Center for STEM Learning
UNIVERSITY OF COLORADO **BOULDER**

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CENTER FOR STEM LEARNING 2015 ANNUAL REPORT

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MISSION

The mission of the 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.

VISION

The vision of the Center for STEM Learning 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. The Center seeks 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.

VALUE PROPOSITION

The Center for STEM Learning serves as a unique and innovative approach to address the Chancellor's priorities for campus: reputation, retention, and new models for revenue.

The Center for STEM Learning:

- Connects national groups, networks and resources focused on improving STEM education with CU Boulder – CSL connects CU Boulder to a variety of national programs and brings resources to CU-Boulder to help transform faculty practice and programmatic activity
- Supports campus infrastructure and builds capacity for STEM education – CSL supports campus infrastructure for advancing capacity and effectiveness in STEM education. CSL staff advise OIT staff on areas of focus, including the development of analytic tools (e.g., those from the Bay View Alliance) for making evidence based decisions, and importing new tools for faculty practice (e.g., *nota bene*, a web-based collaborative annotation tool from the Massachusetts Institute of Technology, and *Calibrated Peer Review*, a web-based writing and peer-review tool from the University of California, Los Angeles). CSL staff are also advising and supporting campus commissions to advance the institution. Key committees include the Provost's Taskforce on Persistence (increasing retention) and the campus and system wide taskforces in technology use (e.g., online, distance education, and MOOCs)

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

CSL Organizational Structure

Three key staff hires are designed to greatly enhance the center's capacity to improve STEM education at CU-Bolder and beyond.

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

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

The new CSL Program Manager/Interim Director will oversee day-to-day operations and take on leadership of the center. Duties will include: coordinating center programs, projects and events, building and maintaining both internal and extramural relations, supervising CSL staff, managing center public relations, developing and implementing strategic and development plans, and data collection. Anne-Barrie Hunter was hired. She is co-director of Ethnography & Evaluation Research, an independent research unit here at CU. For 25+ years, she has conducted research on and evaluations of initiatives designed to improve college science teaching in STEM fields and to increase student access to and success in STEM, particularly for students from groups traditionally underrepresented in the sciences.

Drs. Valerie Otero and Noah Finkelstein, co-directors of CSL, continue to serve as senior advisors to the CSL Program Manager/Interim Director Hunter.

The Fellows of the Center for STEM Learning meet biannually to review CSL programs, activities and financial reports and provide feedback. As necessary, Fellows also collaborate in working groups to advance CSL's work.

An executive board is comprised of 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

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sit on the executive board. The executive board will serve as the primary policy-making body of the center. The executive board meets annually; however, a meeting was not yet been held.

An external advisory board to oversee CSL programs and support development is in the process of being put together based on Fellow recommendations.

PROGRAMS

The Center for STEM Learning (CSL) sponsors three different types of programming:

I. Programs associated with campus funding (i.e., the Annual Fall CSL Symposium, faculty and graduate student *Chancellor's Awards for Educational Excellence,* Community College Summit, one-on-one consultations and professional development workshops)

II. Programs funded by external grants. CSL houses two kinds of external grants:

   A. Conducting original STEM and discipline-based education research (i.e., *Talking about Leaving* Revisited*,* SITAR, TRESTLE)

   B. Initiatives to improve STEM education access at CU (i.e., NSF Creating Academic Pathways in STEM (CAPS) INCLUDES initiative, Research Experiences for Community College Faculty)

III. Programming associated with extramural efforts (i.e., APLU, AAU, Bay View Alliance, AAC&U)

All program activities supported by the Center for STEM Learning in 2015 are reported below.

I. CAMPUS-SUPPORTED PROGRAMS

Funding for campus-supported programs comes from the Provost's Office and the Graduate School—the majority of which goes toward the faculty and graduate student Chancellor's Awards for Excellence in STEM Education and the annual CSL Fall Symposium, where Chancellor's Awardees are celebrated. Programs supported by campus funding, also include one-on-one consultations with STEM faculty, professional development workshops and STEM community seminars.

- ***Annual Center for STEM Learning Symposium on STEM Education:*** This event is held at the end of September every year and celebrates CU Boulder's internationally recognized STEM education initiatives. In October of 2017, CSL Celebrated the 9th annual symposium. The event highlights ground-breaking STEM education projects on campus, engages campus STEM education scholars, and brings together key CU-Boulder stakeholders to transform STEM education.

  Keynote Speakers: Dr. Susan Elrod, Provost and Executive Vice Chancellor for Academic Affairs at the University of Wisconsin – Whitewater, former Interim Provost at California State University, Chico & Scholar; former director of PKAL; scholar of Institutional Change.

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2015 Annual Center for STEM Learning Symposium on STEM Education Attendee Breakout.

Year	*Under-grad.*	*Grad.*	*Post doc*	*Fac.*	*Inst./ Lecturer*	*Research*	*Staff*	*Admin*	*K-12/ HS/ 2YC*	*Other Guests*	*Totals*
2015	9	22	3	49	10	11	38	5	22	22	**191**

- **Chancellor's Awards -** The Chancellor's Awards for Excellence in STEM Education (CA) is a competitive grant program offered through CSL and represents the Center's main programmatic initiative. The goal of the CA program is to support faculty and graduate student engagement in innovative research on student learning and implementation of research-based STEM education program initiatives.

  In 2015, seven Chancellor's Awards were granted to 10 faculty across several STEM departments (CBE, EBIO, MCDM, PSYCH & NEUROSCI) and the School of Education. Two graduate students received Chancellor's Awards (PSYCH & NEUROSCI and ATLAS).

2015 Faculty and Graduate Student Chancellor's Awards for Excellence in STEM Education Grantee Breakout.

Year	*Tenure Track/ Researchers*	*Post-doc/ Instructors/Staff*	*Graduate Student*	*Total Individuals*
2015	2 EBIO 2 EDUC 2 MCDB 1 CBE 1 PSYCH & NEUROSCI	2 SASC	1 ATLAS 1 PSYCH & NEUROSCI	**12**

Between 2009 and 2015, CSL has funded a total of 68 Chancellor's Awards: 33 to a total of 48 faculty members (there are multiple faculty investigators working collaboratively on Chancellor's Awards, and two SASC academic coordinators have received funding twice). Thirty-five awards have been granted to a total of 34 graduate students (one graduate student received funding twice).

- **Community College Summit: Using Research in STEM Education to Improve Teaching and Learning: A Conference for Community College Faculty** (2015) **–** On April 3, 2015, CSL hosted a one-day conference at CU Boulder for STEM faculty and staff at Colorado two-year colleges designed to foster partnerships among faculty and researchers across Colorado's institutions of higher education.

  Forty-eight people registered for the full day conference, representing the following 10 institutions: Aims Community College (1 registrant), Arapahoe Community College (4 registrants), Community College of Aurora (3 registrants), Community College of

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Denver (8 registrants), Front Range Community College (14 registrants), Lamar Community College (2 registrants), Otero Junior College (3 registrants), Red Rocks Community College (8 registrants), Trinidad State Junior College (3 registrants), and University of Colorado Boulder (2 registrants). Of these registrants, 37 people attended the full-day conference, representing 8 two-year institutions and CU Boulder.

In addition to the attendees, the conference engaged 19 faculty members, staff and researchers to provide workshops, presentations and informal networking. Workshops were provided by seven CU faculty and researchers – Cindy Buchenroth (EBIO), Yuen-Ying Carpenter (PhET), Stephanie Chasteen (CSL), Jenny Knight (MCDB), Laurie Langdon (LA Program), Andrew Martin (EBIO), and Kathy Perkins (PhET). Presentations were provided by Noah Finkelstein (CSL, Physics), Anne Gold (CIRES), and Heidi Loshbaugh (Community College of Denver). In addition, Valerie Otero (CSL, Education), Eric Stade (CU Mathematics) and Michael Skirpan (CU Computer Science) joined the participants for lunch. Four panelists contributed to a panel discussion -- Angie Generose (Community College of Denver), Sarah Grover (CU Psychology), Andrew Martin (CU EBIO), and Michael Skirpan (CU Computer Science). In addition, Anne-Barrie Hunter (CSL Managing Director), Gabrielle Katz (CSL Faculty Liaison), William Tarantino (CSL Business Manager), and Robbie Martinez (CSL Administrative Assistant) attended the conference and participated throughout the day.

2015 Community College Summit Attendee Breakout.

Faculty/Researchers	*Staff*	*Community Colleges*	*Total*
21	4	14 Front Range Community College 8 Community College of Denver 8 Red Rocks Community College 4 Arapahoe Community College 3 Community College of Aurora 3 Otero Junior College 3 Trinidad State Junior College 2 Lamar Community College 1 Aims Community College	**71**

Over the course of the day (morning and afternoon sessions), this event brought together 71 STEM faculty, administrators, staff and researchers, representing 8 two-year institutions (Arapahoe Community College, Community College of Aurora, Community College of Denver, Front Range Community College, Lamar Community College, Otero Junior College, Red Rocks Community College, Trinidad State Junior College, 2 four-year institutions (CU Boulder and Metropolitan State University of Denver), and the private sector. Participants learned about STEM education innovations and research taking place at CU Boulder and in the community college system through workshops and presentations, and had opportunities to network with colleagues from a diverse set of institutions. The following discussion of conference successes is based on our own observations at the conference, informal discussions with participants, and the results of our online conference evaluation survey (request sent out to all attendees).

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The conference schedule included intentional networking opportunities during lunch, breaks, and at the end-of-day reception, as well as informal opportunities that occurred during workshops. At lunch, tables were assigned according to discipline in order to promote conversations across institutions. Each table included at least one faculty member or researcher from CU Boulder, in addition to 6-7 two-year college participants in each discipline. The lunch time conversations were lively, and appeared to be meeting our goals of promoting cross-institutional connections. For many of the CU faculty and researchers presenting at the conference, this was their first opportunity to connect with colleagues from two-year institutions and to learn about the two-year college context. For the two-year college participants, this was a rare opportunity to connect with colleagues from different institutions, and the first opportunity to build partnerships with CU Boulder.

Overall impact - The mission of the Center for STEM Learning (CSL) is to improve STEM education at CU Boulder, and to serve as a state, national, and international resource for such efforts. This conference advanced CSL's mission by sharing research-based pedagogical techniques and ideas with a broad audience of STEM educators from Colorado's two-year institutions of higher education, and by creating a unique opportunity for STEM educators and stakeholders to build partnerships for future collaborations.

- **Professional Development Opportunities –** During the 2015 spring semester, Dr. Stephanie Chasteen planned and offered a series of professional development opportunities directed at CU STEM faculty members. These included one-on-one faculty consultations and a series of workshops focusing on active teaching and learning pedagogies.
    - **One-on-one faculty consultations** - In order to provide targeted, individual support for faculty engaged in STEM education efforts in:
        - course redesign;
        - use of active learning,
        - creation of learning goals;
        - design of assessments;
        - ways to use Learning Assistants (LAs);
        - how to conduct educational research (e.g., pre-post testing, statistical analysis, etc.) and
        - regular partnership and coaching through a course (including feedback on goals, activities, assessment, and observations and data on instruction).

    A total of 8 faculty, staff, or research associates contacted Dr. Chasteen.

Spring 2015 One-on-one Faculty Consultation Participation.

Number of faculty/Staff	***Focus of Consultation***
Requesting consultations	4 in course redesign; 4 education research

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Made an appointment, but did not follow through	1 in course redesign
Requesting follow-up consultations	3 indicated follow up not necessary; others did not reply

Overall, respondents were very pleased with the consultations, which they felt represented a unique opportunity to receive direct, focused help towards a long-term goal.

- **Faculty Development Workshops** – Dr. Stephanie Chasteen coordinated a series of workshops supporting the three main strands of discipline-based education research (DBER):
  - Clickers and peer instruction,
  - assessment, and
  - education research.

Additionally, members of the CSL community were able to arrange to observe a select group of classrooms using clickers in an exemplary way.

Because several workshops offered through the Faculty Teaching Excellence Program are synergistic with these goals, circulated memos and flyers list both CSL- and FTEP-sponsorship of these workshops

Eight workshops were presented.

Spring 2015 Faculty Development Workshops and Attendee Breakout.

Workshop	Presenters	Participants	Evaluations[1] (Average on 5-point scale;
Writing great clicker questions	Chasteen (Feb 25)	2 1 postdoc, 1 faculty 1 EBIO 1 ECEE	Ranking: 5. Personally use: 5. Pass on: 4.5.
Using PhET with Clickers	Carpenter (Mar 10)	3 3 faculty 1 CBEN 1 ATOC 1 CogSci	Ranking: 4.5. Personally use: 5. Pass on: 4.5.
Clicker classroom field trip	Various	5	N/A
Clicker classroom field trip debrief (for those who observed classes)	Chasteen (Mar 12)	4 4 faculty 2 LEEDS, 1 APS, 1 MCEN	Ranking: 4.5. Personally use: 5. Pass on: 5.
Getting peer instruction to	Knight and Chasteen (Apr 8)	4 2 faculty,	Ranking: 5. Personally use: 5.

[1] *How would you rank this Center for STEM Learning Event? (Poor-Outstanding). I will personally use ideas I heard here in courses I teach (Not likely-Very likely); I will pass on ideas I heard here to my colleagues (Not Likely-Very likely). Averages reported to the nearest half-point.*

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work in your class		1 postdoc, 1 grad 1 LEEDS, 1 Mech Eng., 1 CSCI	Pass on: 4
Feedback to influence student learning	Webb (Mar 19)	3 2 postdocs 1 research staff 1 PHYS, 1 CHEM, 1 CSCI	Ranking: 5. Personally use: 5 Pass on: 4
Designing exams to drive student learning	Chasteen & Langdon (April 7)	4 3 grad students, 1 postdoc 3 CHEM, 1 CSCI	Ranking: 5. Personally use: 5 Pass on: 5
Designing small educational studies	Van Dusen & Dancy (Mar 18)	4 2 grads 1 postdoc, 1 staff 2 CSCI, 1 CHEM, 1 MATH	Ranking: 4. Personally use: 5. Pass on: 4.5.
Assessing student learning using pre/post tests	Van Dusen & Dancy (Apr 9)	4 1 faculty, 2 grad, 1 postdoc 2 CSCI, 1 CHEM, 1 MATH	Ranking: 4.5. Personally use: 5. Pass on: 4.5.
TOTAL	**33 participants (not necessarily unique) 11 faculty, 8 grads, 7 postdocs**		

Overall, workshops were attended by a small number of participants, but observations, as well as workshop evaluations, indicated that the conversations during these small workshops tended to be very rich, high-quality, intimate discussions about issues of teaching and learning. Thus, while workshops did not reach a large number of participants, they (a) provided a forum for focused conversations about teaching and learning in STEM, and (b) served a population of graduate students and postdocs who may not feel welcome at other campus professional development offerings (such as Graduate Teacher Program or Faculty Teaching Excellence Program).

- **Fellows' Meetings –** CU faculty and research faculty who serve as Fellows to CSL meet quarterly to review CSL's activities and provide input and feedback on CSL activities. There are currently 30 Fellows representing the range of STEM departments, including APS, CHEM, EBIO, GEOSCI, PHYS, MATH, MCDB, as well as several engineering departments, the School of Education, CSL, CARTSS, ATLAS and NCWIT; ~20-25 Fellows attend each meeting.

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In 2015, Fellows' meetings were held:
- March 2
- September 8
- December 10

- **Weekly Discipline-Based Education Research (DBER) Seminar Series** - The Discipline-Based Education Research (DBER) seminar is a multi-disciplinary weekly series that emphasizes discipline-based STEM education research. It is a forum for faculty, staff, researchers, postdoctoral and graduate students and undergraduates interested in education research and course transformation to share their research and ideas and to get feedback on their work. ~20-30 STEM faculty, graduate and post-doctoral students attend weekly.

2015 Fall DBER Schedule.

Sep 1	**Laura Border** "TIGER Research on Academic Retention"
Sep 8	No DBER
Sep 15	No DBER
Sep 22	**Michelle Smith**, University of Maine, "Strategies to Promote Instructional Transformations in STEM Education"
Sep 29	**Maria Fysaraki**, visiting scholar from LMU, Germany, "Conceptualizing and Supporting Awareness of Argumentative Collaboration"
Oct 6	**Ian Her Many Horses,** "From lived experiences to game creation: how scaffolding supports elementary school students learning computer science principles in an after-school setting"
Oct 13	**Dimitri Dounas-Frazer,** "Model-Based Reasoning in Upper-Division Lab Courses"
Oct 20	**Kate Goodman,** "Aesthetics and Expanding Perception in Fluid Physics"
Oct 27	**Andrew Martin,** "Effect of curriculum on student interaction and collaboration" **Enrique Lopez,** "Using an Asset-Based Approach to Examine Why Students Succeed in Science"
Nov 3	**Shaw Ketels,** "Testing two pedagogical prescriptions in the use of clickers"
Nov 10	**Susan Miller,** "Creation of a Video-Based Survey Protocol to measure Computational Abstractization"
Nov 17	**Erin Furtak,** "Learning Progressions, Professional Development, and Student Achievement in High School Biology: Results of the Elevate Study"
Dec 1	**Becca Ciancanelli**
Dec 8	**Mike Klymkowsky,** "Exploring student thinking about the ubiquity and roles of molecular level stochastic processes through beSocratic-based diagnostics."

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2015 Spring DBER Schedule.

Jan 21	**Michael Skirpan** *View Michael's Presentation Online*
Jan 28	**Mike Ross** and **Emily Haynes**
Feb 4	**Alice Healey,** (Psychology/Neuroscience) *Related PowerPoint Slides from Alice Healey*
Feb 18	**Kate Goodman** and **Jiffer Harriman**, (ATLAS)
Feb 25	**Valerie Otero** (School of Ed)
Mar 4	**Dave Underwood**
Mar 11	**Cory Pavicich** (ATC), and **Sarah Miller** (Engineering)
Mar 18	**Melanie Cooper** (Chemistry, MSU)
Apr 1	**Enrique "Henry" Suarez** and **Ryan Glover**
Apr 8	**Vicki Hand** (Education)
Apr 15	**Mike Klymkowsky** (MCDB)
Apr 22	**Stephanie Chasteen** (SEI)
Apr 29	**Sarah Wise** (EBIO) and **Jenny Knight** (MCDB)

- **STEMinar** - The STEMinar is a graduate student organization at CU Boulder which seeks to promote interdisciplinary interaction among graduate students in STEM departments. The STEMinar hosts bi-weekly seminars given by graduate students about their research. Additionally, the STEMinar publishes a bi--annual journal featuring submissions from STEMinar participants, and gives out a number of research grants each year to support graduate students.

  In 2015, STEMinar ran 16 seminars, 8 in the Spring, 8 in the Fall. No information is available for attendance for the 8 fall semester seminars. ~200 graduate students attended 8 seminars in the spring.

II. EXTERNALLY-FUNDED GRANT-SUPPORTED PROGRAMS

Type II programs are funded by external agencies, providing IDC support to CU, CSL and collaborating departments, institutes, and colleges. Note that Otero's 15M+ in STEM education grants have not run through CSL due to constraints by the School of Education, however, external grants have supported much of her work with CSL.

A. Original STEM and Discipline-Based Education Research

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- **TRESTLE** (2015-2020) - TRESTLE is a multi-university project aimed at implementing and studying a model of STEM education reform, with the ultimate goal of achieving widespread adoption of empirically-validated instructional methods, and thus improving learning and educational outcomes for both STEM students and non-STEM students. In the first year of this grant, PI Chasteen has launched a competitive grants program directed at course transformation and faculty professional development. PI: Stephanie Chasteen; *Grant amount: $258,134.*

- **Talking about Leaving Revisited** (2012-2018) **-** The 1997 book *Talking about Leaving: Why Undergraduates Leave the Sciences* identified numerous factors that affect STEM persistence. Although there have been widespread efforts over the past 15 years to address these factors, we don't really know if these efforts have had any impact on students' experiences and whether these experiences, in turn, have influenced student persistence in STEM fields. This study explores current factors affecting students' decisions to stay in or leave their STEM majors. PI Anne-Barrie Hunter; *Grant Amount: $2,389,935.*

- **The STEM Institutional Transformation Action Research (SITAR) Project** (2015-2020) (also referred to as the DAT initiative) - The STEM Institutional Transformation Action Research (SITAR) Project, housed in the Center for STEM Learning, aims to improve undergraduate STEM education by professionalizing educational practice through measurement, assessment, and cultural change. We focus on department-wide change to achieve more coherent, long lasting reforms. PI Noah Finkelstein, Co-PIs: Melissa Dancy, Daniel Reinholz, Stanley Deetz and Joel Corbo; *Grant amount: $398,946.*

2015 SITAR Participant Breakout.

Year	*Undergrad.*	*Grad.*	*Post doc. /Instructor*	*Faculty*	*Staff*	*Total*
2015	1	3	4	12	1	**21**

- **Partnerships for Informal Science Education in the Community (PISEC)** (2014 - 2018) - PISEC is jointly sponsored by CSL and the JILA Physics Frontier Center, and is engaged in ongoing partnerships with local primary education sites to provide afterschool opportunities for students, especially under-represented minority (URM) students, to explore and develop excitement for science. Typically, PISEC will partner with 3-5 sites per semester and maintain weekly hour-long afterschool sessions where students, facilitated by volunteers from CU Boulder—typically graduate or undergrad students—explore hands-on science activities while practicing scientific skills, such as hypothesis-building, experimentation, scientific writing, reflection, etc. PISEC sites typically run for 8-10 weeks throughout the semester and culminate in a field trip where students visit CU, tour labs of their mentors, and participate in fun experiments. Since, 2015, PISEC has

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partnered with six different primary sites, implementing its weekly afterschool program at each. In spring 2017, PISEC began partnering with high school sites as well, and has implemented a high school program at two sites since then. PISEC has also hosted approximately five visits to the JILA PFC. PI: Noah Finkelstein, Co-PI Katie Hinko; *Grant amount: $3,400.*

PISEC only started recording student demographic data this semester, but approximately 90% of PISEC volunteers were graduate students this semester and participation is similar for previous semesters.

- **SciGirls** (2015 - 2018) - This three-year professional development initiative is designed to help career and technical education (CTE) educators and guidance counselors recruit and retain more girls in science, technology, engineering and math (STEM) pathways, specifically in technology and engineering. PI: Brad McLain; *Grant amount: $242,045.*

2015 SciGirls Participant Breakout.

Year	*Students*	*Faculty*	*Staff*	*Contractors*
2015	252	2	3	1

- **Bayer International Science Teens Annual Summer Camp** (Annually) - This innovative program has been designed for a small, select group of U.S. and international students from 12 countries who join together for hands-on, field-based experiences on human anatomy and physiology led by Dr. Brad McLain, XSci educators, and Anatomy in Clay creator Jon Zahourek. ANATOMY IN CLAY® models have been used in over 6,000 high schools, colleges, veterinary schools, and bodywork training programs. Camp attendees stay on the campus at the University of Colorado, Denver, for one week and on-site in a national park in Leadville, Colo., for the second week. PI: Brad McLain; *Funding amount: ~$130,000 annually from the Bayer foundation.*

2015 Bayer International Science Teen Camp Participant Breakout.

Year	*Students*	*Faculty*	*Staff*	*Contractors*
2015	20	2	3	6

- **The Access Network** (2015 - 2018) - The Access Network consists of six university-based programs co-working with graduate and undergraduate students across the country towards a vision of a more diverse, equitable, inclusive, and accessible STEM community. To realize this vision, Access and its member programs empower students as co-leaders, giving them voice and ownership over local and national efforts. Access sites focus on fostering supportive learning communities, engaging students in authentic

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science practices, and attending to students' development as STEM professionals. PI: Joel Corbo, Co-PI: Daniel Reinholz; *Grant amount: $23,179.*

- **Creating and Studying a National Network of Centers of STEM Education** (2015-2020) - The University of Colorado Boulder is one of the lead public campuses partnering with the Association of Public and Land-grant Universities to create a national network of about 200 campus STEM education centers. The network will provide programming and resources for established and new STEM centers including conferences, learning communities, an online engagement platform, toolkits of resources for centers and directory of centers for the community and external stakeholders. CU leads in the development and study of this network. PI: Noah Finkelstein; *Grant amount: $217,133.*

- **Photo Origami** (2014-present) - This project is part of a $2 million, 4-year NSF EFRI grant. While its primary focus is the development of a light-activated photo polymer, it also includes a rich outreach plan including a public education installation, working with an artist, and increasing opportunities for populations underrepresented in STEM. Geometry Point (a public park) is planned for installation based on mathematics, with a focus on how geometrical shapes "fold," hence the key component of Photo Origami.

  Project activities are being conducted in collaboration with CU Science Discovery, including the Summer Mentorship program (which brought in $300,000 additional grant money), summer camps, and outreach programs to over 10,000 teachers, in partnership with CSL, CU Outreach and Engagement, and the CU School of Engineering. *Grant amount: $472,737.*

2015 Photo Origami Education Outreach Activities and Locations.

Date	*Location*	*Program Type/Title*	*K-12 Students*	*K-12 Teachers*	*University Students*	*Adults*	*Total*
6/20/2015	CU Boulder~Science Learning Labaratory, Boulder CO	Photo Origami REM	2	0	0	0	2
7/3/2015	CU Boulder~Science Learning Labaratory, Boulder CO	Engineering is Everywhere Summer Camp	16	0	2	0	18

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7/24/2015	CU Boulder~Science Learning Labaratory, Boulder CO	21st Century Materials Science Summer Camp	16	0	2	0	18
7/27/2015	Syracuse University Biomaterials Instutute, Stracuse NY	Photo Origami and 3D/4D Design and Printing Teacher Professional Development Workshop	0	11	2	2	15
8/17/2015	CU Boulder~Idea Forge, Boulder CO	Photo Origami Teacher Professional Development Workshop for BVSD Teachers	2	50	4	4	60
10/12/2015	CU Boulder~Science Learning Labaratory, Boulder CO	Exploring Physical Science STEM Workshop Pilot Program	10	0	1	0	11
10/24/2015	CU Boulder~Science Learning Labaratory, Boulder CO	Engineering is Everywhere Teacher PD Workshops	0	6	0	0	6
11/4/2015	CU Boulder~College of Engineering, Boulder CO	Photo Origami/Centa rus HS programs	65	4	0	0	69
11/4/2015	CU Boulder~College of Engineering, Boulder CO	Photo Origami/Centa rus HS programs	85	6	0	0	91
11/19/2015	Northeast Junior College, Sterling CO	Exploring Physical Science STEM Workshop	70	14	0	0	84
11/20/2015	Northeast Junior College, Sterling CO	Exploring Physical Science STEM Workshop	95	19	0	0	114

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11/20/2015	Colorado Science Teachers Assoc. Conference, Denver CO	Photo Origami Teacher Professional Development Workshop	0	9	0	0	9
12/11/2015	Northwest BOCES, Steamboat Springs CO	Exploring Physical Science STEM Workshop	100	21	0	0	121
TOTALS			**461**	**140**	**11**	**6**	**618**

B. Initiatives to Improve STEM Education Access at CU

The Center for STEM Learning, the Office of Diversity, Equity, and Community Engagement (ODECE) and Center for Applied and Engineering Sciences (CAES) have partnered together to write grants to support initiatives designed to broaden access and diversity in STEM at CU Boulder.

- **Student support for joining the AAAS "Catalyzing Advocacy in Science and Engineering"** annual workshop. The competition is open to any full-time CU Boulder graduate student or upper-class undergraduate in appropriate STEM fields. From 2013-2017, CSL has partnered with the Graduate School to support the CIRES Center for Science and Technology Policy Research which hosts this initiative. 2-4 graduate students are sent each year.

- **S-STEM**: CSL staff and ODECE cooperated on writing and submitting a $5M NSF STEM scholarship grant to support STEM baccalaureate achievement of first-generation and low-SES students. Ultimately, submission was unsuccessful; CSL will resubmit in the next proposal cycle.

III. EXTRAMURAL EFFORTS

Type III programming running through CSL connects CU Boulder with prominent, prestigious national policy organizations focused on institutions of higher education and improving college-level teaching in STEM disciplines.

- **APLU**
  - ***Science and Mathematics Teaching Imperative*** - In 2008, APLU launched the Science and Mathematics Teaching Imperative (SMTI) in response to the National Academies' recommendation in *Rising Above the Gathering Storm* (2006) to prepare 10,000 new science and mathematics teachers each year. To join SMTI, the president of each higher education institution and system made a

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commitment to increase the quantity and quality and improve the diversity of secondary science and mathematics teachers prepared on their campus.

- ***Network of STEM Education Centers (NSEC)*** - Addressing calls from the White House and National Academies for multi-institutional approaches to transform undergraduate STEM education, we are building a national network of STEM Education Centers. These centers serve as the campus hub for improving the STEM learning experience for students, broadening participation in STEM, understanding teaching and learning, broadening the impact of campus research, and supporting national and regional scale improvement in STEM education.

- **AAU**
  - The Association of American Universities (AAU) is engaged in an initiative to improve the quality of undergraduate teaching and learning in science, technology, engineering, and mathematics (STEM) fields at its member institutions. It is an initiative based on overwhelming existing research to influence the culture of STEM departments at AAU universities so that faculty members are encouraged to use teaching practices proven to be effective in engaging students in STEM education and in helping students learn, particularly at the first-year and sophomore levels. In partnership with member universities, AAU works to understand the wider setting in which educational innovations take place — the department, the college, the university and the national level – and address the key institutional elements necessary for sustained improvement to undergraduate STEM education. AAU is committed to addressing the institutional and cultural barriers to reforming undergraduate STEM teaching and learning at research universities.

    The AAU Undergraduate STEM Education Initiative project at University of Colorado Boulder targets changes in both culture and structures to foster coherent, long-lasting reforms. The project uses a three-layer approach that focuses on faculty practices, departmental culture, and administrative support/policies.

- **Bay View Alliance (BVA)** - The Bay View Alliance is an international network of research universities exploring strategies for cultural change to support and sustain the widespread adoption of instructional methods that lead to better student learning. Outcomes from participation in the Bayview Alliance include:

  - Participation in RAC 1 Collaborative Transformation of Entry-Level Courses has examined course transformation programs as catalysts for change in faculty teaching practices and culture. The aim of this work is to learn how course transformation initiatives can advance the larger BVA goal of increasing faculty adoption and adaptation of evidence-based teaching methods supporting effective student learning. The TRESTLE grant award is a direct outcome of engagement with the Bayview Alliance.

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- Participation in Learning Analytics RAC 3: Big data analytics and institutional research software development: DASEE; Development of a course observation tool: OPLE and now the VIP service running in ASSETT.
- Participation in RAC 4 (Transforming the Evaluation of Teaching) has explored the process of transforming approaches to teaching evaluation, building on significant prior investments in STEM education reform programs and draws on a common framework grounded in two decades of scholarship on scholarly teaching and its evaluation and peer review of teaching. As an outcome of Bayview Alliance participation in RAC 4, Noah Finkelstein was awarded an NSF collaborative proposal to support implementation and evaluation adoption of improved methods for teaching evaluation.

- **Visits hosted by CSL -** In addition to the listed programming activities, the Center for STEM Learning serves as a clearinghouse for local, national and international institutions of higher education seeking to learn directly about STEM and discipline-based education research informed by the expertise of researchers in these fields at CU Boulder.
  - Colorado State University
  - Florida International University
  - University of Utah
  - Boston University

- **International Visitors -** In addition, over the past three years CSL has hosted a variety of individual visitors and teams from Japan, Korea, Brazil, Mexico, Ireland, England, Germany, Finland, and Sweden.

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BUDGET

Three Year History

Sources of Funds	FY14	FY15	FY16
General Fund Budget	$ 255,034.00	$ 442,127.00	$ 290,700.00
Auxiliary Funds	$ 6,059.00	$ 130,457.29	$ 10,000.00
Sponsored Projects	$ 884,396.69	$ 806,459.02	$ 1,188,235.85
Gift Funds*	$ 178,734.19	$ 134,440.87	$ 173,237.90
Other - please describe	$ -	$ -	$ -
Total	$ 1,324,223.88	$ 1,513,484.18	$ 1,662,173.75

* This should only include current gifts and endowment income (2xxxx and 3xxxx CU Foundation Funds)

Uses of Funds	FY14	FY15	FY16
Faculty/Exempt Salary	$ 487,438.28	$ 576,282.96	$ 748,769.23
Classified Salary	$ 1,069.00	$ 20,336.63	$ 30,480.68
Graduate Student Salary	$ 4,806.03	$ 46,194.23	$ 92,993.21
Hourly Salary	$ 3,958.50	$ 15,946.11	$ 14,029.64
Benefits Excluding Tuition Remission	$ 120,379.55	$ 141,221.08	$ 192,095.18
Tuition Remission	$ -	$ 27,608.78	$ 31,514.28
Operating Expenses	$ 243,391.02	$ 347,500.43	$ 238,423.71
Travel	$ 39,426.80	$ 48,690.64	$ 68,744.67
Financial Aid	$ -	$ -	$ 3,250.00
Fixed Assets	$ -	$ -	$ 48,228.73
GAIR	$ 463.62	$ 247.08	$ 1,697.22
F&A	$ 206,340.20	$ 177,024.19	$ 270,722.34
Transfers	$ (4,411.06)	$ 147,297.61	$ (69,323.37)
Other - please descibe	$ -	$ -	$ -
Total Expenses	$ 1,102,861.94	$ 1,548,349.74	$ 1,671,625.52
Total	$ 1,102,861.94	$ 1,548,349.74	$ 1,671,625.52
Annual sources less uses:	$ 221,361.94	$ (34,865.56)	$ (9,451.77)
Cumulative sources less uses:	$ 221,361.94	$ 186,496.38	$ 177,044.61

* Note: CSL seeds grant work for projects ***not*** running through the CSL; that is, CSL provides Chancellor's Award funding for efforts that are subsequently funded by external agencies such as NSF. The subsequent awards often operate through faculty members' own departmental units, and that DAICR is not returned to CSL, but to those academic units. ~$9M has resulted in extramural grant funding seeded by CSL Chancellor's Awards and is currently running to other departments / units in the 2012-2017 timeframe.

BUDGET USES

The majority of the Center for STEM Learning (CSL) budget is comprised of salary paid to conduct extramurally-funded research and sponsored projects. Salary is also provided for ~1.75 FTE staff (business manager, administration, program development and evaluation), modest support for the faculty co-directors (0.5-1 summer month salary), and student workers.

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Programmatic work includes the funding of the faculty and graduate student Chancellor's Awards for Excellence in STEM Education, STEM symposia, workshops, outreach, and community engagement.

Funds for travel (internally- and externally-funded), support hosting visitors / speakers, and sending CSL Fellows / leadership to participate in STEM education programs outside CU.

Materials and supplies are also budgeted for standard business operations of the CSL.

EVALUATION

As the operations of CSL are multi-faceted and multi-layered, so too are evaluation measures and efforts.

Administrative oversight. Coupled with our organizational structure and reporting, we produce Annual Reports and Executive Summaries that are shared publicly, and given specifically to:

- All members of our advisory board
- All Fellows (and reviewed on a regular basis in Fellows' meetings)
- The Dean of the Graduate School, to whom the Center reports, and the
- Provost

In addition, CSL's Project Management team meets annually with both the Dean of the Graduate School and the Provost to review Center activities, discuss funding, and priorities moving forward. Copies of Executive Summaries and extensive (roughly 100-page) reports can be found at: https://www.colorado.edu/csl/about/brochure-summaries-info-sheets-reports. The FY15 executive summary is included at the end of this document.

Biannual Fellows meetings allow Fellows' feedback on Center operations, budget, programming, and direction. Materials are prepared to share at Fellows' meetings and agendas and minutes from these meetings are kept for review by the Project Management Team and Fellows.

CSL signature programs undergo their own review. In particular, the Chancellor's Awards for Excellence in STEM Education (CSL's largest expenditure funded directly by the Provost's Office and the Graduate School), follows the scholarly peer-reviewed proposal process and is reviewed through: survey of awardees, analysis of award proposals and outcomes, tracking of subsequent funding / uptake, and annual project reports submitted by Chancellor's Award PIs. Dr. Chasteen conducted evaluation of professional development activities that she organized and implemented and provided written reports describing results.

Sponsored Project Evaluation. Each sponsored project running through the Center conducts its own annual evaluation. This work appears in annual reports to funders (NSF, Bayer, etc.). An example of these reports is the Bayer sponsored summer-camps running through CSL (http://www.xsci.org/bayer-international-science-teen-camp-2016/).

Evaluation of research and development projects in CSL also occurs through peer review of publications. We estimate ~15 peer-reviewed pieces from sponsored projects annually.

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Annual review of CSL staff is conducted. These annual merit reviews allow the leadership opportunity to ensure alignment of activities with center mission, and the opportunity to assess and reprioritize staff time and center resources.

External evaluation of CSL was previously supported by NSF-funding which allowed the Center to hire an external evaluator. This is no longer the case.

FUTURE GOALS

In the coming mid-scale term of one to five years, the Center is well positioned to assist the campus to develop and strengthen capacities around its teaching and learning mission to assure meaningful and effective outcomes for students and the University. It can uniquely contribute to the broader campus-wide initiatives in creating a centralized point for providing proven teaching and learning resources for administrators, faculty scholars and researchers, graduate students, and other campus professionals. In the coming five years, the Center will:

- Building on success of partnerships with AAU, APLU, the Alfred P. Sloan Foundation, and other national organizations, the CSL will continue contributing to and shaping the national discussion around STEM education.
- Funded research being conducted through CSL will continue contributing to and shaping national policy on undergraduate retention and persistence in STEM fields.
- The Center can significantly advance the nascent statewide STEM education efforts, such as building out the *STEM Education Roadmap* (http://www.coloradoedinitiative.org/)
- Through significant connections with leading journals, press and media outlets, CSL can showcase the success of our foundational work in advancing education, impacts on student persistence efforts and excellence in education.

Long-term outcomes of a robust Center for STEM Learning will be to secure our primacy in the space of STEM education, enhance our reputation throughout the state and nation, and establish productive partnerships and linkages regionally, statewide, nationwide and internationally.

Opportunities to enhance student success and retention through CSL programmatic initiatives include:

- increasing the use of postdoctoral Science Teaching Fellows (STFs) and ongoing development of effective assessment resources across all STEM fields. Through partnership in a centralized campus effort for teaching and learning, CSL could scale STFs across the entire campus;
- fostering foundational R&D by supporting and expanding our internationally-leading efforts in discipline-based education research (DBER);
- implementing DBER faculty lines across STEM departments. While a few departments currently house faculty in DBER, many more are seeking these agents of transformation and (e.g., mathematics, EBIO, MCDO and Integrated Physiology);

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- instituting a DBER graduate program across STEM disciplines in parallel with faculty DBER lines
- initiating a STEM teaching certificate for participants in the Learning Assistants program.

Long-term projections of Center impact on campus capacity and success include: anchoring a coordinated effort around teaching and learning; supporting 20 faculty lines and 50 graduate students in DBER; advancing programs that impact the majority of all undergraduate and graduate students on campus, and; further enhancing the preparation of future K20 teachers.

In terms of revenue, CSL is positioned to bring in millions of dollars of direct and indirect funding based on our national reputation and track-record as a leader in in discipline-based education research and transforming STEM education.

- The Center is positioned for fund-raising at large scale to secure federal grants to expand the operations of CSL.
- As the CU-Boulder Advancement office has reorganized and established pathways for supporting the Center and STEM education, there is tremendous potential for funding from foundations and private donors. For example, the Helmsley Trust, the Moore Foundation, the Alfred P. Sloan Foundation, Raytheon, 3M and Google are funding STEM Centers and programs across the country. The Center provides mechanisms and activities for us to coordinate with prospective donors.
- The Center's ongoing cooperation and collaboration with the preparation of proposals from other University departments and institutes to funding agencies will continue to enhance and make these proposals highly competitive.
- The Center is active in developing and submitting proposals to support infrastructure and systems level change directed at strengthening and expanding quality and access to STEM education at CU Boulder and statewide.

CSL will continue to serve as a campus-wide resource for the Broader Impacts requirements of many national funders. For the next five years, funding projected to come into the Center is in the millions of dollars, and to the campus overall through support of the Center is 11.3 million.

SUMMARY

The Center for STEM Learning seeks to fulfill its overall goals and objectives in alignment with the Chancellor's priorities for campus. CSL serves as a uniquely qualified partner in accomplishing the goals of continuing national renown in innovative STEM education and research, building and extending undergraduate student success and retention along with improved access and inclusiveness, and increasing revenue.

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CSL 2015 EXECUTIVE SUMMARY

Mission: *The mission of the 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.*

Vision: *The vision of the Center for STEM Learning 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. The Center seeks 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.*

Value proposition: *The Center for STEM Learning serves as a unique and innovative approach to address the Chancellor's priorities for campus: reputation, retention, and new models for revenue.*

EVIDENCE OF CSL CAPACITIES AND ACCOMPLISHMENTS

Reputation: *As national attention continues to focus on STEM education, CU-Boulder is seen as a national resource and innovator in this space*: **Boulder is seen as a national leader in STEM education**.

- The Center provides the collective home for many of the most-cited DBER scholars in the NRC 2015 Reaching Students report, as well as for our weekly DBER seminar series.
- CU-Boulder is highly engaged in prestigious national efforts to improve STEM education: CU Boulder is one of eight national demonstration sites selected to participate in the AAU STEM Education initiative and one of nine members of the Bay View Alliance. Additionally, with the APLU, CU-Boulder is building and hosting a national network of ~150 STEM education centers.
- Faculty Fellows of the Center serve on many, high-profile national committees in STEM education, including the National Academies and other national committees shaping education policy and practice in STEM fields
- The Center architected, hosted, organized, and ran a workshop as part of the President and First Lady's *College Opportunity Initiative* of 2014 for university presidents and leaders.

Student Success / Retention / Investing in the Student Experience: *The Center incubates, hosts, and advances new models of educational change and effective practices.* **Promoting student success and persistence in STEM is a priority of the CSL community**.

- The Center serves as resource, connector, and advocate for the nearly 100 programs in STEM education on the CU Boulder campus, advancing our collective mission for excellence and inclusion in STEM education and success for students across initiatives.
- The Center directly seeds innovation and advancement of student success through the Chancellors awards for STEM Educational Excellence. To date 35 faculty awards and 33 graduate awards have been granted, transforming STEM courses on this campus and

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contributing to the research base in science education.

- Through Center support to graduate students, there have been nearly a dozen Ph.D.s in discipline-based education research (DBER) across STEM fields.
- The Center hosts programs that are innovative and serve to advance students and teachers—from kindergarten through college. (Photo Origami, Talking about Leaving Revisited)
- The Center serves as a home for interdisciplinary discussions that advance our understanding of student learning and educational spaces and student success. Weekly DBER sessions and the graduate student STEMinar, are two such examples.

Models of Revenue: *The Center seeds new funding streams, supports extramurally-funded work from foundations and federal sources, and allows for agile and innovative approaches to revenue development.*

- Chancellor's Awards to 35 faculty have resulted in 11 NSF grants totaling roughly $5M, and more than $1.5M in F&A (indirect) to this institution.
- More than $4.6M in extramural funding runs though and is managed by the Center.
- Additionally the Center provides support and advising of national-scale grants that require education or broader impacts. Current (2015) activities of support include shaping the broader impacts and educational components of the current BioFrontiers National Research Training grant submission (~$2+M) and a current NSF STC proposal (~$49M)
- There is huge potential for development and advancement for CSL through active solicitation from the CU Foundation.

Additional Outcomes Advancing our Institution

The Center plays a key role in policy and advocacy in the region (BASEC), state (state legislature and the Colorado Education Initiative) and nationally (AAU, APLU, BayView Alliance) and serves as a primary resource to connect campus initiatives and programs (e.g. Grand Challenge, Spaces Initiatives, Student Persistence, etc.) to key individuals and people who are engaged in the study and transformation STEM education.

CSL FUTURE GOALS AND OBJECTIVES IN ALIGNMENT WITH INSTITUTIONAL MISSION

In the coming mid-scale term of one to five years, the Center is well positioned to assist the campus to develop and strengthen capacities around its teaching and learning mission to assure meaningful and effective outcomes for students and the University. It can uniquely contribute to the broader campus-wide initiatives in creating a centralized point for providing proven teaching and learning resources for administrators, faculty scholars and researchers, graduate students, and other campus professionals. In the coming five years, the Center will:

Enhance Reputation: *The CSL is positioned to move from being recognized as one of the national leaders in university-based STEM education to being the leader in STEM education.*

- Building on success of partnerships with AAU, APLU, the Alfred P. Sloan Foundation, and other national organizations, the CSL will continue contributing to and shaping the national discussion around STEM education.
- Funded research being conducted through CSL will continue contributing to and shaping

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national policy on undergraduate retention and persistence in STEM fields.

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Long-term outcomes of a robust Center for STEM Learning will be to secure our primacy in the space of STEM education, enhance our reputation throughout the state and nation, and establish productive partnerships and linkages regionally, statewide, nationwide and internationally.

Enhance Student Success / Retention: *The Center is ideally situated to serve as a resource to support the campus commitment to enhancing student success and retention.*

Opportunities to enhance student success and retention through CSL programmatic initiatives include:

- increasing the use of postdoctoral Science Teaching Fellows (STFs) and ongoing development of effective assessment resources across all STEM fields. Through partnership in a centralized campus effort for teaching and learning, CSL could scale STFs across the entire campus;
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Long-term projections of Center impact on campus capacity and success include: anchoring a coordinated effort around teaching and learning; supporting 20 faculty lines and 50 graduate students in DBER; advancing programs that impact the majority of all undergraduate and graduate students on campus, and; further enhancing the preparation of future K20 teachers.

Enhance Revenue: *The Center is positioned to bring in millions of dollars of direct and indirect funding based on our national reputation and track-record as a leader in in discipline-based education research and transforming STEM education.*

- The Center is positioned for fund-raising at large scale to secure federal grants to expand the operations of CSL.
- As the CU-Boulder Advancement office has reorganized and established pathways for supporting the Center and STEM education, there is tremendous potential for funding from foundations and private donors. For example, the Helmsley Trust, the Moore Foundation, the Alfred P. Sloan Foundation, Raytheon, 3M and Google are funding STEM Centers and programs across the country. The Center provides mechanisms and activities for us to coordinate with prospective donors.

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