

## YEAR 2: I<sup>3</sup> TOWARDS AN INSTITUTE FOR STEM EDUCATION

In the second year of this project (2009-2010) major strides were made toward realizing the goals of the endeavor, supporting institutional innovation through integration. Key successes include creating mission and vision statements for a center; producing a very successful initial stakeholders reception and an accompanying campus-wide inaugural symposium; continuing and expanding the weekly Discipline Based Education Research (DBER) seminar; a visit to the White House in honor of the university's commitment to STEM education by PI, Chancellor Philip DiStefano; engaging in major campus fundraising initiatives; and making striking progress toward becoming an official University of Colorado center, far ahead of the targeted date. These and other works of this project will be described in more detail in this report.

### 1. PROJECT OBJECTIVES (FIVE YEAR):

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I<sup>3</sup> at the University of Colorado at Boulder works primarily to integrate three existing lines of work supported by the NSF: (1) course transformation, particularly at the undergraduate and graduate levels, (2) undergraduate and graduate teacher preparation, 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 I<sup>3</sup> effort builds upon efforts to integrate programs by building a *distributed* center of STEM education research and transformation. This center for STEM education 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 I<sup>3</sup> 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, which integrates multiple efforts in STEM education.

To better establish an identity and to define the goals of a Center more clearly, the NSF I<sup>3</sup> supported program has created the working name of iSTEM (Integrating STEM Education) and developed both mission and vision statements. They are:

**MISSION:** To build an infrastructure of institutional support in order to promote STEM education reform through course transformation, discipline-based education research, and teacher recruitment and professional development.

**VISION:** We facilitate change in STEM education by integrating an interdisciplinary community of scholars, promoting and sustaining existing reform efforts, sponsoring new programs, advocating for diversity and access, influencing relevant policy, and fundraising. We are building a Center for STEM Education at CU-Boulder.

#### 1.1. INTEGRATING, SUPPORTING, AND RUNNING PROGRAMS

##### 1.1.1. SYMPOSIA

Initial efforts have linked over 25 programs through discussions and a needs assessment in connection with an initial baseline evaluation (see section 7.1.). Program links were added and

strengthened through participation in the First Annual Symposium and the associated reception for stakeholders.

Planning for the Stakeholders Reception and the First Annual Symposium began in year one of this grant. These events were held on August 30 and 31, 2009 and were a tremendous success. The Stakeholders Reception had 47 attendees, including several University of Colorado regents, a representative from the Colorado State Legislature, members of the Colorado Department of Education, four high-level university administrators, and three Nobel laureates. Following this evening reception was a half-day symposium, which was aimed at people involved in STEM education programs on campus. The Symposium had 107 participants, including six high-level university administrators and 28 faculty (among whom were two Nobel laureates and several members of the National Academies). The program began with a keynote address from the provost and followed with a poster session that supported networking among constituent programs.

Both events raised awareness of the iSTEM effort and of all of the work going on at the university in STEM education. They gave participants a chance to meet and get to know each other better and helped in the formation of networks that will be ongoing. The Stakeholders Reception generated a number of invitations to the iSTEM team. For example, Valerie Otero was invited to tour Colorado with the chancellor and two of the directors of iSTEM were invited to present to the regents of the University of Colorado at their June 2010 meeting. Suggestions from participants at the symposium have led to plans for focused mini-symposia described in more detail later in this report.

Plans are under way for the Second Annual Symposium. It will be a half-day event and will showcase existing STEM Education efforts through an interactive poster session. We hope to host a nationally leading keynote speaker. We anticipate bringing in key stakeholders in STEM education from CU Boulder, the surrounding community, the state legislature, businesses, national labs, and other groups. Based on the success of the inaugural symposium, we expect a strong turnout.

In addition, participants in the First Annual Symposium suggested holding smaller, more focused gatherings for people working on related topics. In response, we are initiating a series of mini-symposia. Plans are under way for the first of these. Scheduled in early September 2010, this will be a half-day event for CU Boulder programs involved in K12 STEM teacher professional development. We also plan to organize mini-symposia in the areas of research on undergraduate STEM teaching and learning, informal STEM education and community partnerships, and the Learning Assistant Model during the 2010-2011 academic year.

#### **1.1.2.DBER**

In year two, the Discipline Based Education Research (DBER) seminars built on the success of year one and expanded to hold 36 seminars. DBER brought together faculty and graduate students from over 14 disciplinary departments and three Schools. Attendance averaged 22 people. 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 MIT, Arizona State University, and the University of Texas in Austin. A complete calendar of DBER meetings, presenters, and topics can be found at: <http://www.colorado.edu/ScienceEducation/>.

#### **1.1.3.LA MODEL**

The Colorado Learning Assistant (LA) Model is a flagship program of the iSTEM initiative. The LA program embodies the tripartite mission of course transformation, educational research, and teacher recruitment and preparation. With the support of iSTEM / I<sup>3</sup>, the LA program has grown to include 80 undergraduate appointments per semester, spanning nine different departments. We continue to collect data, documenting the positive impact of LA-supported courses, which feature interactive, research-based practices. We are in the midst of transitioning the LA-program to internal support, rather than grant-funded support. Currently, departments, deans, and the provost all contribute to the LA program. The LA-program is also currently poised to expand into the engineering school.

#### 1.1.4.PER@C

iSTEM also continues to support the Physics Education Research Group at Colorado (PER@C), which is one of the newest and largest research programs in PER 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, 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.

#### 1.1.5.CHANCELLOR'S AWARDS FOR EXCELLENCE IN STEM EDUCATION

An iSTEM award program, the Chancellor's Awards for Excellence in STEM Education, provides funding to faculty and graduate students who excel in discipline-based education research and/ or promoting education within their department through course transformation. This program has supported and stimulated a flowering of STEM education research on at CU Boulder.

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

In the first year of this program (2009-2010) four faculty were funded. Their projects were:

*Video Resources for Lower Division Computer Science Curriculum*

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

*Teaching and Learning Biology at CU: Course Evaluation and Revision Project*

*Development of Pre-Post Tests for Upper Division Electricity and Magnetism Tutorials*

In addition to materials used in courses at CU Boulder this support resulted in:

- Conference Presentations:
  - Furtak, EM. (2009). Toward learning progressions as teacher development tools. Paper presented at the learning progressions in science conference, Iowa City, IA.
  - Furtak, EM, Roberts, S, Morrison, D, Henson, K & Malone, S. (2010). Linking an educative learning progression to teacher practice: results of an exploratory study. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.
  - Furtak, e.m. (2010). Transforming the teaching of natural selection through a professional learning community. Paper presented at the modern biology goes to school symposium, Zurich, Switzerland.

- Organized and chaired a session at the NARST conference, held in March 2010 on “Exploring the Utility of Discipline-Specific Pedagogy Courses in Science Teacher Recruitment and Preparation.”
- An invited talk to be given at the 2010 American Association of Physics Teachers conference
- Publications
  - A manuscript that describes the course and our findings about student access to educational research careers is currently in preparation to be submitted to a journal such as Science or The American Biology Teacher
  - A paper to be submitted (summer 2010) to the Physics Education Research Conference on student learning difficulties in E&M
- The generation of a dozen online activities, implemented through the University of Washington's Catalyst system, available online at: <http://per.colorado.edu/cts>.

Their projects, currently in progress, are:

*Development of a Capstone Concept Assessment to measure integrated content retention in biology*

*Variation in Working Memory and the Optimal Design of STEM Labs*

*Learning Goals and Course Materials for Advanced Undergraduate Physics Laboratories*

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

Chancellor's Awards for Excellence in STEM Education for graduate students provide half-time (25%) graduate research fellowships for up to one academic year (or summer). They are available to support discipline-based STEM education research and educational transformation. Funds are meant to provide a match to funds from other sources. Preference is given to proposals involving PhD-level STEM education research within with the College of Arts and Sciences and Engineering.

In the first year of this program (2009-2010) seven awards funded eight graduate students. Their projects were:

- Reforming Undergraduate Biology Teaching Through Formative Assessment: Distractor-Driven Multiple Choice Items as Instructional Tools
- Undergraduate Climate Change Curriculum Development and Validation
- Longitudinal Study of the Implementation and Impact of LAs on Teaching and Learning in Undergraduate Mathematics
- Tablet Teaching Pilot Program
- Understanding Students' Difficulties with Cosmology
- A mixed-methodology study of the origins and impacts of the gender gap in college physics
- An examination of conceptions of teaching and learning physics in graduate TAs and undergraduate LAs

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  - Furtak, e.m. (2010). Transforming the teaching of natural selection through a professional learning community. Paper presented at the modern biology goes to school symposium, Zurich, Switzerland.

- B. Spike and N Finkelstein, "Eliciting Beliefs of Recitation Instructors Through Video Commentary," 2010 Summer Meeting AAPT: Portland, OR, Jul 2010.
- Poster Presentations
  - Students' reasoning difficulties with cosmology, C. S. Wallace, E. E. Prather, D. Duncan, & CATS, Cosmos in the Classroom 2010: A Hands-on Symposium on Teaching Astronomy to Non-science Majors, Boulder, CO, August 2-4, 2010.
  - Students' reasoning difficulties with cosmology, C. S. Wallace, E. E. Prather, D. Duncan, & CATS, 215th Meeting of the American Astronomical Society, Washington, DC, January 5, 2010.
- Publications
  - Submitted to the *Physical Review Special Topics: Physics Education Research* journal; the paper is currently in review

In the second year of the Chancellor's Awards for Excellence in STEM Education, three graduate students were funded. Their projects, currently in progress, are:

*Undergraduate Students' Climate Change Conceptions*

*Understanding Students' Difficulties with Cosmology*

*What Works in Undergraduate Physics Education? A Research Synthesis*

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

Based on the success and interest in the Chancellor's Awards, we will be offering a second round of funding to begin January 2011.

## 1. DIVERSITY AND ACCESS

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iSTEM has three major areas of focus (educational transformation, educational research, and professional development). Cutting across each of these thrusts are efforts in policy, media / advocacy/ fundraising, and diversity & access. Efforts directed at diversity / access that coordinate across and supplement existing programs on campus that partner with or are supported by iSTEM / I<sup>3</sup>, include:

- Newly formed Office of Diversity Equity and Community Engagement (ODECE): CU Boulder has established a new vice chancellor-level position focusing on diversity and access. The iSTEM directors are the STEM education consultants to this office. More information is available at <http://www.colorado.edu/odece/>. Recently, NSF I<sup>3</sup> PI's partnered with ODECE directors on an NSF proposal to increase STEM scholarships.
- The Colorado Diversity Initiative (CDI), which works to improve diversity and access in STEM, is a strong collaborator with the iSTEM effort, particularly for undergraduate and graduate scholarships. More information is available at <http://www.colorado.edu/GraduateSchool/DiversityInitiative/>.
- Partnerships in Informal Science Education in the Community (PISEC) is an out-of-school program that simultaneously supports the development of children and of undergraduate and graduate students at CU Boulder. More information is available at <http://spot.colorado.edu/~mayhew/PISEC/index.htm>.
- Partnerships with MESA / Colorado MESA: the PISEC director, who is partially supported by iSTEM, serves on the St. Vrain MESA (Math Engineering Science Achievement) executive board. Finkelstein (co-PI) was recently asked to serve on the state board of MESA, which focuses on K12 access and diversity in STEM.

- Minority Bridge Program in physics: 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).
- The STEMS Seminar is a grassroots student movement to support underrepresented minorities in STEM with community and scholarship. Student seminars are run by and for students and are attended by 25-35 students per week.
- Each year CU Boulder sends a delegation of 10 students to the joint annual meetings of the National Society of Black Physicists and Hispanic Physicists and uses them as a focal point for discussion and support of diversity and access. The STEMS seminar grew from this community.
- S-STEM proposal for Community Neighborhoods: Building on the success of physics, the Director of the CDI and the vice chancellor from ODECE, and Co-PI Finkelstein submitted the NSF S-STEM proposal described above. The grant was not funded but we anticipate resubmitting.

Through the Chancellor's Awards for Excellence in STEM Education, iSTEM is supporting a faculty member from the College of Engineering & Applied Sciences' program Assessing YOU'RE@CU: A New Program to Promote Diversity in Engineering. She says of her efforts, "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 lowerclassmen – and particularly target retention of underrepresented minorities and women, encourage undergraduates to seek graduate degrees, and provide mentoring training for graduate students."

## 2. OUTREACH & POLICY WORK

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In January of 2010, Philip DiStefano, PI and CU Boulder chancellor, was one of four public research university leaders invited to an event at the White House to honor and celebrate a commitment to STEM Education. This honor was given in recognition that the University of Colorado at Boulder has doubled the number of STEM majors completing secondary math and science teacher certification compared to five years ago and has more than tripled the number of physics and chemistry majors enrolling in teacher certification programs in the past three years. During the visit to the White House, the CU Boulder joined about 120 other universities in pledging to address the national shortage of science and math teachers.

Increasingly, the iSTEM Directors recognize their roles in policy, and are called upon to participate in policy discussions. As we seek to establish a Center for STEM Education, to promote existing efforts and to nucleate innovative new efforts, we see policy as a key lever in promoting change, both nationally and for Colorado and our region. Recent efforts have largely, but not exhaustively, focused on the national level.

- Following his testimony (February 4, 2010) before the U.S. Congressional House Science and Technology Committee ([http://science.house.gov/Publications/hearings\\_markups\\_details.aspx?NewsID=2723](http://science.house.gov/Publications/hearings_markups_details.aspx?NewsID=2723)), Finkelstein has continued to work with members of the committee and staff in the reauthorization of the America COMPETES Act. In particular, there are five new / renewed components of America COMPETES that we have participated in shaping:
  - Broader impacts requirements from NSF could now take on a more scholarly approach
  - Emphasis on sustaining and scaling educational reforms
  - STEM education research grand challenges

- STEM education research postdocs
- Coordination of federal programs in STEM education
- In a similar vein, the iSTEM directors and staff from CU Boulder's Office of Government Relations have been working with our congressional representative, Jared Polis, and his staff:
  - We hosted Congressman Polis and briefed him on our iSTEM efforts on February 8, 2010.
  - Finkelstein and CU Boulder staff met with Polis's lead educational staffer (Protopsaltis) on April 5th to discuss efforts overall and how these are impacted by and impact the ESEA reauthorization.
- Otero advised two dozen states in their Race to the Top applications (Federal ARRA funds), in the National Governor's Association meeting in Washington DC (December 2009), highlighting the Colorado Learning Assistant Model.
- Project directors (Otero and Finkelstein) serve to advise and present at the Association of Public and Land-grant Universities (APLU) Science and Mathematics Teacher Imperative (SMTI)
- Finally, we are excited about and plan to draw on the expertise of a CU Boulder faculty member who leads many efforts in STEM Education transformation. Professor Carl Wieman will be assuming the associate director post at the Office of Science Technology Policy in the White House.

At the state level we are beginning to make inroads into the policy efforts.

- Four of the six iSTEM directors joined the state committee to apply for federal Race to the Top funds. While the proposal was not funded in the first round, this document does shape state policy in education. We are pleased to have representation (Finkelstein co-chaired the Hard to Staff Subject Areas subcommittee), and see this as an area of continued need and attention at the state.
- We are poised to work with the state legislature in fall 2010. In particular, we are arranging for a meeting with the legislature's Joint Education Committee.

Contributions in this area were also made by the iSTEM directors on various organizations, committees and advisory boards.

- Kotys-Schwartz, D.; Concept Inventory Hub (CiHUB.org) National Review and Evaluation Board
- Stade, E Member, Fall 2009, of the Equitable Distribution of Teachers and Principals in Hard to Staff Subjects Subcommittee of the Great Teachers and Leaders Working Group (Colorado's Race to the Top Competitive Grant Working Groups).
- Stade, E Member of the Committee on Academic Sponsors of the Mathematical Sciences Research Institute (MSRI), Berkeley, CA, 2008--2010. Organizer of the workshop "Preparing Future K12 Math Teachers -- the Role of University Math Departments," held at MSRI March 5, 2010. Also presented at the workshop: title of talk was "Preparing Future K12 Math and Science Teachers -- The Colorado Learning Assistant Model." Gmail - Agenda & a Reminder <https://mail.google.com/mail/?ui=2&ik=6fd477161f&view=pt&se>.
- Stade, E Member of the CU Leadership Team for APLU-SMTI (the Association of Public and Land-Grant Universities' Science and Mathematics Teacher Imperative), August 2009--present.

To address the needs of the community and to represent the Boulder-region to the state, iSTEM directors have led the formation of a Boulder Area STEM Education Coalition (BASEC) to build community (among CU Boulder, industry, national labs, workforce efforts, non-profits, community centers, and others), and represent the region. This organization is an official center of the Colorado STEM Network. BASEC has had three meetings in 2010. Sixty-five people from more than twenty organizations have participated. BASEC has secured funding for office space and salary from Boulder County.

### **3. CENTER FOR STEM EDUCATION**

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iSTEM is making significant progress toward becoming an official CU Boulder center far ahead of the targeted date. By the end of next year we anticipate that a center for STEM education will be established at the University of Colorado. This center may be a stepping-stone towards a full-fledged institute at CU Boulder. As a center, we will have administrative control, operation and representation at CU Boulder. If we opt to become an institute, we can roster faculty and have graduate lines / program. As a Center, our mission and vision are established. The key communities supported by this Center are established. We are currently finalizing the administrative structure and are drafting a center proposal. The directors of iSTEM will serve as the governing board of this center. In August or September of 2010 we anticipate having a stakeholders meeting where we propose and share information about the goals and structure of this new center. One of the issues being addressed is the location of this center. Two leading proposals are to house the center in the Institute for Cognitive Sciences (ICS) or to house it directly in the Graduate School. Each option benefits from being cross-institutional, allowing us to serve constituents from the School of Education, the College of Arts and Sciences, and the College of Engineering and Applied Sciences. ICS is one of the longest standing institutes at CU Boulder and hosts many nationally regarded centers. The Graduate School would potentially provide more freedom and focus more on the efforts to integrate existing efforts that are distributed across campus.

#### ***3.1. BRANDING, PR, AND MEDIA RELATIONS***

We have started to coordinate our efforts in branding, policy, media relations, and fundraising. A recent meeting (April 12, 2010) brought together leading representatives from the offices of University Communications, Photography & Videography, Alumni Relations, Fundraising, Strategy & Branding, and Government Relations. We seek to be one of the major foci of the University's upcoming capital campaign (currently there are two major identified initiatives: bio technology and energy). We have a case-statement on the importance of STEM education for CU Boulder, and established a budget for the long-term (5 year) growth of this project, identifying our goal of \$10+M to establish the center and fund associated administrative and academic positions, research support, and space.

#### ***3.2. FUNDRAISING***

The iSTEM directors have been working hard on fundraising, both for constituent programs (such as the Colorado Learning Assistant (LA) Model) and for the organizational structure that supports these constituents (i.e. the center).

We have secured funds for many such programs (as noted above, the Colorado Learning Assistant Model has secured funding for the coming years and the BASEC community program has funding for administrative support). We have been in discussion with other statewide efforts (Battelle seeks to create a parallel to its success with the Ohio STEM Learning Network in Colorado. We participated in meetings with Battelle and NREL on April 9.). In the first week of June, project Director Otero joined our chancellor on a statewide tour of Colorado to raise funds for CU Boulder. A (and perhaps the) prime focus of discussions was STEM education. CU Boulder has committed a half time position to fundraising for STEM education.

The Learning Assistant Model is a critical pillar of iSTEM and as such, we have focused efforts to secure funding for it. The overall strategy for sustaining and institutionalizing the Learning



Assistant Model is to segue from extramural grant funding to internal funding. First we will utilize temporary funding committed from the departments, deans and senior administration. Next we seek to provide a mixture of endowed positions and funds from the general operating budget of the University of Colorado at Boulder. Finally, and only possibly, we could foresee a statewide level of funding for such programs across all institutions of higher education in Colorado. We are currently investigating the potential for state-level scholarships for students who participate in LA-style activities. We have secured funds for the LA-program to expand and operate for the coming 1-2 years through temporary recurring funds at CU Boulder. With coordination of the University of Colorado Foundation (our fundraising arm), we are identifying donors for endowed positions. Concrete steps that have been taken this year are:

- Mid January: Many DBER faculty make personal contributions to the LA Program through the CU Foundation in order to send a strong and clear message to senior administration about funding priorities
- February 2: Presentation to the Dean's Council about the LA Program - Positive responses from each of the Deans of 9 different Colleges at CU.
- February 25: Meeting with STEM Department Chairs about fundraising - Chairs gave unanimous support for making fundraising for STEM education a priority
- March 11: Subset of Directors meet with the Chancellor to secure funding for the LA program for the fall - Verbal commitment was given for temporary funding AY 2010-2011.
- June 24: Professors Otero and Finkelstein (project Directors) will make a presentation about the LA program to the Regents of the University of Colorado.

iSTEM has also played a strong role in supporting grant proposals from the directors and other iSTEM affiliates.

- Finkelstein serves as Co-PI on two iSTEM related and linked grants:
  - Co-PI, NSF DRL REESE, Understanding and Reducing the Gender Gap in Math and Science: Cognitive, Social, and Neural Mechanisms in Identity Threat, \$999,865, 2009-2012
    - Studies ranging from the clinical to the controlled learning settings to study plausible mechanisms of stereotype threat. Studies examine the role of working memory as a mechanism of stereotype threat.
- Finkelstein is Co-PI, NSF DUE Noyce, STEM Colorado's Streamline to Mastery, \$1,499,569, 2009-2015
  - A Noyce program to support early career teachers who are supported to become master teachers. Creating a continuum from the LA program, Noyce Fellows, CU Teach and now the Masters degree program.
- Finkelstein is also waiting to hear on three NSF grants that are related to and supported by iSTEM:
  - S-STEM grant, CU Scholarships for STEM: A Continuum of Support for STEM Education, \$600,000, 2010-2013. This project will provide scholarships to advanced undergrads and introductory graduate students in STEM to support Community Neighborhoods and improve climate and community at CU Boulder.
  - TUES, Using a Research-based Approach to Reform Upper-division Laboratory Courses, XXX get info here An effort to use research based approaches to improve our upper division, junior / senior level laboratories
  - FIRE, Interdisciplinary Research in Informal Science Education (IRISE), 2010-2012, \$200,000. A grant to simultaneously support the integrated research of a postdoctoral fellow in informal science education in STEM, and to develop an afterschool informal science education network.

- Kotys-Schwartz is involved in the pending grant: NSF PRISM \$1.2 million University of Colorado-Boulder PRISM: Digital Explorations (DE)
  - The program will engage up to 1,000 undeclared freshman and sophomore students in unique computer based activities that will encourage them to declare, increasing numbers each semester, majors or minors in STEM areas.
- Stade is PI on the grant: "CMTL: a Community of Mathematics Teachers and Learners," in force 9/09--8/11. Funded by the CU Outreach Committee. Grant amount: \$16,000.
- Stade is Co-PI on the pending grant: "Designing and Assessing Mathematics for Systems Sciences." Proposal submitted 05/26/2010 to the National Science Foundation, TUE (Transforming Undergraduate Education). Requested amount: \$200,000 for two years.
- Stade is Co-PI on the pending grant: "Developing Student-Centered Tutorials for the Undergraduate Calculus Sequence." Proposal submitted 05/26/2010 to the National Science Foundation, TUE (Transforming Undergraduate Education). Requested amount: \$199,985 for two years.

iSTEM Directors have consulted on and supported many other NSF proposals and awards, including, 5 CAREER Awards (3 awarded so far) in physics, grants in engineering (GK12, and an effort to create an Engineering Education Research Center), and other STEM initiatives on campus (notably both the other major campus initiatives: 1) Renewable and Sustainable Energy Institute, and 2) Colorado Initiative in Molecular Biotechnology).

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#### 4. MANAGEMENT

The iSTEM directors continue to meet weekly or bi-weekly. Their efforts have led to the activities and progress detailed in this report.

In addition, a full time project administrator, Ms. Kate Kidder, has been hired with, matching funds from the university, to replace the previous project administrator, Ms. Brown. Ms. Kidder maintains financial records and documentation; estimates/forecasts budget needs, and oversees budget compliance to ensure that all expenditures are in line with CU Boulder and NSF regulations. Ms. Kidder also manages human relations, maintains, updates, and creates promotional materials and web infrastructure, tracks participation in events and keeps notes of all meetings (DBER, iSTEM directors meetings, etc.), and provides general administrative support for the group. Under the supervision of the iSTEM directors and an independent contractor, Ms. Kidder will also conduct an internal evaluation of the project in the coming months.

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#### 5. DISSEMINATION AND NETWORKING

##### *5.1. WEB PRESENCE*

The iSTEM website, initiated in year one, continues to serve to announce meetings, link communities at Colorado, advertise the graduate and faculty awards, and archive events supported by the program. Although it has not yet achieved the goal of being a community portal, it is an important source of information about iSTEM programs and activities and a place to find university-based resources for STEM education. Please visit the website at <http://www.colorado.edu/istem/>.

##### *5.2. REVIEWED JOURNAL ARTICLES / BOOK CHAPTERS*

1. C. Henderson, A. Beach, and N. Finkelstein, "Four Categories of Change Strategies for

- Transforming Undergraduate Instruction," in Päivi Tynjälä, Marja-Leena Stenström & Marjatta Saarnivaara (eds). *"Nothing is Permanent but Change" Transitions and Transformations in Learning and Education (anticipated 2010)*.
2. V Otero, S Pollock, and N Finkelstein, "A physics department's role in preparing physics teachers: The Colorado Learning Assistant Model," *American Journal of Physics*, (to appear).
  3. C. Baily and N. Finkelstein, "Teaching and understanding of quantum interpretations in modern physics courses," *Phys. Rev. ST Physics Ed. Research* 6, 010101, (2010).
  4. C. Henderson, N. Finkelstein, & A. Beach A. "Beyond Dissemination in College science teaching: An Introduction to Four Core Change Strategies." *Journal of College Science Teaching*. **39**(5), 18-26, (2010).
  5. Goldberg, F. Otero, V., & Robinson, S. (accepted). Design principles for effective physics instruction: A case from Physics and Everyday Thinking. *Accepted to the American Journal of Physics*, December, 2009.
  6. Otero, V. & Harlow, D. (2009). Getting Started in Qualitative Physics Education Research. In C. Henderson and K. Harper (Eds.), *Review of Physics Education Research*, 1 (2).
  7. N. Lasry, N. Finkelstein, E. Mazur, "Are most people too dumb for physics," *Phys Teacher*, **47**, 418-422 (2009).
  8. C. Turpen\* and N.D. Finkelstein, "Not all interactive engagement is the same: Variations in physics professors' implementation of Peer Instruction," *Physical Review ST: Phys Educ. Research* 5, 020101, (2009).
  9. C. Baily\*, and N.D. Finkelstein, "Development of quantum perspectives in modern physics," *Phys. Rev. ST Phys. Educ. Res.* 5, 010106 (2009).

### **5.3. REVIEWED CONFERENCE PROCEEDINGS**

1. Eisenhart, M. and Kotys-Schwartz, D. "The Meaning of Interest in Engineering" Proceedings, 2010 American Educational Research Association, Denver, CO.
2. Otero, V. (2010, June). Science Learning as the Objectification of Discourse, *International Conference of the Learning Sciences*, June 28-July 2, 2010, Chicago, IL.
3. Kotys-Schwartz, D., Knight, D. and Pawlas, G. "First-Year and Capstone Design Projects: Is the Bookend Curriculum Approach Effective for Skill Gain?" Proceedings, 2010 American Society for Engineering Education Annual Conference & Exposition, Louisville, KY.
4. Knight, D., Kotys-Schwartz, D., and Pawlas, G. "Triangulation: An Effective Assessment Tool for Capstone Design Program Evaluation?" Proceedings, 2010 Capstone Design Conference, Boulder, CO.
5. Otero, V. (2009). Evolution of Theoretical Perspectives in my Research. In C. Henderson, M. Sebella, & C. Singh (Eds.) *2009 Physics Education Research Conference Proceedings*. Melville, NY: AIP Press.
6. Gray, K. & Otero, V. (2009). Analysis of former Learning Assistants' Views on Cooperative Learning. In C. Henderson, M. Sebella, & C. Singh (Eds.) *2009 Physics Education Research Conference Proceedings*. Melville, NY: AIP Press.
7. L. Kost, S. Pollock, and N. Finkelstein, "Unpacking Gender Differences in Students' Perceived Experiences in Introductory Physics" *Proceedings of the 2009 Phys Edu. Research Conf.*, AIP Press, **1179**, 177-180, (2009).
8. C. Baily\* and N. Finkelstein, "Understanding and Teaching Quantum Interpretations in Modern Physics Courses" *Proceedings of the 2009 Physics Education Research Conf.*, AIP Press, **1179**, 81-84 (2009).
9. C. Turpen\*, N. Finkelstein, and S. Pollock, "Towards Understanding Classroom Culture: Students' Perceptions of Tutorials" *Proceedings of the 2009 Physics Education Research Conf.*, AIP Press, **1179**, 285-288, (2009).

10. J. Bartley\*, M. Mayhew\*, N. Finkelstein, "Reaching Students through Informal Science Education" *Proceedings of the 2009 Physics Education Research Conf.*, AIP Press, **1179**, 93-96, (2009).
11. L. Mayhew\* and N. Finkelstein, "Learning to Teach Science through Informal Science Education Experiences" *Proceeding of the 2009 Physics Education Research Conf.*, AIP Press, **1179**, 205-208, (2009).
12. B. Spike\* & N. Finkelstein, "A Study of Undergraduate and Graduate Student Conceptions of Teaching" *Proceedings of the 2009 Physics Education Research Conf.*, AIP Press, **1179**, 281-284, (2009).
13. Kotys-Schwartz, D., Knight, D. and Pawlas, G. "From First Year Engineering Projects to Senior Capstone Design: What Skills Are Our Students Gaining?" *Proceedings, ASME 2009 International Mechanical Engineering Congress & Expo, Lake Buena Vista, Florida.*  
Margolis, J., Kotys-Schwartz, D., Knight, D. "The Post-Graduation Attrition of Engineering Students: An Exploratory Study on Influential Career Choice Factors" *Proceedings, ASME 2009 International Mechanical Engineering Congress & Expo, Lake Buena Vista, Florida.*

#### **5.4. INVITED TALKS**

1. V. Otero and N.D. Finkelstein, "Starting a Colorado Learning Assistant Program," Assoc. of Public and Landgrant University, Science and Math Teacher Imperative annual meeting, Cincinnati, OH, Jun 9, 2010.
2. N. Finkelstein, M. Dubson, and K. Perkins, "Seeding and Sustaining Educational Transformation in a Physics Department," AAPT National SPIN-UP Workshop, New Brunswick, NJ, June 5, 2010.
3. M. Cole, N. Finkelstein and 10 members of LCHC, "Sylvia Scribner Award Address," Am. Educational Research Association Annual Meeting, Denver, CO, May 2, 2010 [invited award address]
4. N.D. Finkelstein, "Achieving Excellence in Undergraduate Education: the Colorado Learning Assistant Model," Boston University, Provost and Dean's Council Meetings, Boston, MA, April 15, 2010.
5. N.D. Finkelstein, "Towards a Scholarship of Teaching and Learning in Science and Engineering," Computational Optical Sensing and Imaging center, University of Colorado, Boulder, Apr 12, 2010.
6. Otero, V. (2010, March). Task Force on Teacher Education in Physics: Findings and Recommendations, Presented at the American Physical Society March Meeting, March 15, Portland, OR.
7. Otero, V. (2010, March). Improving Physics Instruction Using Learning Assistants, Presented at the Colorado School of Mines, Physics Colloquium, March 9, 2010.
8. Otero, V. (2010, February). Preserving Excellence in Undergraduate Education at a Relatively Low Cost. Presented at Auburn University, sponsored by the Association of Public and Land Grant Universities, February 22, 2010. Auburn, AL.
9. Otero, V. (2010, February). Reconceptualizing Undergraduate Education: LA Programs as Experiential Learning Models, presented at the biannual meeting of the American Association of Physics Teachers, February 16, Washington, D.C.
10. N. Finkelstein, "Strengthening Undergraduate and Graduate STEM Education," U.S House of Representatives, Committee on Science and Technology, Research and Science Education Subcommittee Hearings, Washington, DC, Feb 4, 2010.
11. Otero, V. & Pollock, S. (2010, February). Introduction to the Colorado Learning Assistant Program. Presented at the annual meeting of the Physics Teachers Education Coalition, February 12, Washington, D.C.
12. Otero, V., Ananda, V., & Stachurski, S. (2010, February). Bringing it all together: NSF Funding to support the continuum for science teacher preparation. Keynote presented at the annual

- meeting of the Physics Teachers Education Coalition, February 11, Washington D.C.
13. Otero, V. & Pollock, S. (2010, February). Implementing the Colorado Learning Assistant Program at Other Universities. Presented at the annual meeting of the Physics Teachers Education Coalition, February 12, Washington, D.C.
  14. N. Finkelstein, "The Role of New Technologies in Science and Mathematics Education," South African Association for Research in Mathematics, Science and Technology Education Annual Conference, Durban, South Africa, Jan 18-22, 2010 [invited plenary]
  15. N. Finkelstein, "Studying Change," Science and Mathematics Teacher Imperative Leadership Collaborative, Association of Public and Land-grant Universities Provosts' Meeting, Miami, FL Jan 6-8, 2010.
  16. N. Finkelstein, C. Henderson, A. Beach and L. Mayhew, "Creating and Sustaining University-Community Partnerships in Science Education," Am. Geophysical Union annual meeting, San Francisco, Dec 17, 2009.
  17. Otero, V. (2009, December). Stop shining the old pot: New models of institutional change. Race to the Top, STEM, hosted by the National Governors Association, December, 2010.
  18. N. Finkelstein, "Textbooks as Educational Tools," Workshop on Knowledge-Based Textbooks, Vulcan Inc, Seattle, WA Nov 23, 2009.
  19. N.D. Finkelstein, "Understanding When and Why Education Works: the Role of New Technology in Physics Education," Department of Science Teaching, Weizmann Institute of Science, Rehovot, Israel, Nov 10, 2009.
  20. N.D. Finkelstein, "Representation and Analogy Use by Students in Learning Physics," Department of Math Education, Faculty of Education, University of Haifa, Haifa, Israel, Nov 5, 2009.
  21. N. Finkelstein, "Initiative on K-12 Teacher Preparation: University of Colorado," National Advisory Board Meeting of the Center for the Integration of Research Teaching and Learning, Washington DC, Oct 29, 2009.
  22. Otero, V. (2009, October). Moving Education Outside the Classroom: 21st century model for science education and teacher preparation, October 30, 2009, Ewha Woman's University, Seoul, Korea.
  23. Otero, V. (2009, October). New Directions for Teacher Preparation. October 31, 2009, Ewha Woman's University, Seoul, Korea.
  24. Otero, V. (2009, October). The Colorado LA Program: A model education program of tomorrow. Presented at Seattle Pacific University, October 2009.
  25. Otero, V. (2009, October). Educating Scientists to Become Civil Rights Activists. Presented at the meeting of the Hispanic Association of Colleges and Universities, October 23, Denver, CO.
  26. Otero, V. (2009, October). What does it mean to learn physics? Presented at American Physical Society Four Corners Meeting, October 23, Colorado School of Mines, Golden, CO.
  27. Stade, E (2009). "Preparing Future K12 Math and Science Teachers -- The Colorado Learning Assistant Model," Discovery Learning Luncheon Presentation, University of Texas at Austin, September 24, 2009
  28. N.D. Finkelstein, "Theories of Representation and Analogy Use by Students in Learning Physics," Rutgers University, Department of Physics, Sep 4, 2009.
  29. Otero, V. & Ross, M. (2009, September). Authentic Science Activities In The Primary Level Classroom: Investigating the Effects of a Data Collection and Analysis Interface on Primary Level Students' Scientific Literacy. Paper presented at the Multimedia in Physics Teaching and Learning, 23-25 September 2009 University of Udine, Italy.
  30. N. Finkelstein, "Our Classrooms as Cultural Systems: An Examination of Social and Cultural Influences in Two Educational Environments," Physics Education Research Conference, Ann Arbor, July 30, 2009
  31. S. Pollock, N Finkelstein, K Perkins, S Chasteen, M Dubson, S Goldhaber, C Turpen "When Top

Down Meets Bottom Up: Supporting Educational Transformation in a Physics Department,”  
2009 Summer Meeting: Ann Arbor, Michigan, Jul 2009.

N. Finkelstein, “Themes, Foundations and Frontiers: a perspective on goals, theory, models and experiment in PER,” Foundations and Frontiers in PER, National Conference, Bar Harbor, ME 17 Jun, 2009. [plenary].

### ***5.5. CONTRIBUTED TALKS/PAPERS***

1. N.D. Finkelstein, “Teaching and Learning Physics: coordinating physics, education, university and community,” National Association for Research on Science Teaching Annual Conference, Philadelphia, PA, Mar 23, 2010.
  2. N.D. Finkelstein and S. Pollock, “Sustaining Educational Transformation in a Physics Department (part 1 of 2),” APS 4 Corners Sectional Meeting, Colorado School of Mines, Golden, CO, Oct 23, 2009.
  3. S. Pollock, N Finkelstein, S Chasteen, M Dubson, S Goldhaber, K Perkins, C Turpen. “Scaling Educational Transformation in a Physics Department (part 2 of 2),” APS 4 Corners Meeting, Golden, CO, Oct 23, 2009.
  4. L. Kost, S. Pollock, and N. Finkelstein, “Unpacking Gender Differences in Students' Perceived Experiences in Introductory Physics” Physics Education Research Conf. Ann Arbor MI, Jul, 2009.
  5. C. Baily\* and N. Finkelstein, “Understanding and Teaching Quantum Interpretations in Modern Physics Courses” Physics Education Research Conf. Ann Arbor MI, Jul, 2009
  6. C. Turpen\*, N. Finkelstein, and S. Pollock, “Towards Understanding Classroom Culture: Students' Perceptions of Tutorials” Physics Education Research Conf. Ann Arbor MI, Jul, 2009
  7. J. Bartley\*, M. Mayhew\*, N. Finkelstein, “Reaching Students through Informal Science Education” Physics Education Research Conf. Ann Arbor MI, Jul, 2009.
  8. L. Mayhew and N. Finkelstein, “Learning to Teach Science through Informal Science Education Experiences” Physics Education Research Conf. Ann Arbor MI, Jul, 2009.
  9. B. Spike\* & N. Finkelstein, “A Study of Undergraduate and Graduate Student Conceptions of Teaching” Physics Education Research Conf. Ann Arbor MI, Jul, 2009.
  10. Lin, Y., Henderson, C., Finkelstein, N., & Beach, A. “Examining Change Strategies in University STEM Education”, contributed talk, AAPT 2009 Summer Meeting, Ann Arbor, MI, July 28, 2009.
  11. C. Turpen and N. Finkelstein, “Student Perceptions and Instructional Choices in Educational Reform: Studies of Peer Instruction,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  12. L. Kost, S. Pollock, and N Finkelstein, “Gender Differences in Students' Perceived Experiences in Introductory Physics,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  13. B. Spike, and N Finkelstein, “Research on Training Undergraduate and Graduate Student Instructors in Tutorials,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  14. J. E. Bartley, L. Mayhew and N. Finkelstein, “The Potential of Informal Science Education for Development of Individuals and Institutions,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  15. L. Mayhew and N. Finkelstein, “Informal Science Teaching Experience Informs Formal Science Teaching Training,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  16. C. Turpen and N. Finkelstein, “Students' Perceptions of the Use of Tutorials at the University of Colorado,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
  17. L. Kost, S. Pollock, and N Finkelstein, “Unpacking the Gender Gap in Introductory Physics,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.
- C. Baily and N. Finkelstein, “Varying Quantum Interpretations and Implications in Modern Physics Instruction,” 2009 Summer Meeting AAPT: Ann Arbor, MI, Jul 2009.

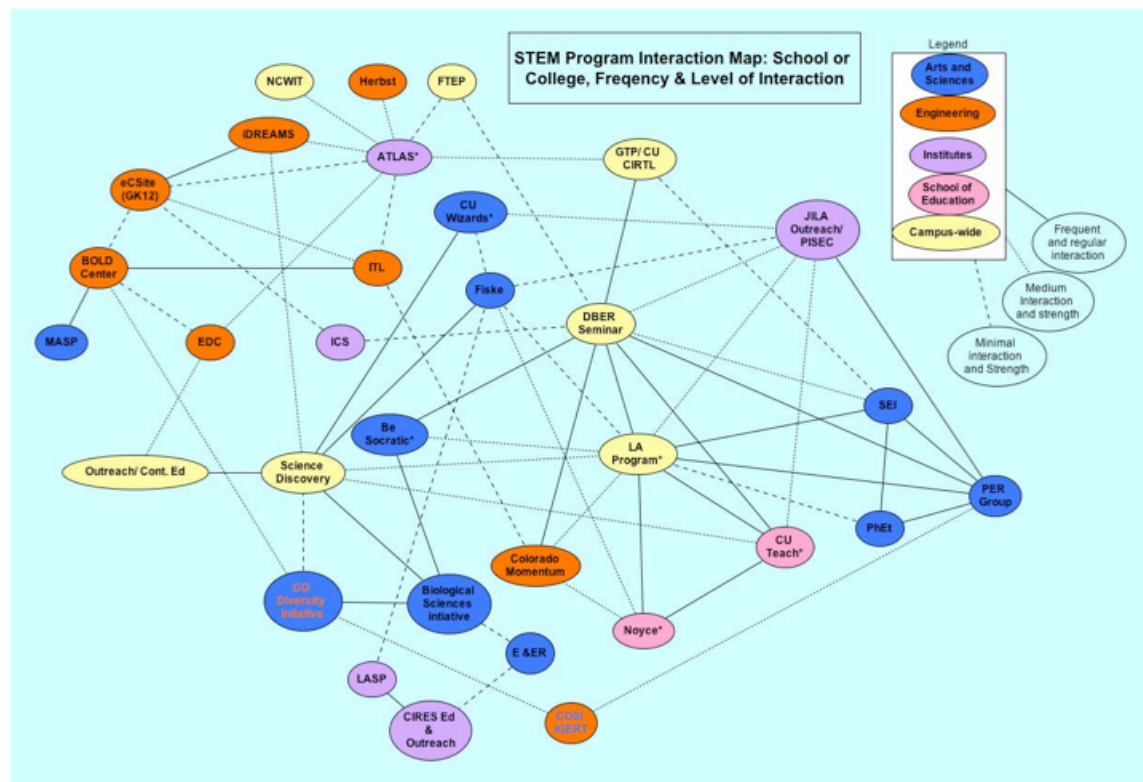
## 6. EVALUATION

### 6.1. BASELINE EVALUATION

In January, 2010 project administrator, Jordan Brown, and consultant, Barry Kluger-Bell, completed and presented to the iSTEM directors the results of the second baseline evaluation, which focused on identifying and categorizing programs on campus involved with STEM education, looking at their current interactions, and determining their possible interest in a future center for STEM education. They identified over 28 programs ranging from those in the three focus areas (course transformation, STEM education research, and STEM teacher preparation) to those working on teacher professional development and those doing afterschool and summer work with children.

They were able to categorize seven major focus areas for STEM Education programs. These include the initial focus areas (course transformation, STEM education research, and STEM teacher preparation) but also incorporate diversity and access, graduate student teaching, work in the formal K12 arena (including teacher professional development, working with children in classrooms, and curriculum development), and work in informal settings with both children and general audiences. Given this, they found the need to broaden the definition of our original three focus areas. Course transformation needed to be thought of as education experience transformation in order to include things like designing K12 curriculum and GK12 programs. STEM teacher preparation had to be expanded to K20 STEM teacher education in order to include K12 teacher professional development programs and graduate student training in teaching.

They asked program leaders about their connections with and knowledge of other programs and did an analysis of what they found. Maps such as the following helped us see where the existing connections are and think about what could be strengthened.



What they saw was that DBER and the LA Program emerge as hubs of activity and integration. Although other programs like Science Discovery and ATLAS appear to be well connected, those connections are more superficial. They found that the Integrated Teaching and Learning Laboratory (ITLL) is hub for engineering education. They also saw that some programs came into existence because of others (e.g. Colorado Momentum grew from the LA Program and the Noyce program). Finally, they saw that there was a lot of room for improvement in interactions between programs in Arts and Sciences and in Engineering.

Suggestions for next steps for program integration focused on providing concrete ways for programs to get involved with each other. These included mini-symposia or topical meetings/trainings, a common web portal, expanding the LA Model into engineering classes, encouraging more involvement of engineering faculty in DBER, and providing some common assistance and resources for evaluation.

There was broad support among those interviewed for a STEM Center. The most requested elements of that center include increased opportunities for networking, support for program evaluation and assessment, leveraging of funds and partnering for grants, support for dissemination, and developing connections for programs involved in working at the K12 level.

## ***6.2. EXTERNAL EVALUATION***

In the Summer of 2009, project external evaluator, Rachel Scherr spent a week at the University of Colorado. She met multiple times with the iSTEM directors and interviewed project stakeholders Chancellor Phil DiStefano, Associate Dean of Engineering Brian Argrow, and Professor of Computer Science Clayton Lewis, recipient of a Chancellor's Award for Excellence in STEM Education, Dean of the School of Education Lorrie Shepard, Associate Dean of Arts and Sciences Susan Beatty, and four graduate student recipients of the Chancellor's Award for Excellence in STEM Education. She arrived at the following conclusions:

### State of project:

The three pillar programs of the project (LA, DBER, and CU-Teach) are flourishing. The project has secured significant participation from high-status individuals in the university community and beyond, including the Chancellor (who is the PI), provost, deans, and state legislators.

The project has begun to raise visibility through branding on brochures, business cards, and a web presence. (Although the website is envisioned as eventually becoming an interactive portal, it is currently only an information resource.) The name of the project is in transition from "I<sup>3</sup>" (an NSF designation) to "Integrating STEM" (hereafter I-STEM).

The project has made awards to both faculty and graduate students under the new "Chancellor's Awards for Excellence in STEM Education" program. These awards support worthwhile STEM education projects as well as increasing the visibility and prestige of those projects.

An upcoming I-STEM kickoff event will showcase and acknowledge the involvement of campus officials and state legislators, raise visibility, and invite community participation.

Project research has identified and tentatively categorized potential I-STEM constituent programs. Project researchers have interviewed program representatives to determine their possible interest



in a future Center for STEM Education. Most of the interest that possible constituents report is in programmatic leveraging and clearinghouse-type services.

The project management team (PMT) holds weekly meetings to engage in the collective design of activities, selection of scholars, planning of public relations, and creation of reports and project materials.

Strengths of the project:

**Involvement of high-status university and community officials:** The PMT (especially Finkelstein) has done a remarkable job securing the participation of high-status officials from the campus administration and from the State of Colorado. The project will surely benefit from the influence wielded by these officials. Most of the stakeholders interviewed by the Evaluator were strongly motivated by the participation of prestigious individuals.

**Pillar programs:** The extremely successful LA program, DBER, and CU-Teach are the pillars on which I-STEM rests. The viability of the present project is significantly due to the strength and visibility of these existing efforts.

**Project management team:** The project management team is a powerhouse. Composed of directors of the pillar programs and representatives of several STEM disciplines, the team engages in very active collaboration to do the substantial daily work that keeps I-STEM moving forward.