



CENTER FOR STEM LEARNING 2016 ANNUAL REPORT

Contents

MISSION.....	1
VISION	1
VALUE PROPOSITION.....	1
CSL ORGANIZATIONAL STRUCTURE	2
PROGRAMS.....	2
BUDGET SOURCES	18
BUDGET USES	18
EVALUATION	19
FUTURE GOALS.....	Error! Bookmark not defined.
SUMMARY.....	22

CENTER FOR STEM LEARNING

2016 ANNUAL REPORT

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).

- 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

Currently, CSL operates without the benefit of a dedicated executive director. In practice, the Center for STEM Learning operates through the Project Management Team, comprised of Drs. Valerie Otero and Noah Finkelstein, co-directors of CSL, Anne-Barrie Hunter, CSL Program Development and Outreach and Evaluation Specialist, and William Tarantino, CSL Business and Program Manager. The Project Management Team meets biweekly, as possible; and once per month at least. Robbie Martinez and Michael Cramer assist Tarantino in office administration.

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 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

This section of the annual report presents programming supported by and running through the Center for STEM Learning and lists all of the events (workshops, colloquia, symposia, etc.) that CSL sponsored in the past year.

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)

The types of programming supported by the Center for STEM Learning 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. On September 28, 2016, CSL Celebrated the 8th annual symposium.

The keynote Speaker was Dr. Elaine Seymour, Director Emerita, Ethnography & Evaluation Research, University of Colorado Boulder; co-author of *Talking about Leaving: Why Undergraduates Leave the Sciences* (Westview Press: Boulder, CO).

Over 150 STEM education stakeholders gathered to celebrate ground-breaking STEM education projects on campus.

2016 Annual Center for STEM Learning Symposium on STEM Education Attendee Breakout.

<i>Year</i>	<i>Under-grad.</i>	<i>Grad.</i>	<i>Post doc</i>	<i>Fac.</i>	<i>Inst./Lecturer</i>	<i>Research</i>	<i>Staff</i>	<i>Admin</i>	<i>K-12/HS/2YC</i>	<i>Other Guests</i>	<i>Totals</i>
2016	4	18	1	54	7	18	31	7	13	14	167

- **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 2016, CSL granted five Chancellor’s Awards to 10 faculty members across several STEM departments (APS, CHEM, GEOSCI, MCDB, PSYCH & NEUROSCI), the College of Engineering and Applied sciences (CBE) and the School of Education. Three

Chancellor’s Awards were granted to three graduate students (CBE, the School of Education, and ATLAS).

2016 Faculty and Graduate Student Chancellor's Awards for Excellence in STEM Education Grantee Breakout.

<i>Year</i>	<i>Tenure Track/ Researchers</i>	<i>Post-doc/ Instructors/Staff*</i>	<i>Graduate Student</i>	<i>Total Individuals</i>
2016	1 MDCB 1 CBE 1 PSYCH & NEUROSCI 1 BIOCHEM	2 APS 2 GEOSCI 1 PSYCH & NEUROSCI 1 EDUC	1 CBE 1 ATLAS 1 EDUC	13

Between 2009 and 2016, CSL has funded a total of 76 Chancellor’s Awards. 38 Chancellor’s Awards were granted to a total of 58 faculty members. (Note: there are multiple investigators on several proposals; as well, SASC and three faculty members received funding twice). In addition, 38 Chancellor’s Awards have been granted to a total of 39 graduate students (just one proposal with multiple investigators; four graduate students received funding twice).

A study of outcomes resulting from Chancellor’s Awards conducted by CSL shows that the Chancellor's Awards program has contributed strongly to:

- course and laboratory development and transformation—focused on student-centered and active teaching and learning pedagogies, largely at the undergraduate level
- A high return on investment—faculty members reported receiving subsequent funding totaling over \$60 million to continue their research
- high success in publishing peer-reviewed articles and disseminating results at professional conferences nationally and internationally
- curricula and instruments being used at other institutions across the U.S.
- multiple personal and professional benefits—the opportunity to explore a new field of interest, engage in science education research, and for graduate students, financial assistance to pursue or complete a Ph.D.

In sum, the CA program has been highly successful in meeting its objective to support faculty and graduate student engagement in innovative research on student learning and implementation of research-based STEM education program initiatives.

- **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 31 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, ATLAS, CARTSS and NCWIT; ~20-25 Fellows attend each meeting.

In 2016, Fellows’ meetings were held:

- March 31
- December 7
- September 20

Meeting agendas and minutes of Fellows' Meetings held are posted for review and commentary on the CSL Fellows' website.

- **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.

2016 Fall DBER Schedule.

Aug 29	Kickoff Meeting: Formats and community matters
Sep 8	Henry Suarez , (School of Education) "Student Voice in Physics Whole-Group Discussions"
Sep 15	"A conversation about faculty assessment: quantifying a multi-dimensional phenotype"
Sep 21	"Conversation about teaching a disciplinary course to students outside that discipline."
Sep 29	"Close up and personal follow-up from STEM Symposium—Talking About Leaving Revisited" View a pdf of Elaine's presentation
Oct 6	Sarah Banchefsky , (Psychology and Neuroscience) #iLookLikeAnEngineer: "Improving Student Outcomes by Reducing STEM Stereotypes"
Oct 13	DBER as a working group "Crafting a statement about student evaluation of teaching"
Oct 20	Dea Greenhoot , (Psychology, University of Kansas) "Team-Designed Improvement of Writing and Critical Thinking in Large Undergraduate Courses"
Oct 27	Mike Klymkowsky , (MCDB) "Defining Scientific Literacy: what does it mean exactly, and how to assess it"
Nov 3	Jessica Alzen , (School of Education) "The Effect of the Learning Assistant Program on Graduation Rates at CU"
Nov 10	Lisa Corwin , (EBIO) "Connecting Lab Course Design to Outcomes: Project Ownership and Intent to Persist in STEM"

Nov 17	Chuck Hayward , (E&ER) "Supporting Instructional Change in Mathematics: The Role of Online and In-person Communities" View a previous paper on inquiry-based learning workshops in mathematics
Dec 1	Bilge Birsoy (MCDB) and Mike Klymkowsky (MCDB) "Development of a Scientific and Experimental Literacy Assessment (SELA) Instrument"
Dec 8	DBER celebration in Fiske Planetarium! Food and beverages served.

2016 Spring DBER Schedule.

Jan 26	Dimitri Dounas-Frazer (Physics) Designing a lab practical to assess physics students' ability to troubleshoot in an electronics course
Feb 2	1. Sara Brownell (Arizona State) Candidate for IPHY DBER assistant professor position 2. Emily Holt (Utah State) Candidate for EBIO DBER assistant professor position
Feb 9	1. Melissa McCartney (AAAS) "Students Reading Real Science: Primary Literature in the Classroom" 2. Michelle Smith (University of Maine) "What Are Students Thinking? Identifying and Helping Students Overcome Conceptual Difficulties in Biology"
Feb 16	Lacy Cleveland (University of Northern Colorado) Integrative Physiology candidate. "Thou shalt not fear science"
Feb23	Emily Moore (PhET) " Increasing the Accessibility of PhET Simulations for Students with Disabilities: Challenges, Progress, and Potential "
Mar 1	JT Laverty (Michigan State University) "Initiating and Assessing Transformation in Science Disciplines"
Mar 8	Faan Tone Liu (Math) and David Webb (School of Education) "Active learning and hands-on activities in undergraduate calculus"
Mar 15	Kate Semsar (MCDB) and Jenny Knight (MCDB) "A survey about the practices and impacts of concept assessments in biology"
Mar 29	Sarah Grover (PSYCH) "Women's Interpersonal Perceptions in Physics"
Apr 5	Jennifer Avena (MCDB) "How are we measuring what students learn? An examination of concept assessments and faculty assessments in genetics."
Apr 12	Laura Border (GTP and CIRTl), Anna Curtis (Graduate Student, Chemistry), Vicky Li (Graduate Student, Applied Math), and Wessam Beitelmal (PhD, Civil Engineering) "Provides an up-date on the GTP's Research on Academic Retention (ROAR) project which is funded on a grant through the CIRTl Network."

Apr 19	Elena Diaz-Billelo (School of Education) "Building 'Comprehensive' or 'Balanced' Assessment Systems in K-12 and Implications for the Higher Education Context."
Apr 26	Sam Severence (Institute of Cognitive Science, Chancellor's Award) and Enrique Lopez , (School of Education)

- **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, 2016, STEMinar was only active in the spring semester; no data is available for the 8 seminars held Spring semester.

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

- **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. PI: Stephanie Chasteen; *Grant amount: \$258,134.*

So far, TRESTLE has held one event on campus to disseminate preliminary project results.

September 2016 TRESTLE Annual Meeting (On- and Off-campus Program) Attendee Breakout.

<i>Faculty</i>	<i>Instructor /Lecturer</i>	<i>Staff</i>	<i>Admin.</i>	<i>Off campus</i>	<i>Total</i>
6	3	2	3	8 University of Kansas 5 Indiana University 5 University of British Columbia 4 Queens University 3 University of California Davis	44

				2 NCHEMS 1 University of Texas San Antonio 1 Brown University 1 Washington University in St. Louis	
--	--	--	--	---	--

- **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** (2016-2020) (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.*

2015-2016 SITAR Participant Breakout.

<i>Year</i>	<i>Undergrad.</i>	<i>Grad.</i>	<i>Post doc. /Instructor</i>	<i>Faculty</i>	<i>Staff</i>	<i>Total</i>
2015	1	3	4	12	1	21
2016	1	3	6	17	5	33

- **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 partnered with six different primary sites, implementing its weekly afterschool program

at each. PISEC has also hosted approximately five visits to the JILA PFC. PI: Noah Finkelstein, Co-PI Katie Hinko; *Grant amount: \$3,400.*

- **NSF/Twin Cities – Latina SciGirls (2015 - 2018)** - Latina SciGirls is developing a Spanish-language series of half-hour television episodes showing groups of girls and their Latina STEM mentors investigating culturally-relevant science and engineering problems of interest to Hispanic communities across the U.S. The project is also creating a series of family and girl-friendly online video profiles of Latina STEM professionals showing the daily life of a female scientist or engineer, and will provide opportunities to connect girls and their families with in-person Latina role models via community outreach in diverse Hispanic communities across the country. PI: Brad McLain; *Grant amount: \$120,234.*

2016 Latina SciGirls Participant Breakout.

<i>Year</i>	<i>Students</i>	<i>Faculty</i>	<i>Staff</i>	<i>Contractors</i>
2016	150	2	3	2

- **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.*

2015-2017 SciGirls Participant Breakout.

<i>Year</i>	<i>Students</i>	<i>Faculty</i>	<i>Staff</i>	<i>Contractors</i>
2015	252	2	3	1
2016	346	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.*

2015-2016 Bayer International Science Teen Camp Participant Breakout.

<i>Year</i>	<i>Students</i>	<i>Faculty</i>	<i>Staff</i>	<i>Contractors</i>
2015	20	2	3	6
2016	30	2	3	8

- 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 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.*

2016 Photo Origami Education Outreach Activities and Locations.

<i>Date</i>	<i>Location</i>	<i>Program Type/Title</i>	<i>K-12 Students</i>	<i>K-12 Teachers</i>	<i>University Students</i>	<i>Adults</i>	<i>Total</i>
1/5/2016	Akron High School, Akron CO	Photo Origami Teacher as Researcher Program	24	2	0	0	26

1/7/2016	CU Boulder~JSCBB, Boulder CO	Exploring Physical Science STEM Workshop	65	7	1	6	79
1/14/2016	Montesorri Peaks Academy, Littleton CO	Engineering is Everywhere STEM Workshop	90	4	0	0	94
1/15/2016	Montesorri Peaks Academy, Littleton CO	Engineering is Everywhere STEM Workshop	87	4	0	0	91
1/29/2016	Colorado Mountain College, Craig CO	Exploring Physical Science STEM Workshop	105	22	0	0	127
2/4/2016	Sherrelwood Elementary School, Northglenn CO	Engineering is Everywhere STEM Workshop	54	2	0	0	56
2/5/2016	Broomfiled Library, Broomfield CO	21st Century Materials Classroom Presentation	21	1	1	1	24
2/12/2016	Granby Elementary School, Granby CO	Exploring Physical Science STEM Workshop	80	12	0	0	92
2/12/2016	Northglenn High School, Northglenn CO	3D Printing and Loan Program Training	14	15	0	1	30
2/24/2016	Cherry Creek School, Denver CO	Photo Origami Teacher as Researcher Program					
2/13/2016	East Grand Middle School, Granby CO	Photo Origami Teacher as Researcher Program	35	2	0	0	37

3/3/2016	St. Vrain School District, Longmont CO	Exploring Physical Science STEM Workshop	81	9	0	4	94
3/5/2016	CU Boulder~Science Learning Laboratory, Boulder CO	Engineering is Everywhere Teacher PD Workshop	0	6	0	0	6
3/13/2016	American Chemical Society's Annual Conference, High School Teacher Day Event, San Diego CA	Photo Origami Teacher PD	0	62	10	10	82
3/21/2016	CU Boulder~JSCBB, Boulder CO	3D/4D Design and Printing Teacher Professional Development Workshop	0	5	0	0	5
4/6/2016	CU Boulder~Science Learning Laboratory, Boulder CO	3D/4D Design and Printing Teacher Professional Development Workshop	0	12	0	0	12
4/8/2016	Colorado Mountain College, Glenwood Springs CO	Exploring Physical Science STEM Workshop	107	21	0	0	128
4/20/2016	West Middle School, Grand Junction CO	3D Printer Loan Program~ loan of 1 Lulzbot A-101 3D Printer					
4/30/2016	CU Boulder~Science Learning Laboratory, Boulder CO	Exploring Physical Science Teacher Professional Development Workshop		10	0	0	10

5/2/2016	Salida Middle School, Salida CO	Exploring Physical Science STEM Workshop	100	21	0	0	121
5/6/2016	Casey Middle School, Boulder CO	3D Printer Loan Program~ 2 week loan of 2 TAZ-Mini 3D Printers					
5/12/2016	STEM Magent Lab School, Northglenn CO	3D Printer Loan Program~ 2 week loan of 3 TAZ-Mini 3D Printers					
5/13/2016	CU Boulder~JSCBB, Boulder CO	Exploring Physical Science STEM Workshop	30	6	0	0	36
5/20/2016	Naturita Central Schools, Naturita CO	3D Printing Teacher Professional Development Workshop	0	10	0	0	10
TOTALS			893	233	12	22	1160

- STROBE: Science and Technology Center on Real-time Functional Imaging** (6/1/2016-8/31/2021) - The mission of STROBE is to create powerful and broadly-applicable real-time nano-to-atomic scale imaging modalities to advance imaging science and increase access, that can be used to address grand challenges in science and technology, while building a diverse STEM workforce. The education and broader participation aspects of STROBE are managed by CSL, ~\$1,000,00. PI: Margaret Murnane; Grant amount: NSF IIA – Sci & Tech Centers STC \$24,000,000.

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.

- Creating Academic Pathways in STEM (CAPS) initiative** - The CAPS project seeks to create a cooperative and transformational infrastructure that streamlines STEM pathways

for diverse students transferring from five Denver-metro 2-year colleges (2YCs) to 4-year colleges (4YCs) in the state of Colorado. By developing a student-centered infrastructure focused on lowering and eliminating barriers that inhibit 2YC student transfer to 4Y institutions, this initiative intends to increase the number of talented 2YC students interested in pursuing a STEM baccalaureate to successfully transfer and graduate, ultimately advancing the technical capacity of Colorado and our nation's workforce. To this end, an NSF INCLUDES grant has been submitted. PI: Sarah Miller (BOLD Center); Co-PIs: Noah Finkelstein, Anne-Barrie Hunter, Sean Shaheen. *Grant amount:* \$265,560.

CSL and the BOLD Center sponsored a "town hall" meetings to garner and assess stakeholders' interest in the INCLUDES initiative.

October 11, 2016 Town Hall INCLUDES Meeting Attendee Breakout.

#	Role	College/School/Organization
12	Faculty	7 A&S
		3 CAES
		1 EDUC
		1 2YC
7	Staff	3 A&S
		2 CAES
		1 CSL
		1 ODECE
6	Administrators	2 CU (A&S, CAES)
		2 CCHE
		1 K-12
2	Researchers	1 National lab
		A&S, CIRES
1	Instructor	A&S
1	Transfer student	A&S (STEM major)
29	Total	

- **S-STEM:** To support efforts in the INCLUDES initiative, 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. Awards should be announced in October 2017.
- **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 2013-2016, 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.

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 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.
 - 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 2016** - 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. As an example, below is the itinerary for a visit from administrators at UT Austin:

University of Texas at Austin (February 18-29, 2016): Visitors:

- Linda Hicke, Dean of the College of Natural Sciences
- Hans Hofmann, Professor of Integrative Biology
- Michael Drew, Assistant Professor of Neuroscience
- Cathy Stacy, Sr. Assistant Dean for Strategy and Planning/Statistics

The goal of the visit is to focus on: the goals, activities, metrics of success, lessons learned of the SEI, LA program, and any faculty teaching professional development initiatives, as well as to see active learning in action, especially in large courses.

February 2016 UT Austin Site Visit Itinerary

<i>Itinerary Activity</i>	<i>CU Boulder Individuals Met</i>
Course observation: teaching with Learning Assistants (LAs): <i>Laboratory Techniques in Neuroscience</i>	Heidi Day, Neuroscience; LA Russell Ravenel
Science Education Initiative (SEI)	Kathy Perkins, Director, SEI, and Stephanie Chasteen, SEI, Internal Evaluator, both Physics; Kate Semsar, Science Teaching Fellow, IPHY
Learning Assistant (LA) program	Valerie Otero, School of Education, Executive Director, LA program; Co-director, Center for STEM Learning; Laurie Langdon, School of Education, Director, LA program
Active learning in large courses and curriculum design	Jenny Knight, MCDB
Innovation in faculty evaluation	Noah Finkelstein, Physics, Co-director, Center for STEM Learning
Course observation: <i>Introduction to Quantitative Thinking for Biologists</i> .	Andrew Martin, EBIO
Course observation <i>Principles of Genetics</i>	Jenny Knight, MCDB
Big data and institutional analytics	Mark Werner, Associate Director of Academic Technology Strategy and Support; Bay View Alliance RAC 3 member
Biological Sciences Initiative (BSI) and Course-based Undergraduate Research Experiences (CUREs)	Deborah Wuttke, HHMI PI, Chemistry and Biochemistry; Julie Graf, Director, BSI and HHMI Co-PI; Tin Tin Su, MCDB; Corrie Detweiler, MCDB; Niels Damrauer, Chemistry; Pam Harvey, Instructor of intro and advanced CUREs
A coherent curriculum project in MCDB and course reform efforts in chemistry (Biofundamentals) and mathematics (Calculus, Systems, and Modeling course redesign)	Mike Klymkowsky, MCDB
Innovative STEM education, SEI, and TRESTLE	Janet Casagrand, IPHY; Andy Martin, EBIO
CADRE	Derek Briggs, Director, Center for Assessment, Design, Research and Evaluation (CADRE)

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.

BUDGET SOURCES

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 describe	\$ -	\$ -	\$ -
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.

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.

Another way to consider the CSL budget:

Base Operating Expenses for the CSL run ~\$145k/year, which provides ~1.75 FTE, consultants, materials, travel, and some programming. As noted in Q5, these are largely funded internally

- Internally-funded Efforts:
 - Annual faculty and graduate Chancellor's Awards for Excellence in STEM Education (~\$120k/ year);
 - Special initiatives like support for the AAAS "Catalyzing Advocacy in Science and Engineering" annual workshop sponsored by CSL and the Graduate School to support the CIRES Center for Science and Technology Policy Research which hosts this initiative.
- Externally-funded Efforts:
 - These are both programmatic and research-based efforts supported by NSF, AAU, Bayer, etc., and mostly go to fund people to conduct research and programmatic work (e.g., grants, workshops, sponsored programs, ~\$710k/year).

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 FY16 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 accounts. 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. For example, the STEM Institutional Transformation Project that is operating in CSL has yielded half-a-dozen publications.

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

Building on six years of success, the Center has tremendous long-term potential for continuing to contribute to the advancement of our institution by serving as a key strategic tool to address the University's priorities of reputation, retention, and new models for revenue.

The Center for STEM Learning's goals and objectives are aligned with the University's 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. While the Center will maintain a focus on STEM fields, 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. CSL creates and advances research-based model programs that improve students' educational experiences, conducts foundational research and development in education, and professionalizes (and recruits professionals) education; we are ideally situated to support and assure the University's success in implementing its mission.

In the next five years, 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. CSL is ideally situated to house a national network of STEM education centers through a \$1.5M 2015 award of an NSE IUSE grant to APLU, CU and UMass.
- The Center can significantly advance the nascent statewide STEM education efforts, such as building out the STEM Education Roadmap, which until CSL became engaged in the initiative, did not include higher education.
- 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.

Additionally, CSL is ideally situated to serve as a resource to support the campus commitment to enhancing student success and retention. CSL can serve as a key actor and anchor to any coordinated / affiliated network of teaching and learning program on campus by housing programs and conducting foundational research and development (R&D). CSL hosts and expands programs that improve educational experience of undergraduates (e.g., the nationally renowned efforts in the Science Education Initiative), where added educational resources such as Science Teaching Fellows, and the development of effective tools for assessment advance departmental commitment to effective educational practices. 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, MCDB and Integrated Physiology);
- Instituting a DBER graduate program across STEM disciplines in parallel with faculty DBER lines
- Initiating a STEM teaching certificate for the Learning Assistants program.

The resources and human capital in the Center will serve any campus move to create a coordinated teaching and learning effort. In addition to the programmatic work of the Center, the staff and faculty director of the center will serve as key resources for building an affiliated

network of programs around teaching and learning. Long-term projections of Center impact on campus capacity and success include: anchoring a coordinated effort 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.

Given our national standing and proven track record, the Center is positioned for fund-raising at large scale to secure federal grants to expand the operations of CSL. We have already been asked to submit to current NSF calls for proposals on the scale of \$1-5M.

- 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. Within the last three months the Center has played an integral role in the submission of the BioFrontiers National Research Training grant (\$3M) and the STC STROBE optics proposal (\$49M)).
- 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 (\$270M/year), 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.
- 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. See the budget projections below.

Thus 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.

SUMMARY

In sum, 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.



2016 EXECUTIVE SUMMARY: THE CENTER FOR STEM LEARNING

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, and to facilitate change in STEM education by integrating an interdisciplinary community of scholars, promoting, sustaining, and evaluating existing reform efforts, sponsoring new programs, advocating for diversity and access, influencing relevant policy, fundraising, and communicating with the public.

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.

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.

Evidence of CSL impact and success:

- Boulder is seen as a national leader in STEM education, and recognized as such by Bruce Alberts (past president of National Academies), and Hunter Rawlings (president of AAU). As detailed below, these prominent and influential national policy-setting agencies fund research studies supported and seeded by the Center.
- Articles about CU-Boulder STEM education and our Center have been published in the New York Times, Science Magazine, and the National Academies Press.
- In the recent National Research Council report, [Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering \(2015\)](#), there is no institution more cited for research and innovation in STEM education than CU-Boulder. The Center provides the collective home for many of the most-cited discipline-based education research (DBER) scholars in this report, as well as for our weekly DBER seminar series.

- CU Boulder was selected as one of eight national demonstration sites for the AAU STEM Education initiative. CU Boulder is one of nine selected members of the Bay View Alliance—a national coalition to study and promote institutional change. With APLU, CU-Boulder is
- Strength of STC
- Biofrontiers IGERT grant
- INCLUDES in
- S-STEM being submitted
- At recent NSF EnFUSE conference: CU a member and participant called out in 5 of the 10 cutting edge STEM transformation efforts: AAPLU, AAU STEM Education Initiative, Bay View, CIRTL, DBER
- building and hosting a national network of ~150 STEM education centers. Each of these initiatives runs through the Center.
- Faculty Fellows of the Center serve on many, high-profile national committees in STEM education, including the National Academies committees, AAU advisory committee, APLU committees, and committees shaping education policy and practice in the fields of physics, chemistry, biology, mathematics, and engineering.
- As part of the President's and First Lady of the United States of America *College Opportunity Initiative* of 2014, the White House Office of Science and Technology Policy co-sponsored four national workshops on STEM education; CU-Boulder was selected as partner to host one of these: the September 29, 2015 meeting for university presidents and leaders. The Center architected, hosted, organized, and ran this workshop.

Student Success / Retention / Investing in the Student Experience

The Center incubates, hosts, and advances new models of educational change and effective practices.

Evidence of CSL impact and success:

- The Center serves as resource, connector, and advocate for the nearly 100 programs in STEM education on the CU Boulder campus. The Center supports these programs that advance all students' success, but particularly for women, underrepresented minorities and first-generation college students. Through the weekly DBER seminar series, online resources, an annual symposium, specialized workshops and conferences, advising, and administrative support, the Center advances 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. There have been 35 faculty awards and 33 graduate awards. These awards have seeded new educational initiatives spanning science and the arts (for instance, LearnChemE, whose online education resources for chemical engineering are downloaded hundreds of thousands of times per year (<http://www.learncheme.com>), and innovative Boulder Laptop Orchestra ([BLOrk](http://www.colorado.edu/music/ensembles/blork-boulder-laptop-orchestra)), which integrates technology with improvisers in an ensemble setting providing live interaction between the two(<http://www.colorado.edu/music/ensembles/blork-boulder-laptop-orchestra>).

- As a result of Center support provided to graduate students, there have been nearly a dozen Ph.D.s in discipline-based education research (DBER) in the fields of engineering, physics, astrophysics, and atmospheric sciences, among other disciplines.
- The center hosts programs that are innovative and advance our understanding of student learning and educational spaces, and directly serve to advance students and teachers. For instance, the influential study, *Talking about Leaving: Why Undergraduates Leave the Sciences* is currently being replicated, and augmented, by researchers here at CU and at the University of Wisconsin (<http://talr.wceruw.org/>) is housed within the Center, as is the experiential science (XSci) project, which researches, develops and provides experiential learning programs to students and teachers across the state and nationally through the Battelle STEMx network (<http://www.xsci.org/>). Currently, the Center hosts a variety such programmatic efforts and is focused on growing these efforts.
- The Center serves as a home for interdisciplinary discussions that advance student success. Center Fellows are currently engaged in efforts to examine graduate programs in STEM education, advance under-represented student access through coordinated research experiences, and more.

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.

Evidence of CSL impact and success:

- Through the Chancellor's Awards, the Center has provided 23 faculty awards (up to \$10k/ each); these have resulted in the award of 11 National Science Foundation (NSF) grants totaling roughly \$5M, and more than \$1.5M in F&A (indirect) to this institution. Notably these grants, while incubated through the Center, are run through departments and directly support the Colleges of Engineering & Applied Sciences, Arts and Sciences, and School of Education.
- In addition to the awards mentioned above, more than \$4.6M in extramural funding is running though (and managed) by the Center. These awards represent significant national projects, including:
 - The Talking about Leaving –Revisited (funded by Sloan and NSF) \$2.2 million
 - Experiential STEM education (XSci, Funded by Merck and Bayer) \$1.6 million
 - Learning Mathematics in the Community (NSF funded) \$350k
 - University-Community Partnerships (PISEC, funded by NSF) \$ 300K
 - Faculty Development/ Nat'l New faculty workshops (funded by NSF) \$210K
- Additionally the Center provides support and advising of national-scale grants that require education or broader impacts work. For example, CSL has successfully contributed to the funding of the:
 - HHMI Biological Sciences Initiative (\$1M) to incorporated course-based research experiences in Biology
 - IQ graduate fellows program in BioFrontiers (~\$3M)
 - COSI-IGERT graduate program in engineering (\$3M).

Current (2015) activities of support include shaping the broader impacts and educational components of the current BioFrontiers National Research Training grant submission (\$3M) and the JILA/Physics Frontier Center's Science Technology Center Proposal (\$25M).

- As the CU-Boulder Advancement office has reorganized and established pathways for supporting the Center and STEM education, huge potential awaits from foundations and private donors. Helmsley Trust (\$270M / year), Moore Foundation, etc. are funding programs across the country in this arena, and the Center provides mechanisms and activities for us to coordinate with prospective donors.

Additional Outcomes Advancing our Institution

Evidence of CSL impact and success:

- The Center plays a key role in policy and advocacy in the region (BASEC), state (state legislature) and nationally (federal programs).
- The Center 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 of educational experiences for our students with the goal of strengthening excellence in STEM education, providing greater access and inclusiveness for student groups traditionally underrepresented in STEM fields, and building the foundations for all students' achievement and success.

CSL Future Goals and Objectives

Building on six years of success, the Center has tremendous long-term potential for continuing to contribute to the advancement of our institution by serving as a key strategic tool to address the University's priorities of reputation, retention, and new models for revenue.

The Center for STEM Learning's goals and objectives are aligned with the University's 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. While the Center will maintain a focus on STEM fields, 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. CSL creates and advances research-based model programs that improve students' educational experiences, conducts foundational research and development in education, and professionalizes (and recruits professionals) education; we are ideally situated to support and assure the University's success in implementing its mission.

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. CSL is ideally situated to house a national network of STEM education centers through a \$1.5M 2015 award of an NSE IUSE grant to APLU, CU and UMass.
- The Center can significantly advance the nascent statewide STEM education efforts, such as building out the STEM Education Roadmap, which until CSL became engaged in the initiative, did not include higher education.
- 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.

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. CSL can serve as a key actor and anchor to any coordinated / affiliated network of teaching and learning program on campus by housing programs and conducting foundational research and development (R&D). CSL hosts and expands programs that improve educational experience of undergraduates (e.g., the nationally renowned efforts in the Science Education Initiative), where added educational resources such as Science Teaching Fellows, and the development of effective tools for assessment advance departmental commitment to effective educational practices.

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, MCDB and Integrated Physiology);
- Instituting a DBER graduate program across STEM disciplines in parallel with faculty DBER lines
- Initiating a STEM teaching certificate for the Learning Assistants program.

The resources and human capital in the Center will serve any campus move to create a coordinated teaching and learning effort. In addition to the programmatic work of the Center, the staff and faculty director of the center will serve as key resources for building an affiliated network of programs around teaching and learning. Long-term projections of Center impact on campus capacity and success include: anchoring a coordinated effort 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

- Given our national standing and proven track record, the Center is positioned for fund-raising at large scale to secure federal grants to expand the operations of CSL. We have already been asked to submit to current NSF calls for proposals on the scale of \$1-5M.
- 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. Within the last three months the Center has played an integral role in the submission of the BioFrontiers National Research Training grant (\$3M) and the STC STROBE optics proposal (\$49M).
- 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 (\$270M/year), 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.
- 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. See the budget projections below.

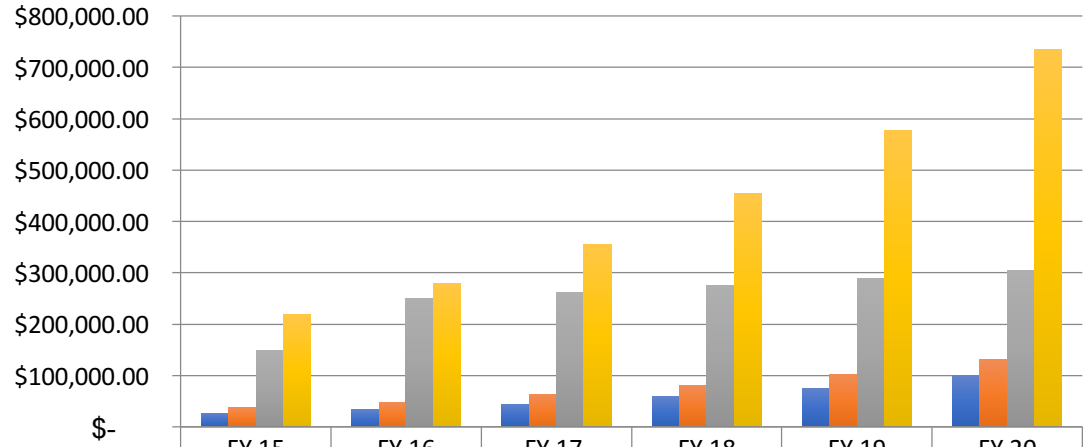
Thus the Center is positioned to bring in millions of dollars of direct and indirect funding based on our national reputation and track-record as a leader in in discipline-based education research and transforming STEM education.

SUMMARY

In sum, 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.



CSL Growth Plan for FY15-FY20



	FY 15	FY 16	FY 17	FY 18	FY 19	FY 20
■ Estimated Indirect Cost Recoveries on Grants & Contracts through CSL:	\$27,801.00	\$35,360.36	\$45,968.47	\$59,759.01	\$77,686.71	\$100,992.7
■ Estimated Indirect Cost Recoveries on Grants & Contracts as a Result of CSL Efforts, Running through PI's Home Departments:	\$39,713.25	\$50,511.67	\$64,246.28	\$81,715.46	\$103,934.6	\$132,195.5
■ Base Operating Budget:	\$150,000.0	\$250,750.0	\$263,287.5	\$276,451.8	\$290,274.4	\$304,788.1
■ Total F&A as a Result of CSL and All Affiliated Awards:	\$220,629.1	\$280,620.3	\$356,923.7	\$453,974.7	\$577,414.8	\$734,419.5