Caltech Center for Teaching, Learning, & Outreach

Five Year Anniversary Update: 2012 – 2017

Executive Summary:

In the fall of 2012, the California Institute of Technology launched the Center for Teaching, Learning, & Outreach: a new office, reporting to the vice provost for education, intended to enhance support for the institute's educational efforts at both the undergraduate and graduate levels, along with partnerships involving preK-12 schools and educators.

Through the CTLO, Caltech's engagement in the educational aspects of its mission is now quite substantial. In its first five years of operation, the CTLO has, for example:

- **Engaged 297 faculty members in high-quality programs and services** (268 of them professorial faculty—over 85% of this population). Participating faculty represent all divisions and ranks, and over half (54%) re-engage with CTLO in significant depth (e.g., through multiple programs, sustained collaboration, and/or in-depth consultation).
- **Worked with 1321 unique graduate students** and 471 unique postdoctoral scholars. Many of them interact with CTLO on multiple occasions during their time at Caltech, as TAs and to enhance their professional development related to teaching and outreach.
- **Helped improve over 90 different Caltech courses** by working closely with instructors on course (re)design, teaching methods, assignments, and assessments, as well as helping instructors obtain and make sense of customized feedback.
- **Increased Caltech's impact on pre-college students, teachers, and parents** in the Pasadena and Southern California region to over 17,500 contacts per year (2016-17).
- **Helped Caltech researchers prepare almost 70 grant proposals** with educational or "broader impacts" components, with a success rate of 55% and an additional 30% receiving entirely positive reviews on educational elements.

CTLO is poised to continue translating engagement into positive impact, building on documented increases in student learning in transformed courses, improvements in students' subjective experience at Caltech, and effects on local preK-12 STEM education. New endeavors and plans include:

- Bringing more **cohorts of faculty** together for sustained work through multi-week programs such as the annual Faculty Summer Short Course and the Inclusive Caltech Core Project (the latter supported by a mini-grant from the Association of American Universities—one of twelve awarded nationally).
- Partnering with **departments and divisions** to pilot deeper and more discipline-specific support, especially for teaching assistants in critical areas with large undergraduate courses such as physics, mathematics, chemistry, and computer science.
- Emphasizing deeply **symbiotic educational outreach** efforts: i.e., those that positively contribute to local/regional preK-12 STEM education and simultaneously provide enriching professional development opportunities to Caltech students and researchers.

With existing staffing and capacity, CTLO is placing an emphasis on sustainable and efficient programming, while continuing to work closely with staff from Development and Institute Relations on fundraising for current and anticipated needs.
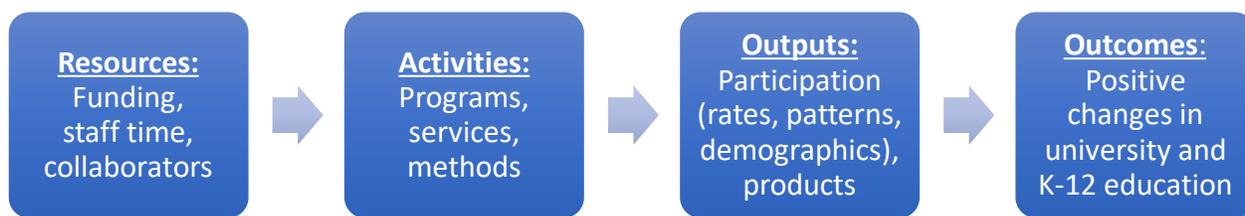
Caltech Center for Teaching, Learning, & Outreach

Five Year Anniversary Update: 2012 – 2017

Details, Trends, and New Directions

The context for university work on teaching and educational outreach is changing.

Setting the scene for CTLO's efforts, the national context among peer institutions and higher education more broadly continues to evolve. In the past year, major national organizations have increased attention and documented progress and ongoing needs for science, technology, engineering, and mathematics (STEM) education improvements: e.g., Five-Year Status Report on the AAU Undergraduate STEM Education Initiative. Others, such as the American Academy of Arts and Sciences, have called attention to the need for an increased focus on educational quality across disciplines: The Future of Undergraduate Education, The Future of America. In addition, the American Council on Education (ACE) has made a more robust case for ways in which improving instructional quality can positively impact institutional finances and the need for institutional commitment to teaching excellence through faculty development. Beyond immediate requirements for attention to STEM education in research proposals, such as NSF's broader impacts criterion, the level of consensus among Caltech's peer institutions about the importance of specific, intentional action on educational quality is clearer than ever. Research universities are increasingly examining ways to motivate and support faculty efforts to implement research-based teaching practices and build strong, diverse pathways into and through STEM curricula. Topics under discussion and reform include reward structures, methods for documenting/evaluating teaching, coordinated actions across disciplines and divisions, and coherent institutional messaging about the importance of educational efforts.

CTLO employs carefully chosen strategies that are known to be effective, tailored to Caltech.

With attention to research on organizational change and effective STEM educational practices—both growing fields of knowledge—CTLO's efforts rely on carefully designed models for impact. Deployment of our internal resources (CTLO funding and staff time) is designed to multiply our efforts and yield results. Appendix 1 shows detailed logic models, indicating how resources and activities produce the observable outputs (participation rates and products of interventions) and outcomes (positive changes in university and K-12 education). In the long term, our efforts are designed to contribute to a sustainable culture of excellence in teaching and educational outreach, improved student learning and experiences, increases in evidence-based educational practices, rewarding teaching experiences for faculty and TAs, an enlarged and more diverse local K-12 STEM pipeline, and increased K-12 and public STEM literacy and engagement.

Resources: Funding, staff time, collaborators	→	**Activities:** Programs, services, methods	→	**Outputs:** Participation (rates, patterns, demographics), products	→	**Outcomes:** Positive changes in university and K-12 education

Overall, the number of CTLO services to Caltech affiliates continues to rise each year.

We define a service as one person participating once in a CTLO offering, providing a measure of the overall volume of activity; if an individual participates several times with CTLO, this counts as multiple services. Peer institutions with similar centers, using the same definition of a service, typically deliver in the range of 0.2 to 0.4 services per student FTE (a normalization for institutional size) per year; in 2016-17, CTLO delivered over 1.0 services per student FTE, indicating the high volume of service we provide.
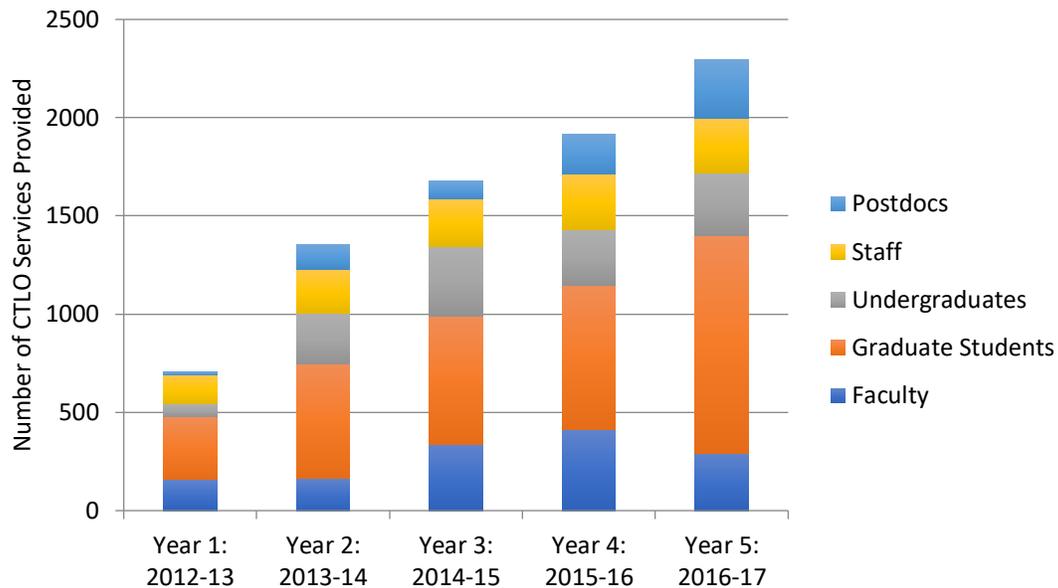
CTLO's reach within the Caltech population is high, with several interesting trends worth noting.

Faculty: the large majority of faculty work with CTLO, most in considerable depth, and with growing interest in group experiences.

In five years, 297 unique Caltech faculty members (268 professorial faculty) worked with CTLO, ranging from individual, in-depth consultations to participation in small and large group programs and events. Taking into account a small number of faculty departures, CTLO has worked with over 85% of all professorial faculty. We now work with approximately 45% of Caltech faculty each year, spanning all divisions and ranks.

The majority (54%) of unique faculty participants have worked with CTLO at moderate or deep levels of engagement in the past five years—that is, they participated in three or more programs and/or one or more in-depth consultations, such as course redesign, grant proposal development, or customized feedback. 34% of unique faculty participants worked with us on both university teaching and educational outreach, 60% on university teaching only, and 6% on outreach only.

Faculty engagement in group events has increased markedly. In CTLO's early years, more faculty worked individually with CTLO than attended group opportunities. The crossover occurred in 2014-15 when, with new funding from the Twenty-Seven Foundation, CTLO began to partner with options and divisions to host discipline-based talks and workshops. In 2015-16 and 2016-17, group participation dwarfed individual consultations, as we continued department/division collaborations, started TeachWeek, and offered a four-week Faculty Summer Short Course. These

visible group events build community and may serve to normalize commitment to teaching. They are also crucial for CTLO's sustainability; while individual consultations are indispensable, they are difficult to scale with limited resources.

Since 2012, CTLO has assisted with 69 research grant proposals containing educational, outreach, and/or broader impacts elements. Of the 44 with decisions rendered within the five-year period, 55% were awarded or advanced to the next round, a success rate that is well in excess of national rates. 30% were declined *with positive reviews of educational/broader impacts elements*, indicating that these components are unlikely to have contributed to the denial of funding. 7% (three proposals) were declined with mixed reviews of educational/BI elements (e.g., reviewers asked for more detail or expressed skepticism about Caltech's small size or ability to contribute to diversity in STEM due to our overall demographics); 9% were declined with review details not available.

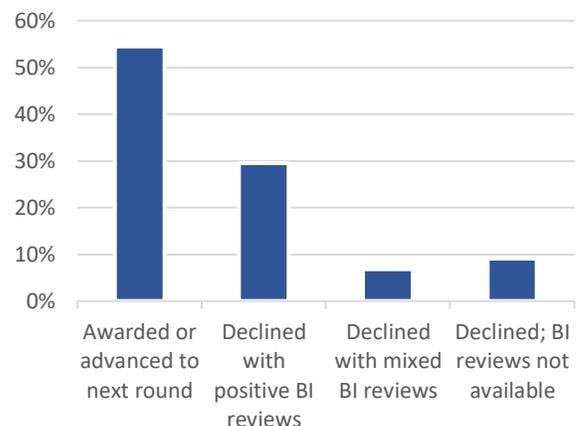**UNIQUE FACULTY PARTICIPANTS BY DIVISION**
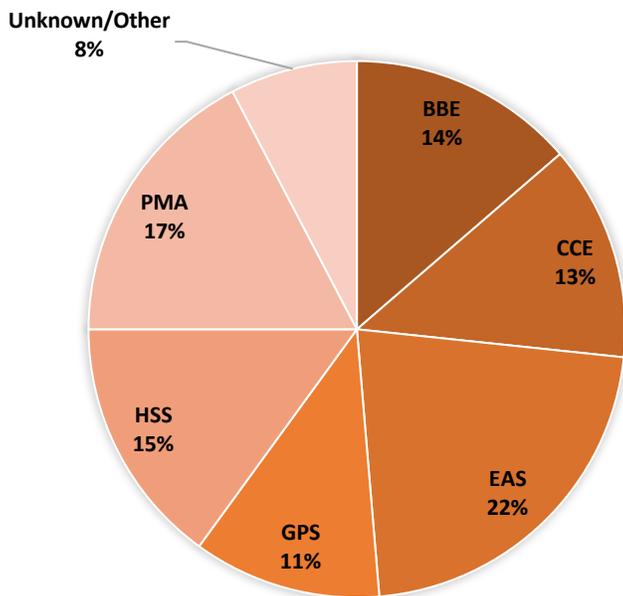
FACULTY SERVICES BY TYPE
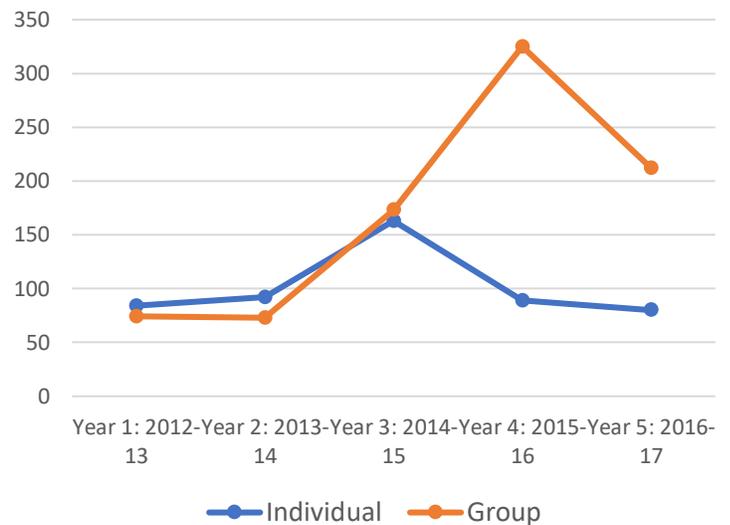
UNIQUE FACULTY PARTICIPANTS BY RANK

Assistant/Associate Professor	29%
Professor	56%
Lecturer/Other	15%

GRANT PROPOSAL OUTCOMES

4

Graduate Students and Postdocs: Interest from these populations also continues to grow.

Graduate Students and Postdocs have especially increased their use of CTLO services and programs in recent years; demand for support on teaching, professional preparation, and interest in educational outreach among both populations is high. We now work with 300-500 unique graduate students each year; in five years, we have worked with 1321 unique graduate students and 471 unique postdoctoral scholars. Much of this work is in the form of group events and programs (over 90% of graduate student services), including the annual Teaching Conference, seminars and workshops offered by the Caltech Project for Effective Teaching (CPET, which is a graduate student initiative predating CTLO, now operating under the leadership of two graduate co-directors with CTLO supervision), and workshops we offer on course design, teaching statements, and through TeachWeek and other opportunities. In order to engage this many graduate students and postdocs, CTLO relies on participation by dedicated cohorts in extended opportunities such as our quarter-long course on university teaching, E110, and the CPET certificates (more information below), so that well-prepared peers with CTLO mentoring are prepared to help lead sessions and programs.

Graduate students mostly work with CTLO on the subject of university teaching and learning (~80% of services), but their participation in educational outreach has been growing, more than doubling from 2015-16 to 2016-17. Graduate student engagement with CTLO has remained steady in some divisions, but grown rapidly in others, especially PMA (Physics, Mathematics, and Astronomy) and CCE (Chemistry and Chemical Engineering), likely due to focused, discipline-specific events and workshops in these areas.
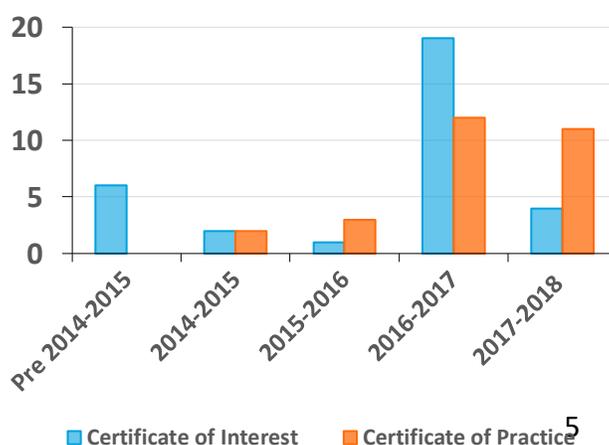
Participation by postdocs in workshops on course design, teaching statements, and other opportunities increased by over 200% from 2014-15 to 2015-16, and by another 50% from 2015-16 to 2016-17. There is a great need for professional development among this population, which CTLO tries to help fill by partnering with the Caltech Postdoc Association (CPA) and making programs of interest available whenever possible, including engagement with educational outreach.

Participation by both graduate students and postdoctoral scholars in the CPET certificate programs has also increased in recent years. The two certificates (certificate of interest in university teaching; certificate of practice in university teaching) allow interested graduate students and postdocs to tailor a program of teaching-related professional development to their interests. They are completed over a one- to two-year period, with extensive reflection and feedback, ending in a letter of completion from CTLO and the Vice Provost. In the case of the more in-depth certificate of practice, successful graduate student participants receive a transcript notation as well.


GRADUATE STUDENT SERVICES BY DIVISION

Year 2: 2013-14 Year 3: 2014-15 Year 4: 2015-16 Year 5: 2016-17

BBE   CCE   EAS   GPS   HSS   PMA
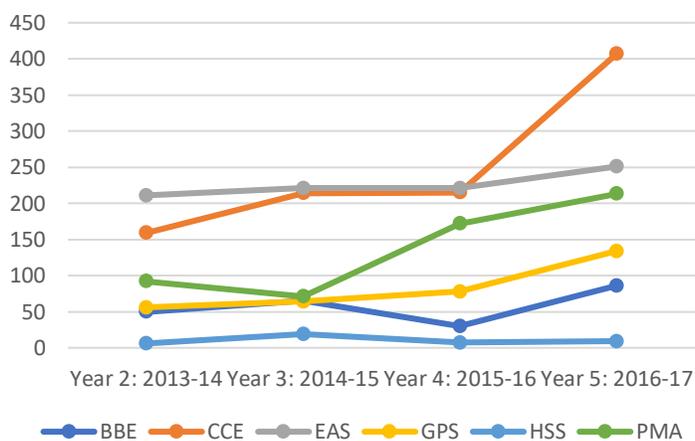
PARTICIPATION IN CPET CERTIFICATES

Certificate of Interest   Certificate of Practice

Undergraduates and staff: topical interests are shifting in different directions.

CTLO continues to support undergraduate TAs, work with undergraduates on educational outreach projects, consult with and advise the undergraduate Academics and Research Committee (ARC), and train course ombudspeople (at ARC's invitation). We are pleased to see undergraduate participation in educational outreach increasing, as Caltech students report that working with K-12 students is rewarding and beneficial in developing communication, teamwork, planning, and leadership capacities, as well as enhancing their motivation to continue pursuing science.

While services to staff are not our primary focus, CTLO advises non-teaching staff on projects, initiatives, and issues related to our areas of expertise. We have observed staff requests for and participation in programs related to university teaching increase in the past two years, as staff responsibilities for managing and coordinating educational efforts have been enhanced by several of the options (especially physics and mathematics), particularly concerning TA training and work.
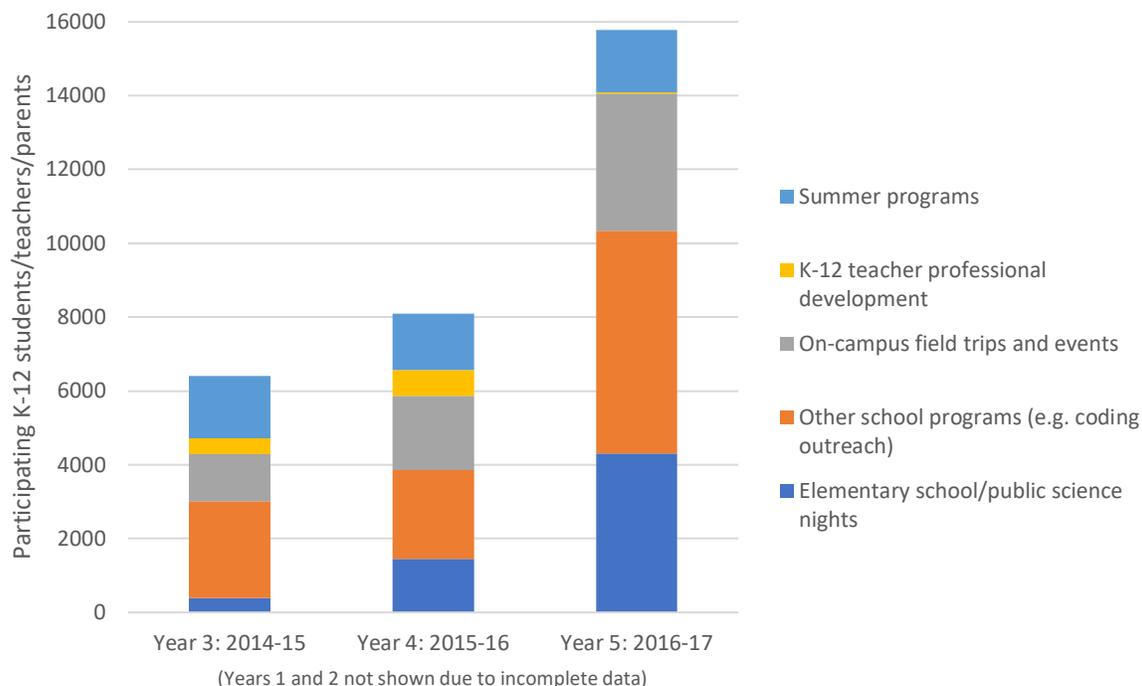
UNDERGRADUATE SERVICES BY TOPIC

STAFF SERVICES BY TOPIC

■ Outreach-related ■ University-related
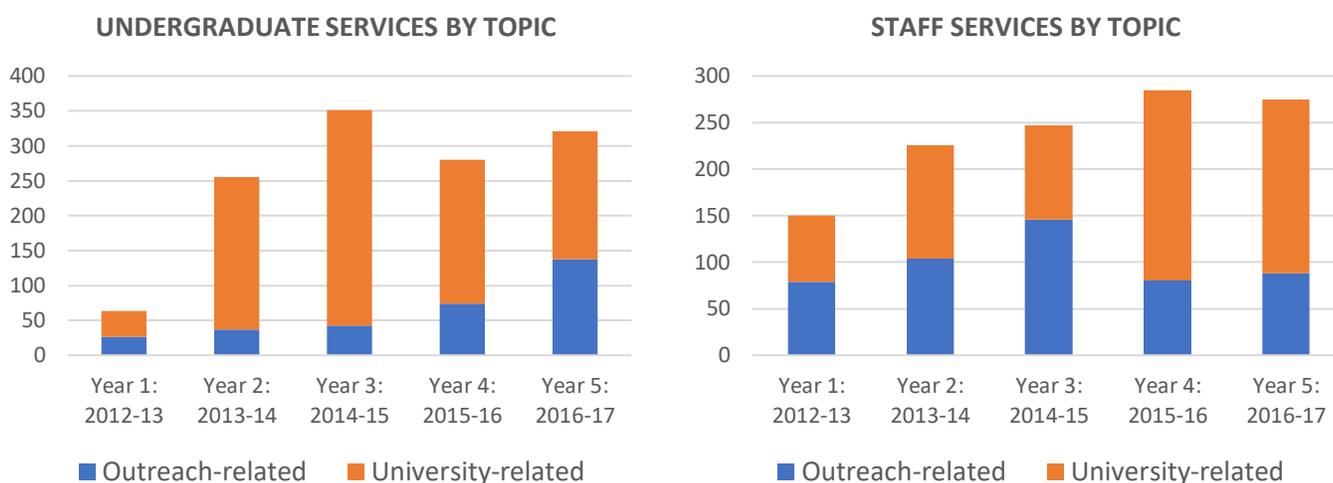
Educational outreach efforts intentionally impact relatively diverse and underserved K-12 populations, while providing enriching opportunities for Caltech students.

The total number of pre-college students, teachers, and parents directly served through outreach programs run or hosted by CTLO in 2016-17 was over 17,500. While there are some repeat participants in that number (many events do not require sign-in and managing a database this large is beyond our current capacity, so we are unable to track unique participants in as much details as campus constituencies), many represent communities at different schools and in different areas throughout Pasadena and Los Angeles. Our work emphasizes engagement with public schools and districts, which in both cities are majority low-income and underrepresented minority students.

We have implemented some changes in emphasis among our outreach programs over time. For example, science nights at local elementary schools and community events are an efficient way to reach many children and families, bolster a culture of science inquiry across the Pasadena Unified School District, and provide meaningful opportunities for Caltech students and researchers to engage with the public on a flexible basis. Engagement in such events increased by nearly 200% from 2015-16 to 2016-17. Simultaneously, we scaled back on teacher professional development—an increasingly regulated domain (e.g., requiring approval for teachers to receive credit for their participation) and more challenging for undergraduates, graduate students, and postdocs to plan and execute.

CHANGES IN EMPHASIS AMONG MAIN OUTREACH PROGRAM CATEGORIES

Year 3: 2014-15   Year 4: 2015-16   Year 5: 2016-17
(Years 1 and 2 not shown due to incomplete data)

Legend:
- Summer programs
- K-12 teacher professional development
- On-campus field trips and events
- Other school programs (e.g. coding outreach)
- Elementary school/public science nights

When CTLO does work with K-12 teachers, we have moved toward more contextual and embedded efforts. For example, the visiting scientists program, developed over the past two years, engages a group of Caltech researchers (graduate students and postdoctoral scholars) in weekly visits to a local elementary school, with CTLO facilitating ongoing collaboration between elementary teachers and Caltech researchers. Preliminary assessments indicate that this program supports both content learning aligned with grade-level science standards and positive attitudes toward science. K-12 teachers also participate in Summer Research Connection, conducting research alongside Caltech investigators and mentoring high school students embedded with them in laboratories.

In Computer Science, CTLO has partnered with outreach staff in the option to offer course credit for Caltech undergraduates' participation in coding outreach. Undergraduates can enroll in a department course, with mentoring from CTLO and a computer scientist, to develop and deliver coding programs in local schools. Again, we emphasize impact on elementary education with combined benefits for Caltech students.

During the summer, day camps focused on science exploration for preK-12 students engage up to 1690 young participants—over 275 at a time during many summer weeks. CTLO is making new efforts to connect pathways among summer programs: for example, young girls who age out of one of the camps ending in middle school, Project Scientist, are now invited to apply for a more selective and longer summer science experience, Community Science Academy, a home-grown CTLO program for older middle and high school students. We are also enhancing and connecting assessment of impact across programs to better understand mid-term and long-term impact of these summer experiences on participants.

Caltech courses are being improved and expanded with CTLO's support, on campus and digitally.

Over the past five years, CTLO assisted faculty with 92 unique undergraduate and graduate courses, distributed across divisions and curriculum levels (especially 100 level and below). CTLO's impact includes working closely with instructors on course design, course revisions, teaching methods, instructional technologies, assignments, and assessments, as well as helping instructors obtain and make sense of customized feedback from students.

We encourage faculty to collect data helpful to them in evaluating the effectiveness of course changes, but tend not to conduct rigorous research in this area, as educational research is not a primary area of emphasis at Caltech. Faculty redesigning courses are often able to compare student performance on similar assessments before and after redesign. In such cases, they regularly observe substantial increases in student learning—as expected, since they have typically implemented research-based strategies with extensive evidence demonstrating impact on learning among populations similar to Caltech students. Redesigned courses in which students have a choice of enrollment have also routinely enjoyed increased student registration rates. We have focused more on conveying these change narratives in other reports, articles, and materials.

COURSES DESIGNED OR REVISED WITH CTLO SUPPORT
BY DIVISION AND LEVEL
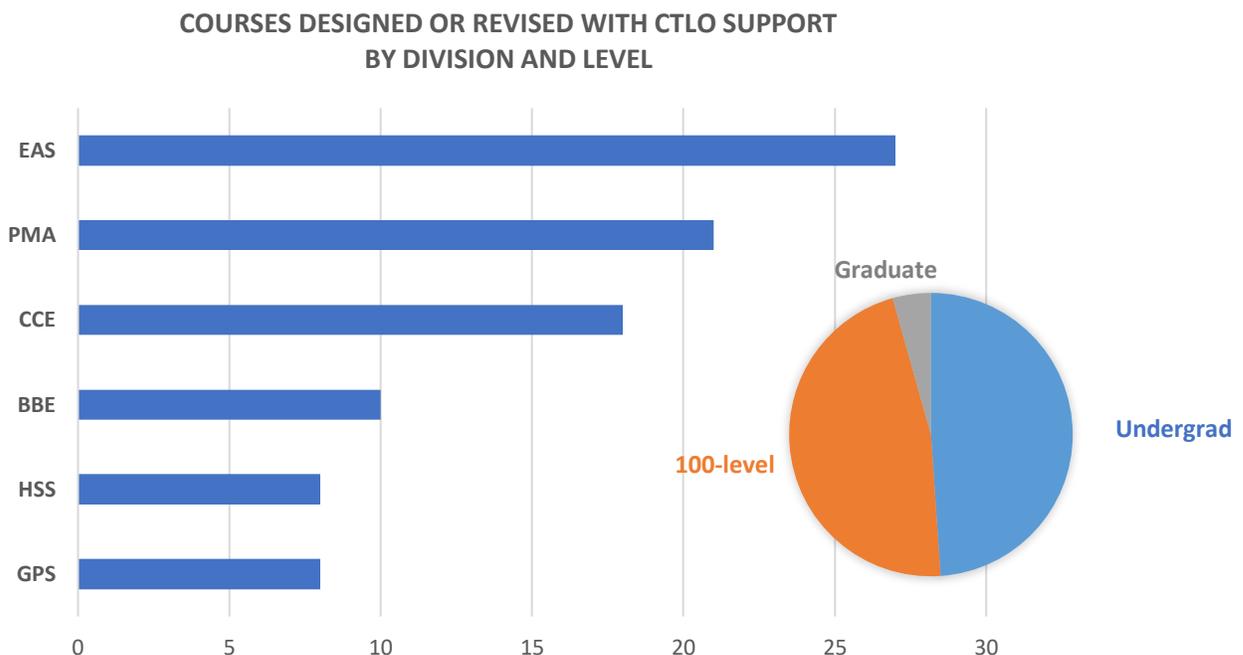
CTLO also supports faculty use of educational technologies and is the primary day-to-day campus liaison to Massive Open Online Course (MOOC) platforms, Coursera and edX, aiding faculty in designing and implementing online learning experiences, troubleshooting, and staying up-to-date on platform changes. Most Caltech MOOCs accompany a Caltech campus course, and the online materials are also used to enhance the learning experience for enrolled Caltech students (e.g., through use of digital materials in a flipped class format, to customize student learning, and for immediate feedback on digital learning exercises). Globally, Caltech MOOCs have enrolled more than 745,000 learners; corresponding campus classes using MOOC materials have had over 1780 Caltech student enrollments.

In Spring 2017, CTLO worked with the Caltech Alumni Association, Caltech Associates, and Development and Institute Relations to support an invitation-only cohort for alumni, parents, and

other Caltech supporters in Professor Mike Brown's MOOC, the Science of the Solar System. The 387 participating friends of Caltech, including alumni graduates from the 1950s to 2016, enjoyed the standard course content plus a private discussion forum, augmented content, and several opportunities for real-time discussions with Brown and CTLO staff, online and in person. With the goals of engaging Caltech alumni in modern teaching approaches, creating a positive Caltech learning experience, raising awareness of the CTLO, and providing opportunities for alumni to interact with each other and faculty, the offering was well-received by participants, who shared praise such as:

- "This has been the best interaction I've had with Caltech as an alum."
- "I've always been proud to be a Caltech alum, and your effort with Mike just reinforces my enthusiasm."
- "I greatly enjoyed the course 'Science of the Solar System'. I hope this will be the start of many online courses for Caltech alumni."
- "I see the flipped classroom experience as a very positive advance in teaching methodology— [it] truly answers the question of how to get students to attend class and interact with their professors. Thank you for all the energy you are putting into improving teaching at Caltech."

This offering won the 2018 CASE District VII Awards of Excellence [Gold Award for Best Use of Social Media/Technology](#).

CTLO is pursuing and expanding several new initiatives and directions in the coming year.

In particular, we are seeking to capitalize on faculty interest in exchange and collegial interaction on teaching, as well as the effectiveness of discipline-specific efforts. With a mini-grant (one of twelve awarded nationally) from the Association of American Universities, CTLO is a leading office organizing and implementing a two-year pilot, the Inclusive Caltech Core (IC2) project, along with the vice provost, undergraduate dean's office, and Caltech Center for Diversity. This work engages faculty teaching Core and other large introductory courses, along with freshman advisors, in timely data about first-year Caltech students, inclusive teaching and advising practices, and feedback regarding student experiences.

The Faculty Summer Short Course continues, with plans to offer a preparatory session for new faculty and/or expand capacity in the future. We are also in the early planning phases of a pilot project to engage experienced TAs as peer mentors, with CTLO training, in order to build greater department-based support for newer TAs in several disciplines that reach all or most undergraduates.

In the educational outreach arena, CTLO is representing Caltech in a relatively new National Association for Broader Impacts (NABI) and bringing back lessons learned from peer institutions about successful programs, assessment strategies, and NSF's increasingly rigorous expectations for broader impacts aspects of research programs—ever more important as funding pressures continue to increase.

With a suite of strategies demonstrated to work well at Caltech, CTLO also seeks to deepen partnerships with offices throughout campus, as well as with faculty governance bodies, in order to find productive ways to collaborate and elevate Caltech's educational efforts in coming years.

Appendix 1: CTLO Logic Models

CTLO employs resources and activities purposefully to achieve short, mid-term, and long-term outcomes. Though the picture of all programs and services together is complex, it realistically represents the process of organizational change and is aligned with modern research and practice, customized to Caltech's institutional structures and context.

a. Logic Model for Impact on University Teaching:

Resources	Activities	Outputs	Short & Mid-term Outcomes	Long-term Outcomes
Materials & Operations	(all)	New Initiatives and Projects		
Funding	Committee Service & Consultation	New Processes and Practices	Reduced Course-related Issues and Concerns	**Sustainable Culture of Excellence in Teaching**
CTLO Staff	Teaching Consultation, Feedback, & Assessment	Redesigned Courses and Curricula	Improved Student Learning (Directly Assessed)	**Improved Long-term Student Learning and Experience**
Guest Speakers	Teaching Workshops	Participation Rates and Patterns		
Caltech Faculty	Major Teaching Events & Conferences	Program Completion Rates and Patterns	Improved Student Experience (Indirectly Assessed)	**Increase in evidence-based educational practices**
Caltech TAs, Students, & Postdocs	Multi-session Teaching Programs & Courses		Instructor Learning (Indirectly Assessed)	**More Rewarding Teaching Experience for Faculty and TAs**
Caltech Academic Options and Divisions	Advising Student Groups and Organizations	Student Initiatives and Projects	(various)	

b. Logic model for impact on K-12 education

Resources → Activities → Outputs → Short & Mid-term Outcomes → Long-term Outcomes

Materials & Operations ---- (all)

Funding

CTLO Staff

Caltech Faculty, Postdocs, & Students

Local K-12 Teachers

Partner Organizations

Outreach Infra-structure Improvement

Outreach Grant Consul-tations

CTLO-run School Year Programs

CTLO-run Summer Programs

Partner-run Summer Programs

New Forms and Procedures

Outreach Best Practice Meetings (across Caltech)

New Proposals Incorporating Outreach

New Outreach from Labs and Departments (incl. Caltech coursework)

New Program Curricula and Practices

New PD Opportunities for Local K-12 Teachers (Number and Demographics)

New Learning Opportunities for Local Youth (Number and Demographics)

Improved and Simplified Processes

Increase in Documented Outreach from Caltech

Improved outcomes for grants involving outreach

Caltech Postdoc & Student Learning (Sci. Education & Communication)

K-12 Student STEM Attitudes

K-12 Student STEM Learning

K-12 Teacher Incorporation of STEM Curricula and Methods

Sustainable Caltech Educational Outreach

Enlarged & More Diverse Local K-12 STEM Pipeline

Increased K-12 and Public STEM Literacy and Engagement