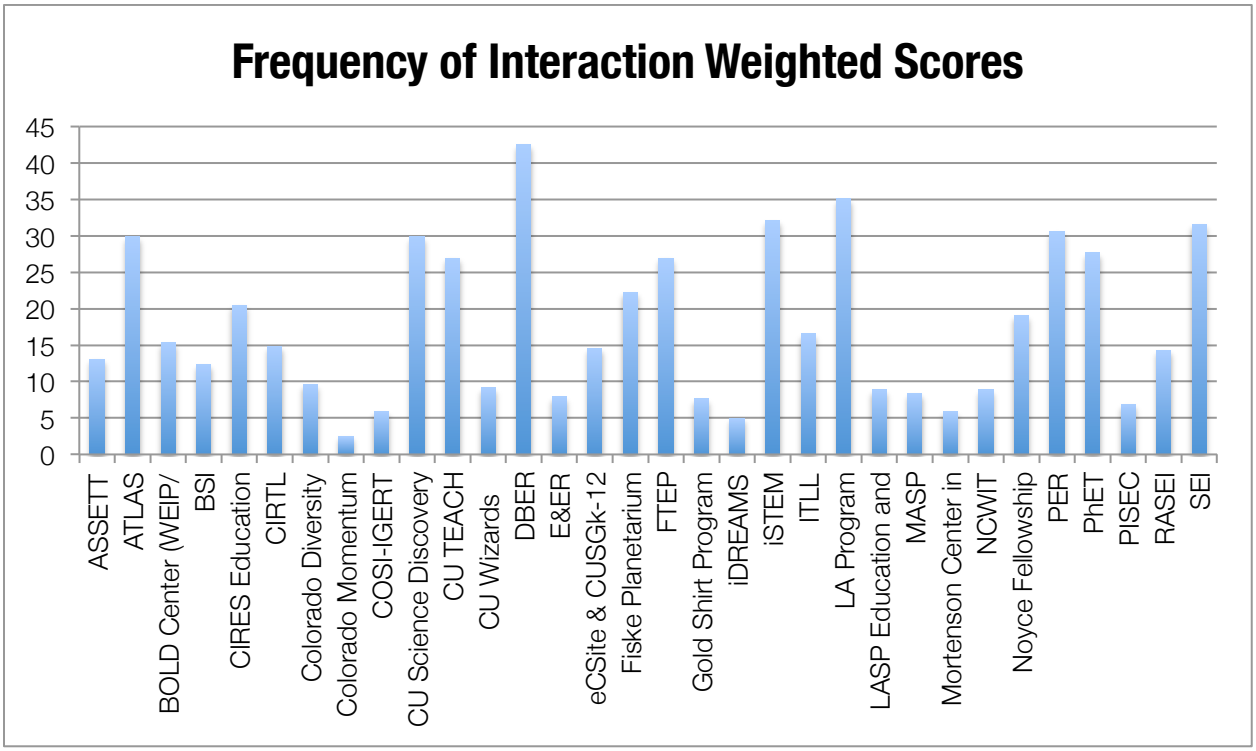
From these scores we can divide programs into three levels of familiarity.

HIGH (score >50)	**MEDIUM** (50>score>30)	**LOW** (30>score)
ATLAS	ASSETT	BOLD
CU Science Discovery	CIRES Education Outreach	CU Diversity Initiative
CU Teach	CIRTL	CU Momentum
DBER	CU Wizards	COSI-IGERT
Fiske Planetarium	eCSite & CUSGk-12	E&ER
LA Program	ITLL	Gold Shirt
PER	LASP Education and	IDREAM
Phet	Outreach Program	MASP
SEI	NOYCE Fellowship Program	Mortenson Center in Engineering for Developing Countries
		NCWIT
		PISEC
		RASEI

Familiarity seems to be based on how wide and large an audience the program serves (e.g. Fiske Planetarium serves a broad audience whereas E&ER serves a small, specialized audience) and that program's connections with the STEM education community on campus (e.g. DBER is strongly connected to the STEM education community on campus whereas NCWIT is not.)

Frequency of Interaction

This chart looks at how often people interact with individual programs. Programs with high scores are those where a lot of the people taking the survey are involved with that particular program and/or cross-program interaction is taking place. The high scoring programs include ATLAS, CU Science Discovery, DBER, ISTEM, LA Program, PER and SEI. The cross-program interactions are, perhaps, better illustrated in the following chart.



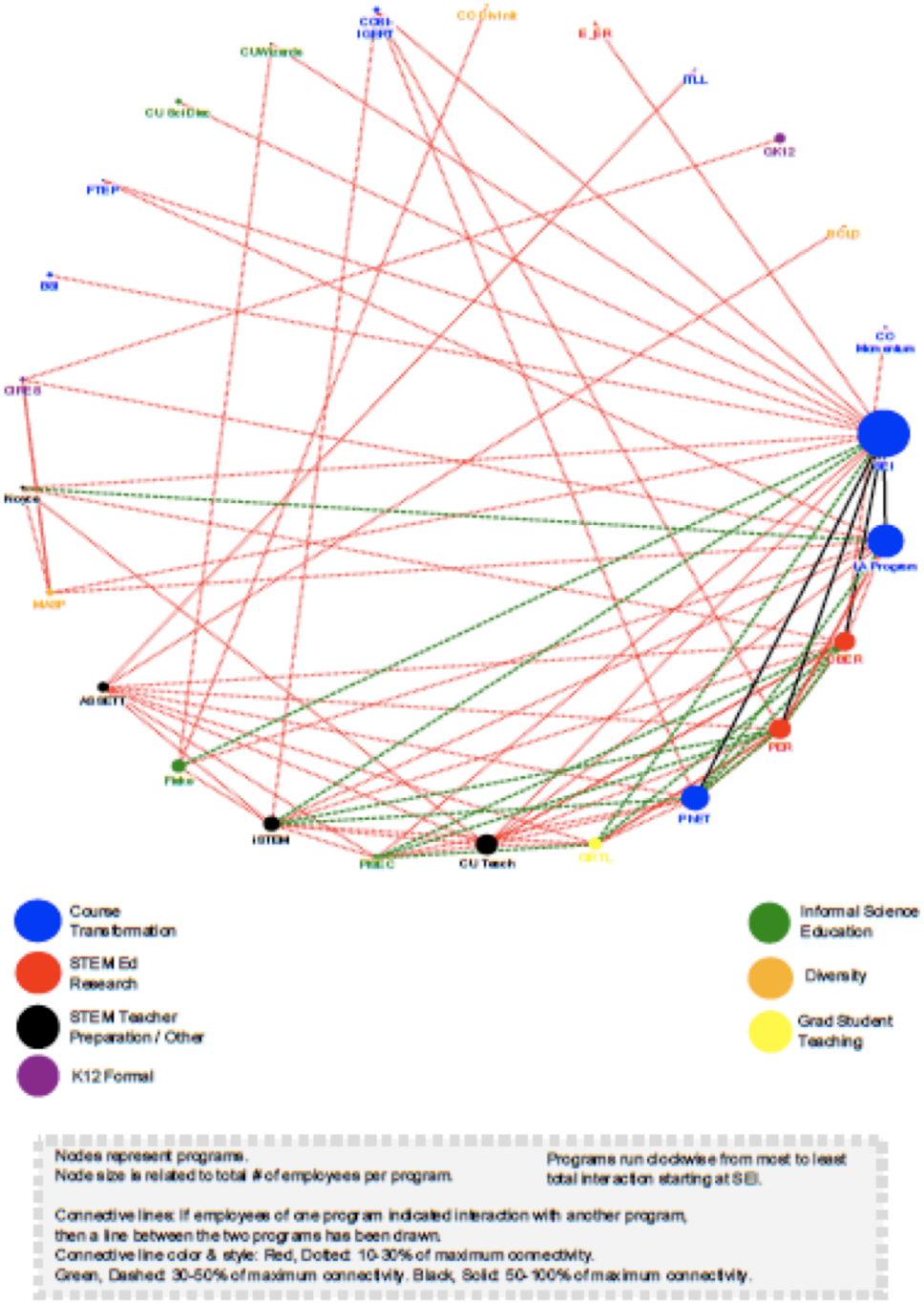
NOTES:

- Frequency of interaction scores measure how many respondents interact with programs and how often they interact. Respondents who do not interact with a particular program are excluded. The scale is normalized as follows:
  - Daily/Weekly = 100
  - Monthly/Quarterly = 67
  - Annually = 33
- Scores are normalized by number of people responding at each level divided by total possible number of respondents.
- In almost all cases, Daily/Weekly interactions with programs represent only staff or faculty working in that program.

Program Connectivity

One of ISTEM primary goals is to increase interaction between programs at CU involved in STEM education efforts. External evaluator, Rachel Scherr, noted that this chart best addresses that area. The connectivity between programs shown here is based on self-reports of frequency of interaction reported by survey respondents that we could identify as being leaders or staff of particular programs. We looked at

frequency of interaction with a particular program from respondents connected to other programs.

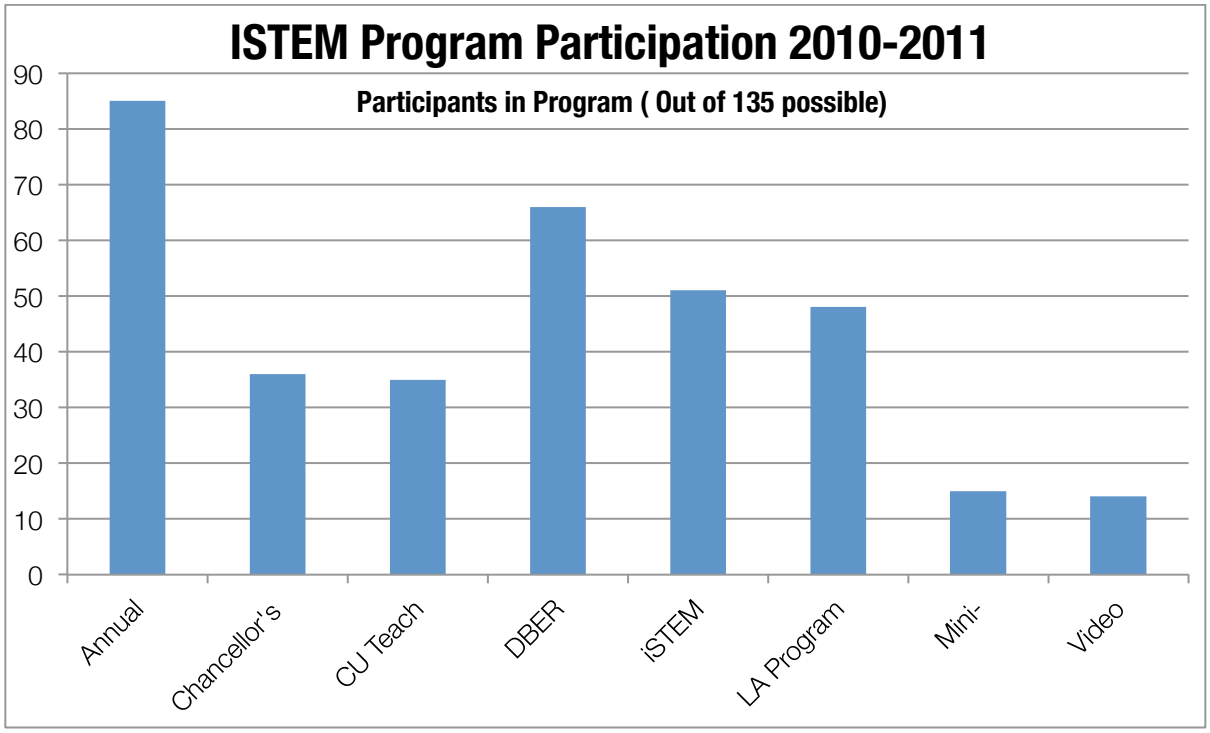


In 2009, a similar analysis was done that also included qualitative data from interviews. In that analysis, DBER, the LA Program and PER emerged as major hubs of interaction. This continues to be true in this survey. However, we also see SEI, and Phet emerging as major hubs of interaction. CIRTL. CU Teach, PISEC, and ISTEM also stand out as strong centers of interaction.

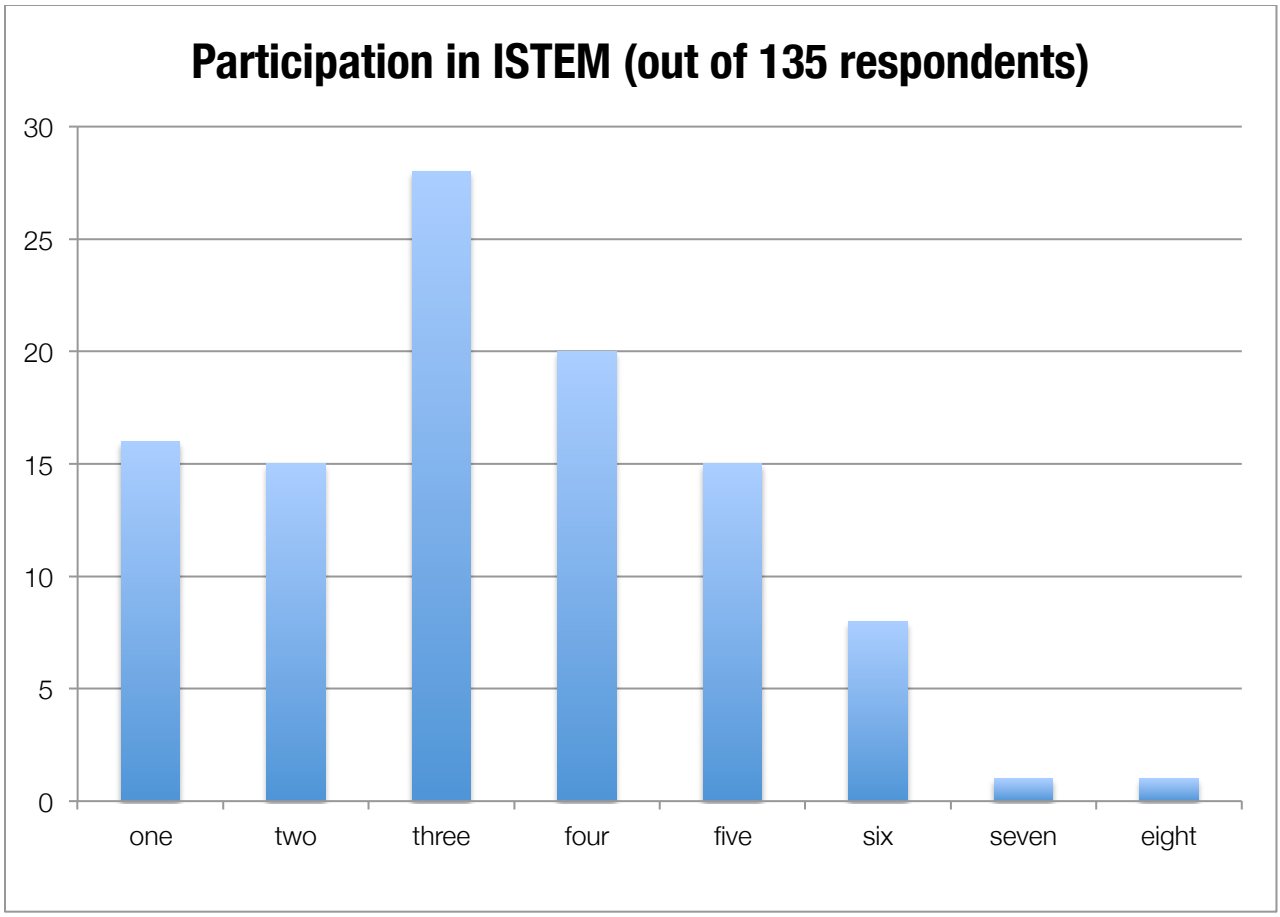
It is interesting to note that the strongest hubs are involved in course transformation and STEM education research followed closely by those involved with STEM teacher preparation. This may be explained by a large of overlap of individuals working in these areas and/or may be an artifact of who responded to the survey. In any case, these programs provide a good base to work from in promoting cross-program interaction.

Program Participation

This chart shows participation in ISTEM programs. It echoes what we saw above in that those programs dealing with STEM education research and STEM teacher preparation are the best attended. Note that the ISTEM website also appears to be well used.



This chart shows number of ISTEM program participation by individual respondents. It indicates that if someone is involved with ISTEM, they tend to be very involved. 75 out of the 135 respondents indicated that they participated in three or more ISTEM events.



NOTES:

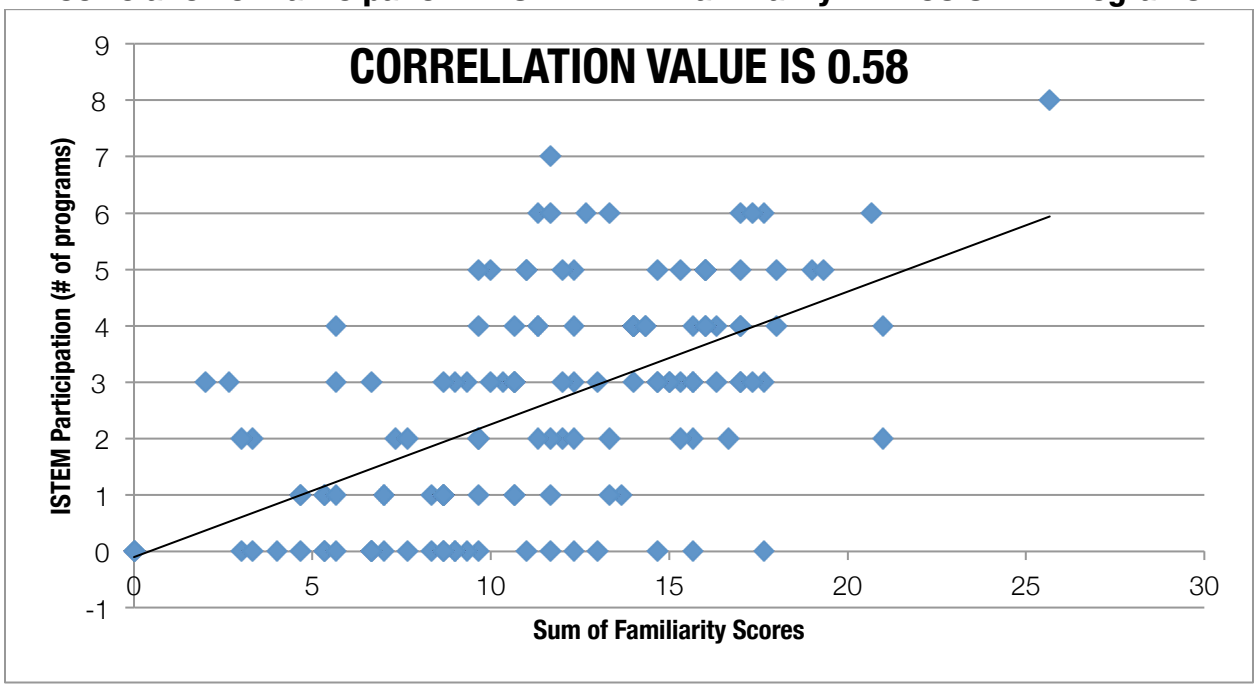
- 73 out of 135 respondents attended 3 or more ISTEM programs

Additional analysis showing overlap of participation in ISTEM events was suggested by Rachel Scherr. That analysis would help answer questions like, “Is there a high overlap of participants in CU Teach and the LA Program?” or “What other programs are participants in the mini-symposiums involved in?” Such analysis may be possible but the efforts involved in producing it is unclear.

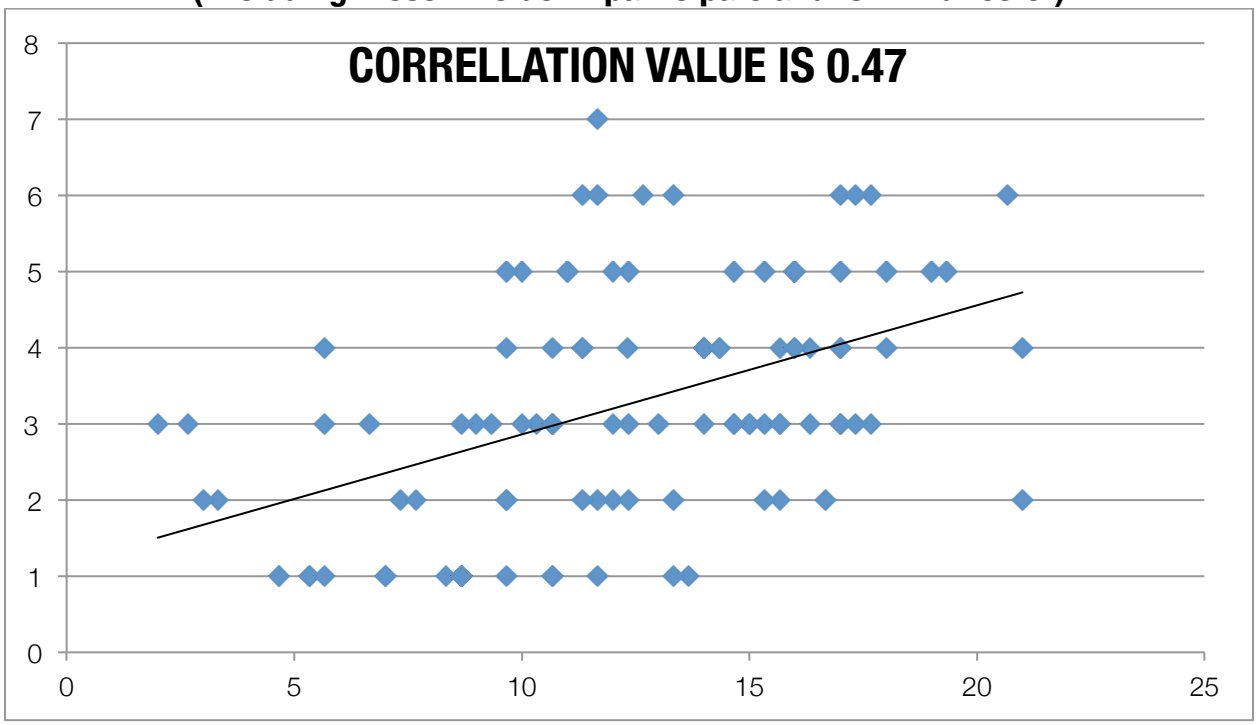
Correlation of Participation in ISTEM with Familiarity with CU STEM Programs

We asked the question of whether there was any correlation between participation in ISTEM and individuals familiarity with CU STEM programs. Chart 7 seems to indicate a significant strong correlation with a correlation coefficient well above 0.5. However this coefficient is strongly affected by outliers and the large number of respondents with no participation in ISTEM. In Chart 8, we removed these values and the correlation coefficient dropped to 0.47. This value and the large scatter in the data indicate some significant level of correlation but not a high one. It will be interesting to keep an eye on this over time as one would hope that participation in ISTEM would build increased familiarity with CU STEM programs, for example, through the poster sessions at the Annual Symposium.

Correlation of Participation in ISTEM with Familiarity with CU STEM Programs



Correlation of Participation in ISTEM with Familiarity with CU STEM Programs (Excluding those who don't participate and ISTEM director)

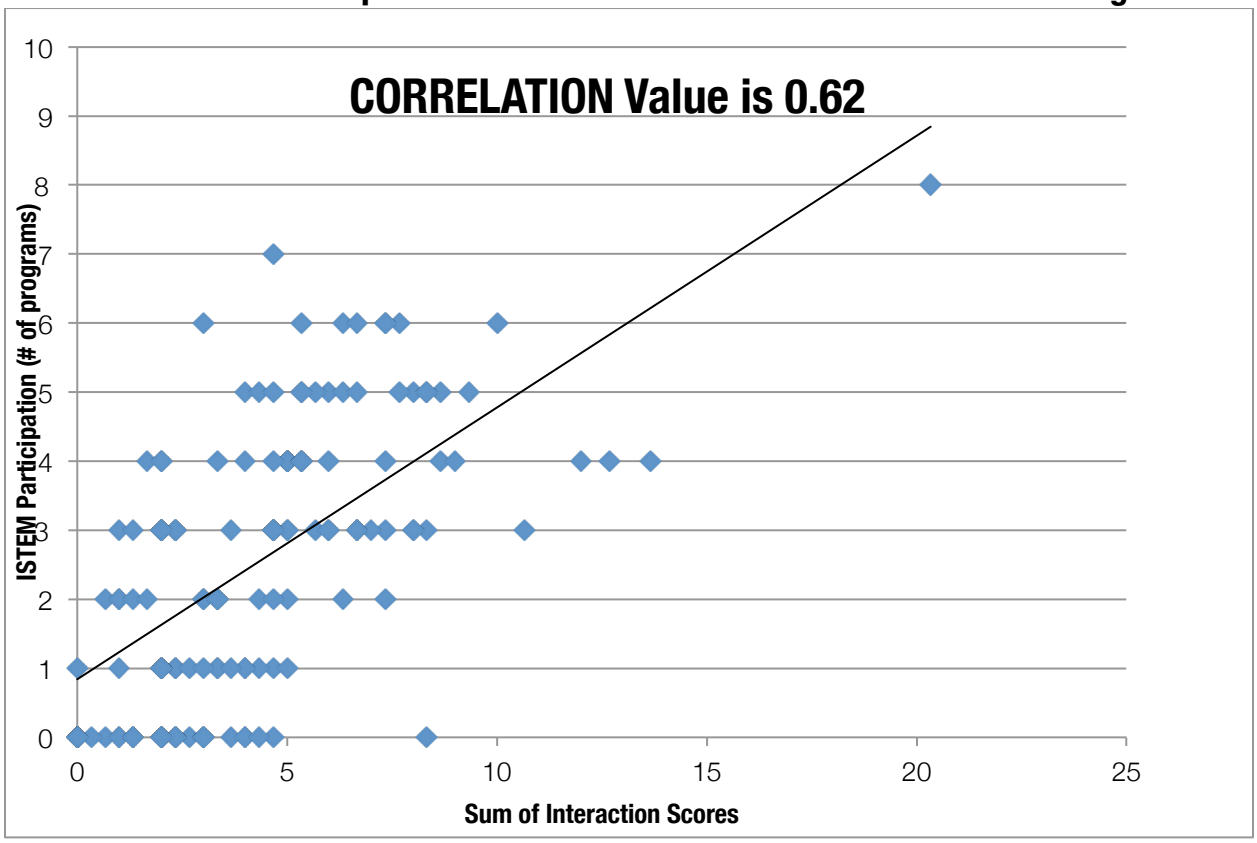


Correlation of Participation in ISTEM with Interaction with CU STEM Programs

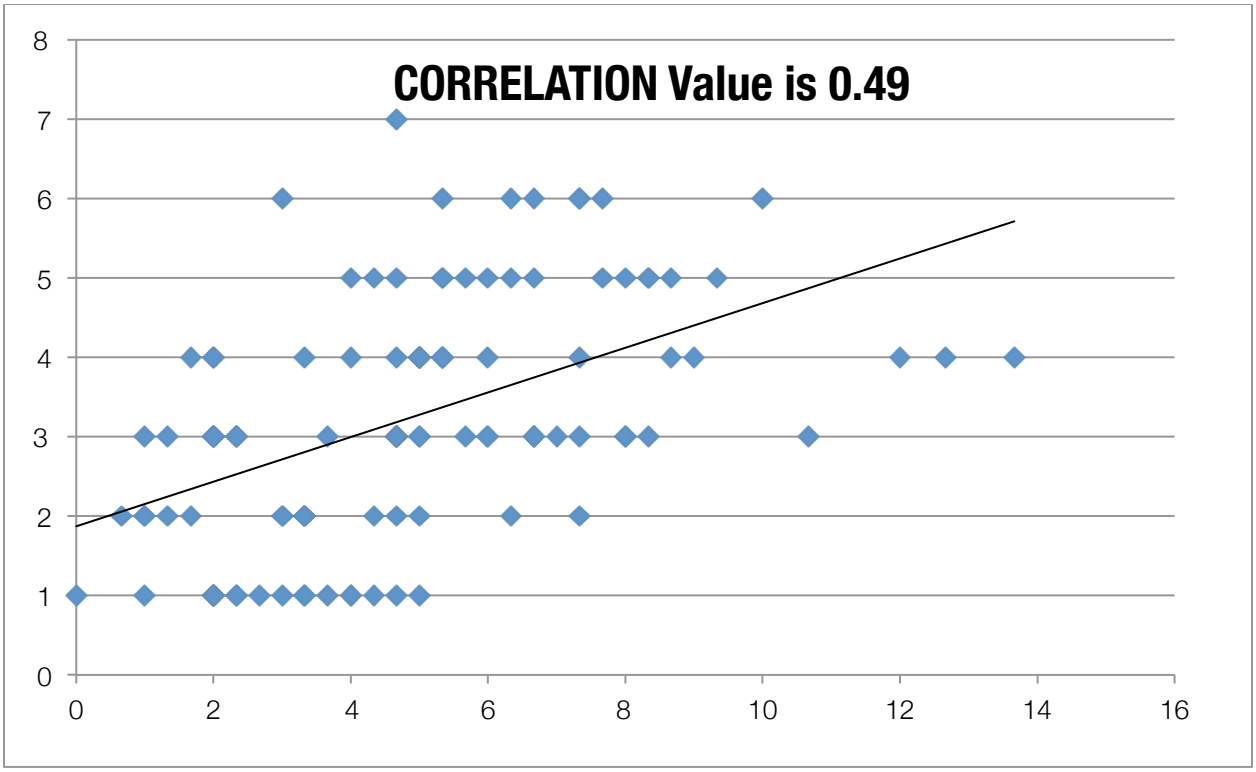
A similar analysis was done around the correlation between participation in ISTEM and individuals interaction with CU STEM programs. Chart 9 seems to indicate a strong

correlation with a correlation coefficient of 0.62. In Chart 10, we again remove the outlier and those with no ISTEM participation. The correlation coefficient goes down to 0.49, still significant but not nearly as strong. Once again, this correlation seems to be a valuable measure to track in future ISTEM surveys.

Correlation of Participation in ISTEM with Interaction with CU STEM Programs

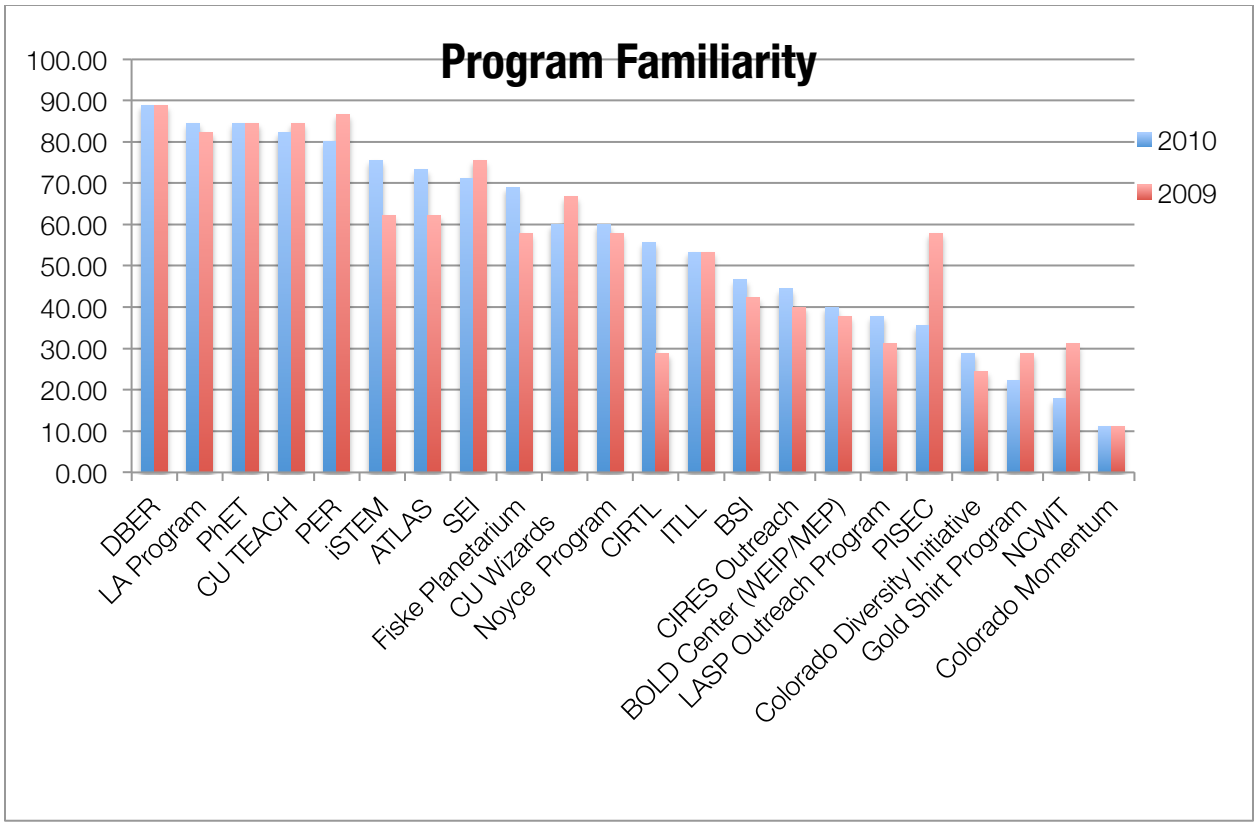


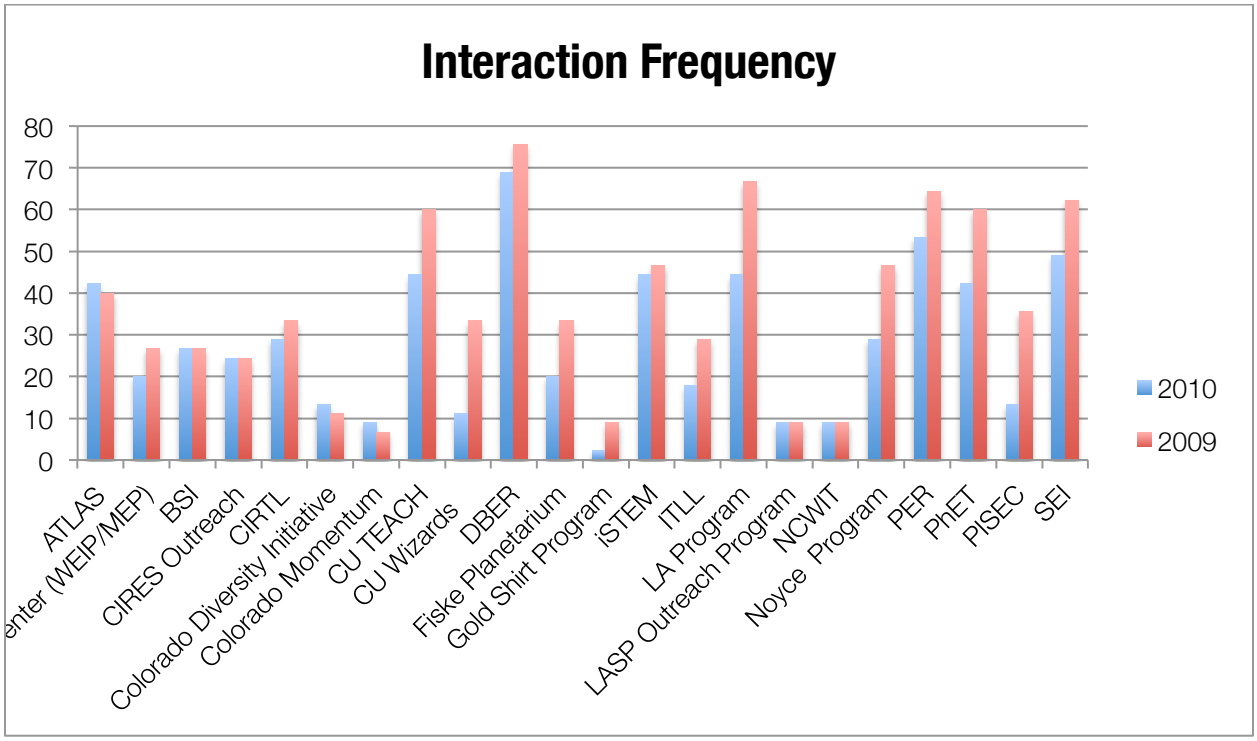
Correlation of Participation in ISTEM with Interaction with CU STEM Programs (Excluding those who don't participate and ISTEM director)



Comparisons with 2009 Survey Data

There were 22 people who responded both to the 2009 survey and the present survey. In 2009 the survey respondents were all program directors or managers, many who had been closely involved with CU STEM programs before ISTEM started. These two charts show very little change in either program familiarity or interaction frequency for this sample population between 2009 and the present. If anything, the average interaction frequency seems to have dropped a bit.





The comparison was complicated by a change in the response categories between the two years. With a broader survey population and more consistent response categories,

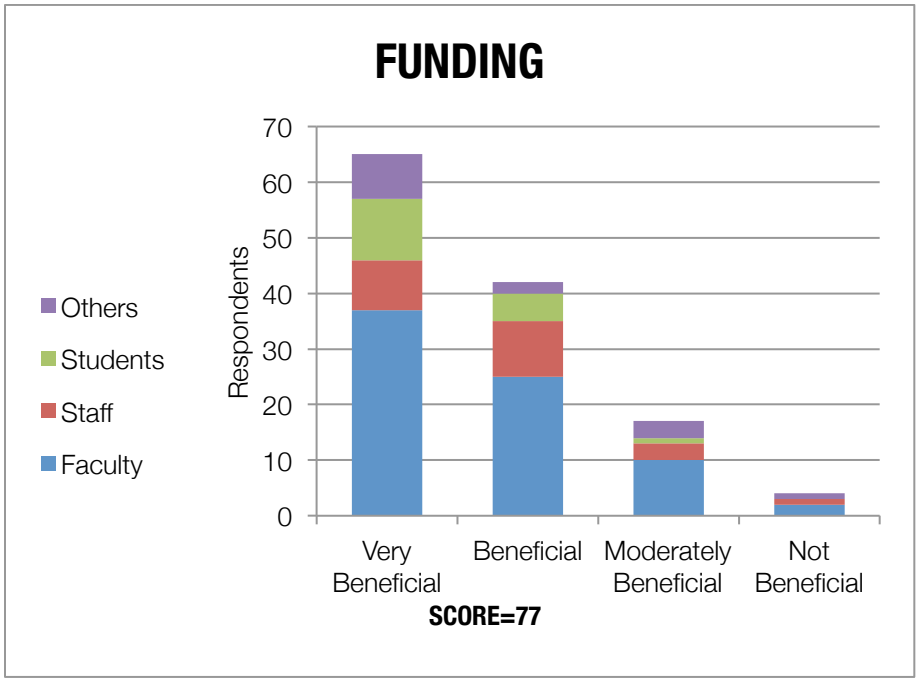
a comparison between this year's responses and future survey responses may yield different results.

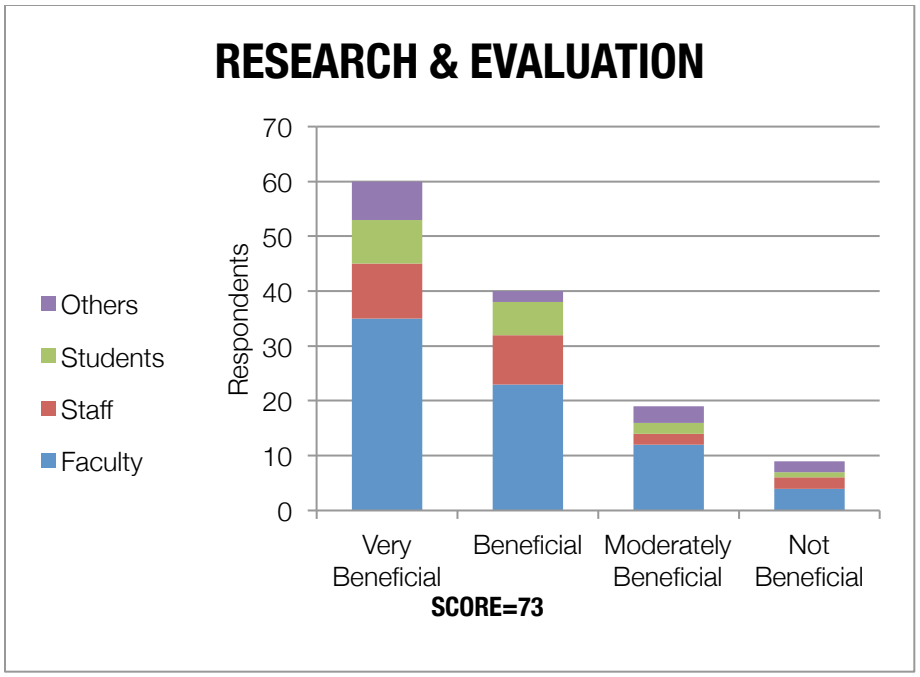
iSTEM Center Priorities

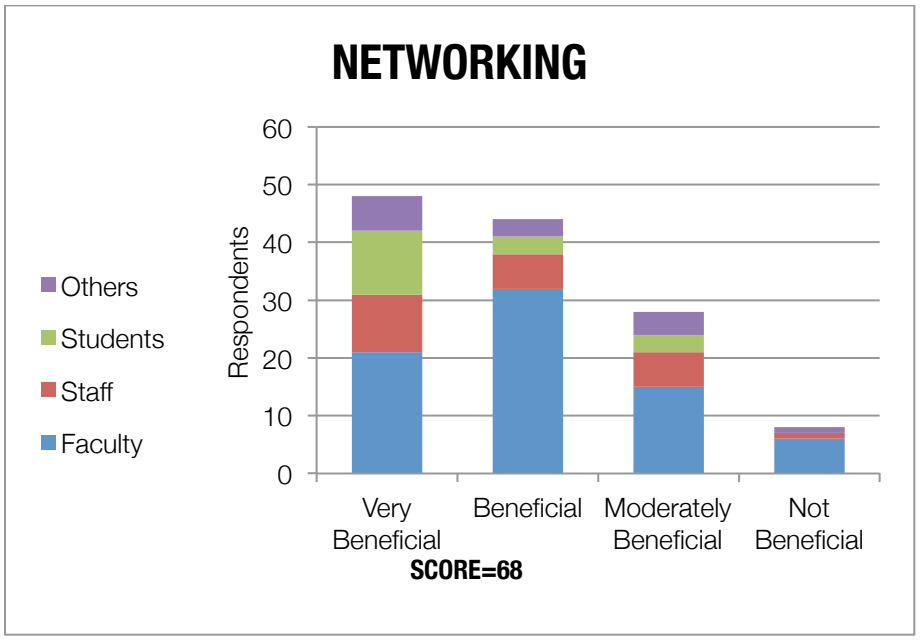
In these charts we can see the result of respondents preferences for what an ISTEM Center might provide. The three areas with highest preference scores were those of funding, research and evaluation and networking. Programming and policy were mid-range preferences. Communication and technical and administrative support were the lowest priority.

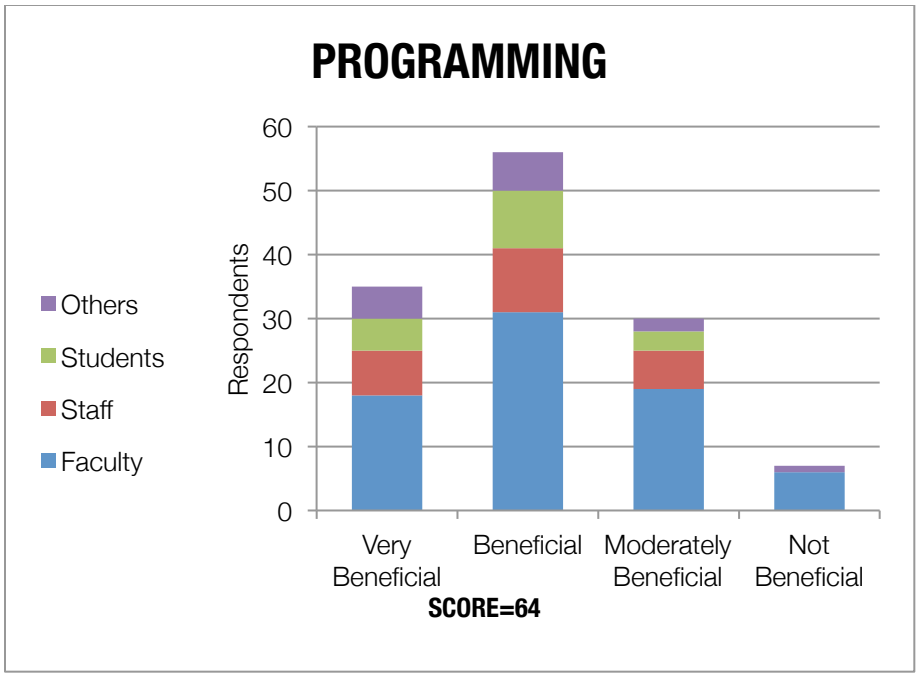
It is not surprising that funding is a high priority as programs in this arena are chronically struggling for funds. In the 2009 evaluation interviews, many people also said that they lacked sufficient resources and expertise to do adequate research and evaluation for their programs so the high score there is also expected. It is gratifying to see that respondents value the networking function that a center could serve as that is one of the primary purposes of the ISTEM program. On the other hand, it is surprising that communication was rated so low since the ISTEM website is well used and communication and networking are closely connected. Perhaps people feel that there are already adequate communication resources on campus.

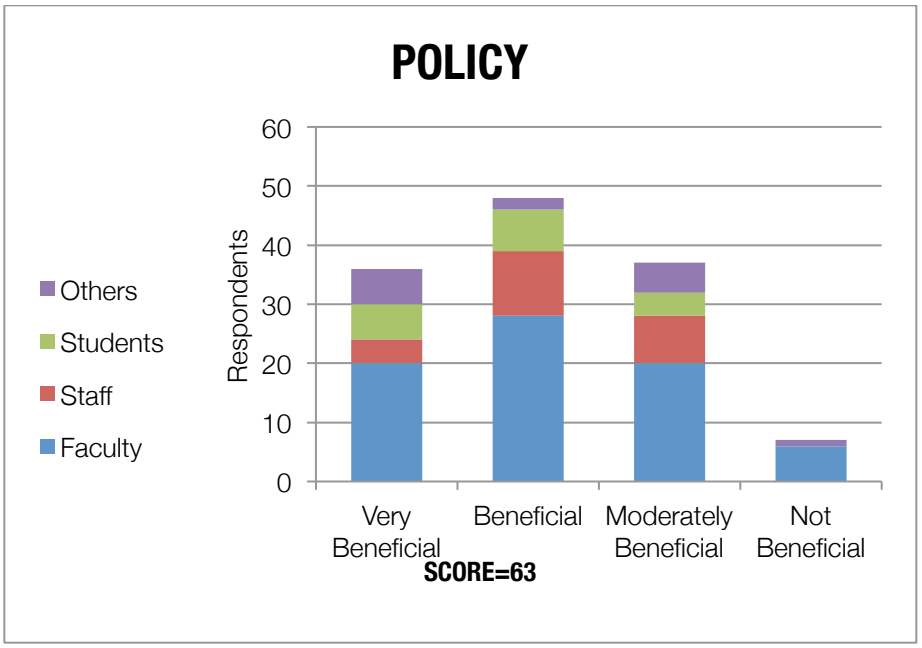
Rachel Scherr suggested that we do not need to pay close attention to this part of the survey, since the ISTEM priorities may be different than what people think that they need and that people may not recognize certain center elements as valuable until they experience them.

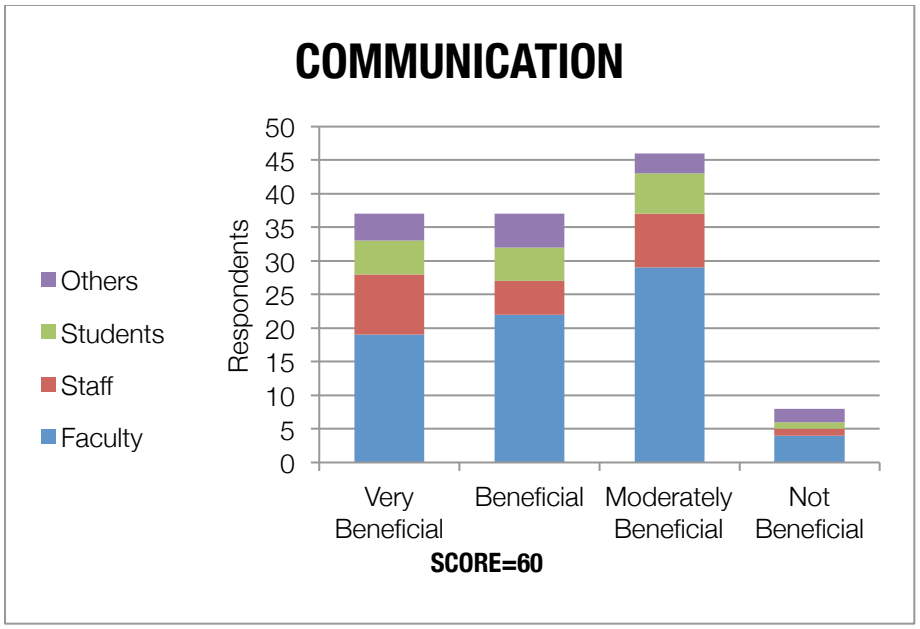


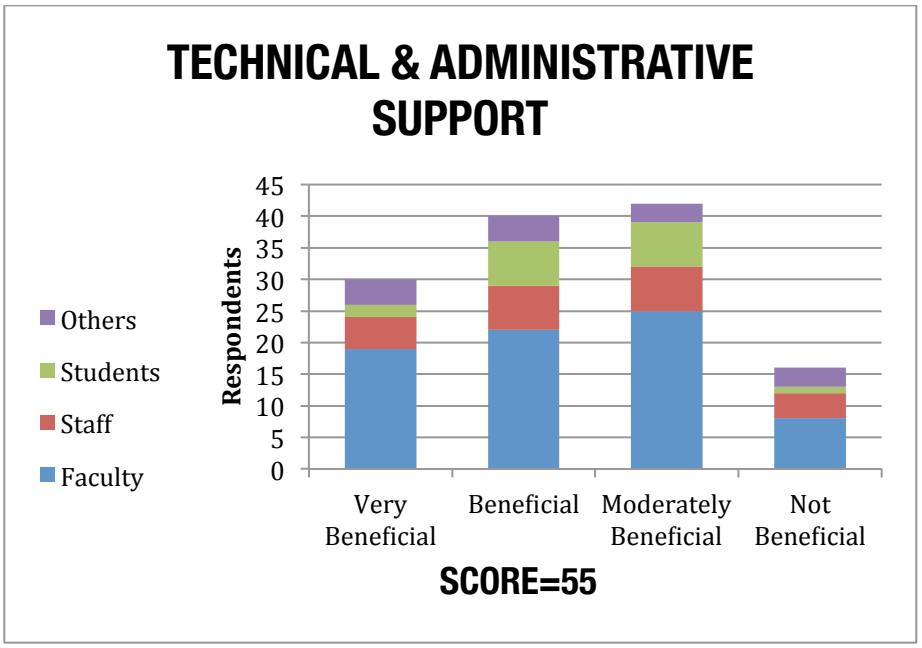

RESEARCH & EVALUATION
Others
Students
Staff
Faculty
Respondents
70
60
50
40
30
20
10
0
Very Beneficial
Beneficial
Moderately Beneficial
Not Beneficial
SCORE=73


NETWORKING
Others
Students
Staff
Faculty
Respondents
60
50
40
30
20
10
0
Very Beneficial
Beneficial
Moderately Beneficial
Not Beneficial
SCORE=68


PROGRAMMING
Others
Students
Staff
Faculty
Respondents
60
50
40
30
20
10
0
Very Beneficial
Beneficial
Moderately Beneficial
Not Beneficial
SCORE=64


POLICY
Others
Students
Staff
Faculty
Respondents
60
50
40
30
20
10
0
Very Beneficial
Beneficial
Moderately Beneficial
Not Beneficial
SCORE=63





NOTES:

- Scores are based on a normalized scale:
  - Very Beneficial = 100
  - Beneficial = 67
  - Moderately Beneficial = 33
  - Not Beneficial = 0

CONCLUSIONS

Overall, this survey indicates a robust STEM education community on the CU campus. Many of the programs are widely familiar and there is a reasonable amount of interaction, particularly, between major programs.

ISTEM has become an important part of this community with broad participation by many in multiple ISTEM activities and some preliminary indication of correlation between ISTEM participation and familiarity with and participation in the STEM education community.

Although we did not see any growth in familiarity or interaction frequency from 2009 to the present this does not indicate that there was no growth. Problems with the selection of sample population and differences between questions in the two surveys make it difficult to come to any solid conclusions based on these surveys. With this year's survey serving as a new baseline, future comparison may yield clearer results.

Finally, the questions about elements of an ISTEM Center on their face point out some differences in priorities. However, overall, they indicate a strong feeling on the part of respondents that a Center that had many of these elements would be of great benefit to their program.