California Education Learning Lab: Annual Report

November 2019

Governor’s Office of Planning and Research
1400 10th Street | Sacramento California 95814
http://opr.ca.gov/learninglab/

Executive Summary

Assembly Bill 1809 (Chapter 33, Statutes of 2018) established the California Education Learning Lab ("Learning Lab") as a competitive grantmaking program to improve learning outcomes and close equity and achievement gaps across California's public higher education segments. Housed in the Governor's Office of Planning and Research, Learning Lab's goal is to fund intersegmental faculty-led projects that incorporate the science of learning and adaptive learning technologies that lead to pedagogical and curricular innovation and improvements in online and hybrid learning environments. Learning Lab's authorizing statute requires initial grants to focus on lower-division online and hybrid courses in Science, Technology, Engineering, and Mathematics (STEM) fields. In later years, other disciplines may compete for funds and funds may be used to support professional development and a curated resource library.

Learning Lab launched in the fall of 2018. With the assistance of seven advisors (see Section 7) who were recruited for their broad STEM disciplinary expertise, expertise in the science of learning and adaptive learning technologies, STEM education improvement experience, and commitment to diversity, equity, and inclusion, Learning Lab published its first request for proposals in December 2018.

For this initial RFP, up to $9 million was available to fund six to nine demonstration projects to support curricular and pedagogical innovations that aim to improve learning outcomes, transform the culture of learning, and close equity and achievement gaps in online and hybrid learning environments within lower division STEM undergraduate curriculum. In order to have the potential for large scale impact, this call was specifically tailored for lower-division "gateway" courses in the following disciplines: biology, chemistry, physics, engineering and computational sciences, including computer science, mathematics, and statistics. Projects were encouraged to develop pedagogical innovations that promote students' sense of belonging in science, students' science identity and connections between science learning and students' personal lives, career aspirations and home communities, leveraging affective components of learning to reduce achievement gaps.

Forty-two intersegmental faculty teams submitted concept proposals in the first round, of which 21 went on to compete in the full proposal round. Nine projects were ultimately selected to receive Year 1 grants (see Section 3 for more details.) All nine projects kicked off their projects on July 1, 2019. Quarterly reporting (alternatively via Zoom and written reports) on milestones and achievements are required throughout the three-year grant period.

In addition to the execution of its 2018-2019 Request for Proposals and ensuing grant agreements with awardees, Learning Lab has focused its efforts on building community across all three segments of public higher education. Learning Lab has more than 200 contacts from across the segments and continues to grow. Moreover, Learning Lab co-sponsored a STEM Equity Conference in October 2019 at the University of California, Berkeley. Additionally, Learning Lab has initiated a student survey project (see Section 5.4) to better understand students' STEM experiences at the various public higher education segments. Finally, Learning Lab is working to collect and share pertinent research on STEM equity gaps and research into approaches for addressing those gaps. Both original research briefs and relevant publications are highlighted on Learning Labs' resources webpage.

Nearing the end of its first year of operation, Learning Lab launched three new grant opportunities in September 2019 for the 2019-2020 award cycle to better align with the academic year. Those grant opportunities are available for review at http://opr.ca.gov/learninglab/grants/.

Unlike other grant or funding opportunities that support the creation of online resources or underrepresented students' success in STEM, Learning Lab continues to encourage the development and dissemination of pedagogical practices, learning resources, technological tools, courses, and course series that demonstrate success in improving learning outcomes and closing equity gaps, and contribute to the fundamental understanding of human learning. In the 2019-2020 Requests for Proposals, Learning Lab grant opportunities will continue to focus on faculty-led projects that:

- Develop and implement curricular and pedagogical innovations;
- Demonstrate the effectiveness of those curricular and pedagogical innovations through a process of rigorous assessment and evaluation (and apply the results of that assessment through a process of iterative improvement);
- Utilize technology tools, including adaptive learning technology, in online or hybrid course environments to support learning outcomes and the collection of learning data for the purpose of advancing research into human learning; and
- Show clear potential for replication and dissemination, as well as capacity to affect positive pedagogical and/or curricular change at scale.

Table of Contents

Executive Summary 2
Table of Contents 4
1. Introduction 6
1.1. Why science of human learning? 6
1.2. Why adaptive learning technologies? 7
1.3. Why online and hybrid learning environments? 7
1.4. Why intersegmental? 8
1.5. Year 1 Summary 9
2. 2018-2019 Request for Proposals 10
2.1. Background 10
2.2. Overview of the Selection Process 11
2.3. Results of the Selection Process 12
3. Summaries of Awarded Projects 16
3.1. The Better Book Project 16
3.2. Giving Ownership of Active Learning to Students in Computer Science (GOALS in CS) 17
3.3. Eliminating Equity Gaps in Online STEM Gateway Courses through Humanized Instruction 18
3.4. The Mechanics of Inclusion and Inclusivity in Mechanics 19
3.5. Developing Student Identity and Self-Perception as Capable STEM Thinkers and Learners 20
3.6. Community Sourced, Data-Driven Improvements to Open, Adaptive Courseware 21
3.7. Building College-Level Number Sense with Adaptive Technology 22
3.8. E-Games for Active Training in Engineering Design 23
3.9. California Challenges in STEM Energy Education 24
4. Outreach Activities and Survey Results 25
4.1. Applicant Survey 25
4.2. Professional Development Survey 26
5. Looking Ahead 28
5.1. 2019-2020 Requests for Proposals 28
5.2. All Teams Meeting 31
5.3. STEM Equity Conference 32
5.4. Student Engagement Project 32
6. Learning Lab Briefs 34
6.1. Enrollment and Completion Gaps in STEM Higher Education 34
6.2. Sources of Enrollment and Completion Gaps in STEM Higher Education 37

6.3. Addressing STEM Enrollment, Completion, and Performance Gaps in Higher Education ... 39
7. Learning Lab Advisors ... 41
7.1. Learning Lab Advisors ... 41
7.2. Learning Lab Technical Advisor ... 44
8. Learning Lab Resources and Definitions ... 45
8.1. Learning Lab Resources ... 45
8.2. Key Definitions ... 48
9. Appendices ... 50

1. Introduction

Assembly Bill 1809 (Chapter 33, Statutes of 2018) established the California Education Learning Lab ("Learning Lab") as a competitive grantmaking program to improve learning outcomes and close equity and achievement gaps across California's public higher education segments. Housed in the Governor's Office of Planning and Research, Learning Lab's goal is to fund intersegmental faculty-led projects that incorporate the science of learning and adaptive learning technologies that lead to pedagogical and curricular innovation and improvements in online and hybrid learning environments. Learning Lab's authorizing statute requires initial grants to focus on lower-division online and hybrid courses in Science, Technology, Engineering, and Mathematics (STEM) fields. In later years, other disciplines may compete for funds and funds may be used to support professional development and a curated resource library.

1.1. Why science of human learning?

Learning science, or the science of human learning, is the study of how human learning takes place. Interdisciplinary in nature, drawing from fields such as cognitive science, neuroscience, computer science, education, psychology, sociology, design studies and more,[1] the science of learning strives to understand how people learn, how to support learning, how to facilitate and enhance learning, discipline-based learning, and the role of technology in enhancing learning and collaboration.[2] The science of learning addresses how people process, gather, and interpret information; how they develop knowledge, skills, and expertise; and the extent to which social and physical context and design environments influence learning.[3] Scaffolding, inquiry or problem-based learning, collaborative learning, game and simulation-based learning, metacognition are all examples of how teaching methods and approaches to curriculum can be influenced by what we understand about learning. Additionally, strategies linked to social psychology and multicultural education emphasize the importance of attending to students' identity and culture when addressing achievement gaps.

One of the goals of the science of learning is to create a positive feedback/continuous improvement loop between theories of learning and practice, which would result in improved student learning and advance the field of learning science.[4] As public higher education strives to educate more students with diverse

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[1] Sawyer, R.K. (2006). *The Cambridge Handbook of the Learning Sciences*. Cambridge, U.K.: Cambridge University Press.

[2] Sommerhoff, D., Szameitat, A., Vogel, F., Chernikova, O., Loderer, K. & Fischer, F. (2018). What Do We Teach When We Teach the Learning Sciences? A Document Analysis of 75 Graduate Programs. Journal of the Learning Sciences, 27:2, 319-351. https://doi.org/10.1080/10508406.2018.1440353.

[3] Ibid.

[4] The Simon Initiative Learning Engineering Ecosystem at Carnegie Mellon University emphasizes: 1) building and leveraging cognitive models of expertise to inform the design of effective student-centered instructional materials; 2) collecting rich data on student interactions and learning outcomes; 3) data analysis via state-of-the-art machine learning and analytic methods; 4) data-informed iterative improvement of the instructional materials; and 5) leveraging these assets to drive fresh insights in learning science. https://chronicle-assets.s3.amazonaws.com/5/items/biz/pdf/SimonLearningEngineeringEcosystem.pdf.

backgrounds in a rapidly changing world, Learning Lab seeks to leverage, increase and apply knowledge of human learning to help the state meet its attainment goals for higher education.

1.2. Why adaptive learning technologies?

Adaptive learning is defined by statute to mean "a technology-mediated environment in which the learner's experience is adapted to learner behavior and responses." Adaptive learning deploys technology to better understand learner experience/learner gaps and assets and use this information to modify learning environments, pedagogical approaches and/or available resources. Adaptive learning solutions have the potential to provide a more personalized learning experience and to produce better learning outcomes for students. Adaptive learning technology also offers opportunities to collect and analyze data on student learning and can support the integration of learning research and teaching practice by encouraging instructors to respond and adapt iteratively to student learning.

In order to have the potential for large-scale impact, Learning Lab considers adaptive learning technologies in the broad sense of deploying technology to better understand learner experience/learner gaps and assets, and to use such information to modify learning environments, pedagogical approaches and/or available resources.

1.3. Why online and hybrid learning environments?

Technological change and the development of online learning environments has transformed the learning experience for both students and faculty. In addition to the growth of online education, students now commonly access course materials and resources electronically and interact with instructors and with one another remotely. Hybrid approaches to course instruction, which integrate online interfaces and content with face-to-face pedagogy, have become increasingly common.

Learning Lab has two interrelated goals in addressing online and hybrid learning environments. First, Learning Lab aims to leverage the pedagogical and curricular possibilities of online and hybrid learning environments. Online course environments provide opportunities to collect student learning data and use that data to support iterative improvement in teaching. They also offer opportunities for innovation in how students interact with course material and resources, as well as with instructors and one another. Learning Lab supports the development of practices, resources, and tools that take advantage of the possibilities of online and hybrid learning environments to improve learning outcomes for students and advance understanding of human learning.

Second, Learning Lab seeks to improve learning outcomes and to close equity and achievement gaps in online and hybrid courses. Enrollment in online courses has increased substantially in recent years and continues to grow. Colleges and universities have identified online courses as means of addressing and reducing course bottlenecks and of expanding access to students who may be unable to attend classes during traditional course hours. Gaps in student performance between online and traditional courses have narrowed, and Learning Lab supports the development of resources, pedagogical practices, tools, and courses and course series that aim to promote continued improvement in student success in online course environments.

It is worth noting that Learning Lab takes a broad view of what qualifies as an online or hybrid course. Online courses allow students to interact, either synchronously or asynchronously, with the course material/lecture/lab work, and other participants and/or instructors/TAs in a technology-mediated, remote environment. Learning Lab understands hybrid courses or blended courses as those that use both "online" and in-person interactions as part of the formal course environment or requirements. A hybrid course would allow some component of the course to be available or accessible in an online environment. For the purposes of the Learning Lab's grant opportunities to date, courses do not have to be officially designated by the institution or department as "hybrid" to be eligible for Learning Lab grant funding.

1.4. Why intersegmental?

The State of California invests significant resources into its public higher education institutions, as well as independent colleges and universities through the Cal Grant program. Intersegmental collaboration (i.e., collaboration across segments, such as between University of California and community college faculty, or California State University and community college faculty, or University of California and California State University faculty) will draw more deeply from diverse faculty experiences with various student populations, as well as make articulation of courses more seamless and widespread adoption of successful pedagogies more likely and robust. Ideally, intersegmental faculty teams will include, STEM faculty members, social and/or behavioral scientists and instructional designers on the proposal team.

Unlike other grant or funding opportunities that support the creation of online resources or underrepresented students' success in STEM, Learning Lab seeks to encourage the development and dissemination of pedagogical practices, learning resources, technological tools, courses, and course series that demonstrate success in improving learning outcomes and closing equity gaps, ***and*** contribute to the fundamental understanding of human learning. Learning Lab grants are accordingly intended to support faculty-led projects that:

- Develop and implement curricular and pedagogical innovations;
- Demonstrate the effectiveness of those curricular and pedagogical innovations through a process of rigorous assessment and evaluation (and apply the results of that assessment through a process of iterative improvement);
- Utilize technology tools, including adaptive learning technology, in online or hybrid course environments to support learning outcomes and the collection of learning data for the purpose of advancing research into human learning; and
- Show clear potential for replication and dissemination, as well as capacity to affect positive pedagogical and/or curricular change at scale.

1.5. Year 1 Summary

Learning Lab launched in the fall of 2018. With the assistance of seven advisors (see Section 7) who were recruited for their broad STEM disciplinary expertise, expertise in the science of learning and adaptive learning technologies, STEM education improvement experience, and commitment to diversity, equity, and inclusion, Learning Lab published its first request for proposals in December 2018.

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2. 2018-2019 Request for Proposals

2.1. Background

Both nationally and in California, female and underrepresented minority (URM) students are more likely to leave a STEM major than their male and non-URM peers and are less likely to graduate with a STEM degree. Research suggests that these gaps in STEM enrollment and completion are the product of cultural and institutional barriers that deter many female and URM students from entering or remaining in STEM. These barriers pose significant equity concerns for California's institutions of higher education as well as the state's growing STEM workforce.

Barriers in STEM prevent women and underrepresented minorities from earning degrees that provide access to high wage careers in science and technology, and from learning skills that are increasingly in demand as technological developments reshape the economy and workforce.[5] As California's overall and college-going populations diversify, the persistence of enrollment and completion gaps among female and URM students in the STEM fields challenges the ability of California's institutions of higher education to meet workforce needs and the demand for graduates with a STEM education.[6]

At 4-year colleges and universities, gateway courses – classes that students ordinarily take in their first or second years which provide essential foundational knowledge for advancement in a program of study – pose particular challenges. These courses tend to be taught in large lectures that provide students with few opportunities to engage actively with course material, or with one another, and generally do not provide broad support for students.[7] When taking STEM gateway courses, students who have interest in pursuing studies in STEM often become discouraged based on performance, uninspiring teaching and curriculum, or lack of connection with potential career goals. As a result, gateway courses contribute to high rates of attrition in the first two years of study; overall, only 61 percent of first-year freshmen entering CSU as STEM majors persist in STEM after two years (See Figure1).

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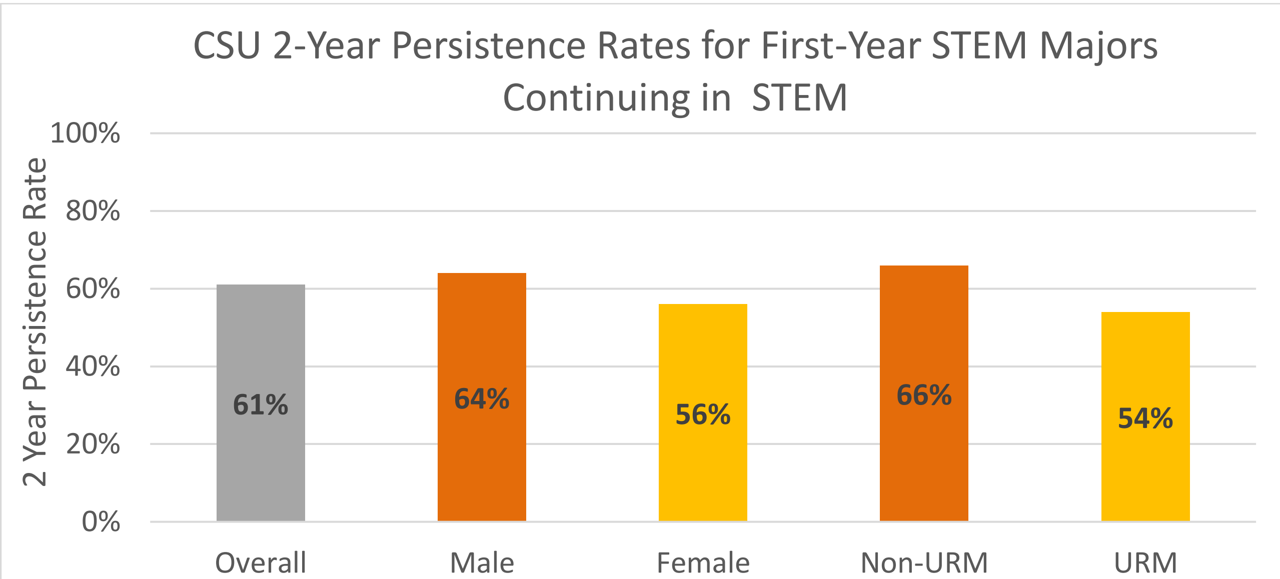
[5] Andrew Chamberlain and Jyotsna Jayaraman, *The Pipeline Problem: How College Majors Contribute to the Gender Pay Gap* (GlassDoor, April 2017), https://www.glassdoor.com/research/app/uploads/sites/2/2017/04/FULL-STUDY-PDF-Gender-Pay-Gap2FCollege-Major.pdf.

[6] California Competes, *Mind the Gap: Delivering on California's Promise for Higher Education* (Berkeley, CA, 2015); Campaign for College Opportunity, *Needed: Sy(STEM)ic Response: How California's Public Colleges and Universities are Key to Strengthening the Science, Technology, Engineering, and Math (STEM) and Health Workforce* (Los Angeles and Sacramento, CA: June 2016).

[7] Josephine A. Gasiewski et al., "From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses," *Research in Higher Education* 53, no. 2 (2012): 229-261, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3596160/; Adrianna Kezar and Elizabeth Holcombe, *Creating a Unified Community of Support: Increasing Success for Underrepresented Students in STEM—A Final Report on the CSU STEM Collaboratives Project* (USC Pullias Center for Higher Education, 2017), p. 8. Retrieved from: https://pullias.usc.edu/csustemcollab/#report.

The impact of demanding gateway courses and traditional pedagogical approaches is magnified for less prepared students as well as for students who feel unwelcome or out-of-place in STEM classrooms. Low rates of persistence in STEM fields are particularly pronounced among female and URM students. About two-thirds of male and non-URM first-year freshmen entering CSU as STEM majors persist in STEM after two years; conversely, only 56 percent of female first-year freshmen and only 54 percent of URM first-year freshmen entering CSU as STEM majors ultimately remain in STEM after year two years.

Figure 1: CSU 2-Year Persistence Rates for First Year STEM Majors Continuing in STEM



URM includes American Indian, Latino, and African American students.
Data represents the Fall 2016 cohort of CSU students.

Through its first RFP, "Improving Equity, Accessibility and Outcomes for STEM Gateway Courses," Learning Lab sought to address these inequities by incentivizing the creation of accessible and welcoming foundational or gateway courses in which all students can succeed, and which will form the basis of future scientific inquiry, reasoning, and evaluation regardless of a student's chosen major or career. In order to have a broad impact across California, projects were required to be co-hosted by intersegmental faculty teams that included PIs/co-PIs from at least two of the State's public higher education segments.

2.2. Overview of the Selection Process

Demonstration projects were selected through a three-stage process involving: (1) submission of letters of intent to submit concept proposals; (2) submission of concept proposals; and (3) submission of full proposals, based on selected concept proposals, from which the final selection of awards were made. For the proposal review process, the members of Learning Lab's Advisory Committee (identified in Section 7) served as the Selection Committee for evaluating and recommending awards. All proposals were reviewed, evaluated, and scored by both external readers and Selection Committee members using a rubric that was posted on the Learning Lab's webpage.

During the Selection Committee meetings, committee members deliberated proposals based on reader and Committee evaluations and the overall likelihood that projects that would increase learning outcomes and close equity gaps in the relevant STEM discipline(s). The Committee also took into consideration the geographic equity of projects and the diversity of awarded institutions.

The Selection Committee used a process consistent with National Science Foundation procedures for reviewing the proposals and making award recommendations. All reviewers and Selection Committee members signed confidentiality and conflict of interest statements. External Readers and Selection Committee members did not review proposals that involved institutions with which they were affiliated and further recused themselves from evaluation of any project where they identified an alternative conflict of interest.

At both the concept and full proposal stages, those teams were that were not selected to advance or for awards received summary feedback of their proposals based on reader and Selection Committee evaluations to inform future submissions for subsequent Learning Lab requests for proposals.

2.3. Results of the Selection Process

In response to the call for proposals issued on December 12, 2018, Learning Lab received 42 Concept Proposals by January 22, 2019. The intersegmental teams that submitted proposals included PIs/co-PIs from all nine UC campuses that enroll undergraduate students, from 21 of 23 CSU campuses, and from 42 of 114 community college campuses. Geographically, 18 applicant institutions were located in Los Angeles or Orange County and 6 were in the San Diego area; 15 applicant institutions were in the San Francisco Bay Area. Of the remaining applicants, 11 were on the Central Coast, 10 were in the Sacramento Valley or the North State, 7 were in the San Joaquin Valley and 5 were in the Inland Empire (see Figure 2).

Learning Lab's Selection Committee met on February 4, 2019, at the Milton Marks Conference Center in San Francisco, to deliberate and determine which applications would advance to next application stage. Based on the evaluations of proposals and its deliberations, the Selection Committee recommended 21 projects for advancement to the full proposal stage. The projects recommended for advancement to the full proposal stage included PIs/co-PIs from 52 institutions of public higher education: eight UC campuses, 16 CSU campuses, and 28 community colleges.

Following submission of full proposals on March 22, 2019, and a three-week review period, Learning Lab's Selection Committee met on April 15, 2019, at the California Community College Chancellor's Office to deliberate on the full proposals. Based on external evaluations and their deliberations, the Selection Committee recommended six projects for "full" awards of up to $1.3 million each. The Selection Committee also identified three projects that put forward promising and innovative proposals, but which committee members judged would benefit from further development and "proof-of-concept" testing. The members of the Selection Committee recommended these projects for funding of up to $500,000 each.

The Director of the Office of Planning and Research approved the Selection Committee's recommendations. The awarded projects include representation from 6 UC campuses, 9 CSU campuses, and 11 community colleges (see Figure 3). Among the projects, there is representation from all regions of California. The projects, moreover, display leadership from all segments of California public higher education: 3 of the projects are hosted by community college campuses, 4 by CSU campuses, and 2 by UC campuses.

Learning Lab staff worked with project teams and host institutions through May and June 2019 to finalize grant agreements with project teams that identified deliverables that teams would produce during the grant period and also established project reporting requirements (which include semi-annual written progress reports and Zoom check-in meetings during the quarters when written reports are not requested). All projects funded in the 2018-2019 RFP cycle officially commenced on July 1, 2019.

Figure 2: Learning Lab RFP 1 Applicants

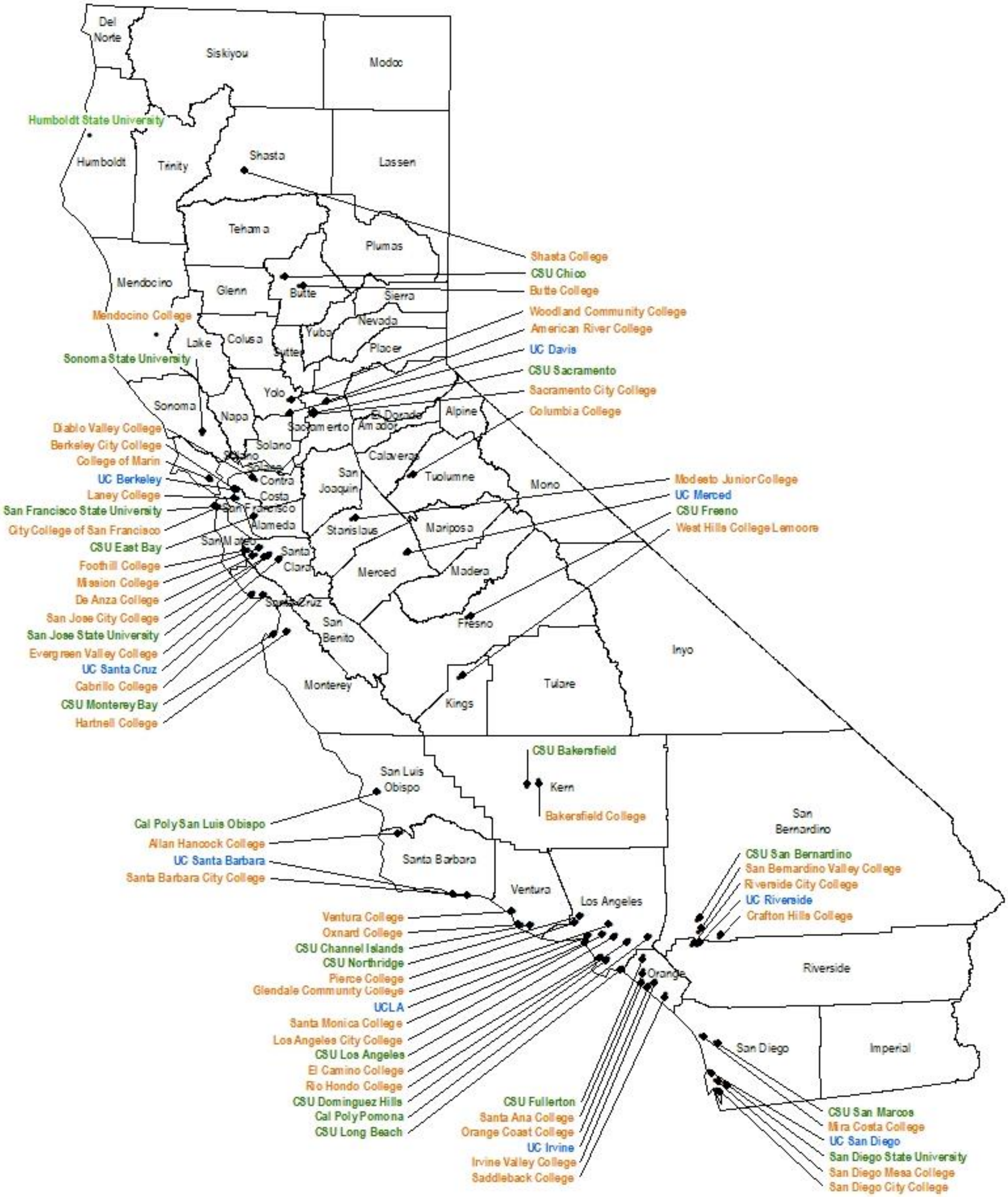


Figure 3: Leaning Lab RFP 1 Awarded Projects

3. Summaries of Awarded Projects

The following section provides an overview of the projects awarded during Learning Lab's first Request for Proposals titled "Improving Equity, Accessibility and Outcomes for STEM Gateway Courses". The intersegmental teams started their projects in July 2019 and the Learning Lab will fund their efforts through June 2021 (3 years).

3.1. The Better Book Project

Region: Los Angeles
Discipline: Statistics
Grant Amount: Up to $1,300,000
Institutions: UCLA, Cal State LA, Los Angeles Pierce College
Principal Investigators: Jim Stigler (UCLA), Ji Son (Cal State LA), Edouard Tchertchian (Pierce College)
Co-Principal Investigators: Karen Givvin (UCLA) & Chris Hulleman (University of Virginia)

"The Better Book Project" will develop, implement, and continuously improve an online interactive textbook for introductory statistics. Statistics is critical not only for gaining entry into STEM careers, but also for excelling in them. Modern computational statistics is arguably more critical for future STEM careers than traditional mathematics courses. In addition, statistics may be the most direct pathway for students seeking to improve their mathematical preparation. This project's innovative design—based on learning science theories of how people develop deep understanding in complex spheres of knowledge—involves repeatedly engaging students with the deep conceptual structure of the subject area (in this case, statistical modeling), and includes a heavy emphasis on simulation, randomization, and other tools for both doing data analysis and understanding statistical ideas. The goal is not simply students' course completion, but the development of flexible and transferable knowledge—i.e., deep understanding—in all students.

"The Better Book Project" begins with an already completed Version 1.0 of a new interactive introductory statistics textbook, then works to improve the book and its implementation at scale. Through this work, the project team aims to create a replicable R&D model that engages researchers, designers/developers, and instructors in the work of scaling the innovation, and of continuous improvement of the book and its implementation. The team will implement a process of continuous improvement, so as to iteratively improve outcomes and reduce gaps among groups of students over time, making a bigger difference for students' success in the long run.

3.2. Giving Ownership of Active Learning to Students in Computer Science (GOALS in CS)

Region: San Diego
Discipline: Computer Science
Grant Amount: Up to $1,038,000
Institutions: CSU San Marcos & MiraCosta College
Principal Investigator: Youwen Ouyang (CSU San Marcos)
Co-Principal Investigators: Nery Chapetón-Lamas (MCC) & Marisol Clark-Ibáñez (CSU San Marcos)

"Giving Ownership of Active Learning to Students in Computer Science" (GOALS in CS) addresses the high rates of students not passing introductory Computer Science (CS) classes. In this project, a collaborative and interdisciplinary team from California State University San Marcos and MiraCosta College will implement an iterative design and development education research process to create innovative hybrid offerings of the introductory CS sequence, recognized in California as C-ID COMP 122 and 132. In contrast to successful CS interventions in high schools, the college introductory CS curriculum typically focuses on how computers interpret instructions and relies on unduly difficult, abstract mathematical models. Pedagogically, the traditional lecture-heavy structure of college CS courses is in stark contrast to successful CS interventions in high school, lacking both real-world problems and the opportunities for students to use prior knowledge and background. They also do not utilize community-building pedagogy, which is a successful strategy to engage women and underrepresented minorities.

Partnering with Carnegie Mellon University (CMU) Silicon Valley, this project's interdisciplinary team will take a "bottom-up" approach to COMP 122 and 132 course re-design with feedback and focus groups from students and faculty. Using the CMU Open Learning Initiative (OLI) platform, the project will develop a comprehensive skill map for learning objectives in COMP 122 and 132, create culturally responsive learning resources and activities, and build a variety of student-focused and selectable modules that are adaptive to students' personal characteristics, background contexts, and learning experiences. In addition to online modules with learning goals assigned and assessed throughout the week, the newly developed courses will include weekly face-to-face lab activities that engage students in project-based learning and help students navigate and better understand the discipline of CS, thereby empowering students at the introductory level to gain a cognitive map of the field itself.

Figure 4: Student Feedback Received in Fall 2019.

> The most effective and enjoyable part of class time is spent working on and practicing codes. Sometimes I don't realize that I don't understand something until I run through it myself. Also, once I understand the concept of what we learned in class or through OLI I find myself getting inspired in finding new ways to creatively write programs.

3.3. Eliminating Equity Gaps in Online STEM Gateway Courses through Humanized Instruction

Regions: Bay Area, Central Valley, North Coast, Orange County
Discipline: Interdisciplinary
Grant Amount: Up to $1,300,000
Institutions: Foothill-De Anza Community College District, Modesto Junior College, Humboldt State University, UC Irvine
Co-Principal Investigators: Michelle Pacansky-Brock (FHDA), Sarah Williams (FHDA), Michael Smedshammer (Modesto JC), Brent Wedge (Modesto JC), Kim Vincent-Layton (Humboldt State), Jeffrey White (Humboldt State), Di Xu (UC Irvine)

Online STEM gateway courses hold significant potential to improve access to STEM education among nontraditional students and students from underrepresented groups in California. Currently, however, the performance gaps between online and face-to-face learning seem to be particularly large among underrepresented minority students. As a result, online learning, without fundamental improvement in instructional effectiveness and student supports, may exacerbate the STEM academic pathway leak for URM students. “Eliminating Equity Gaps in Online STEM Gateway Courses through Humanized Instruction” proposes a 3-year plan to initiate a systemic shift in the culture of online and hybrid STEM instruction across California public higher education institutions.

Guided by the psychological theories about distance learning and social presence, the project team will implement a large-scale, collaborative online professional development program, the Humanizing Academy, to address a crucial challenge to successful learning in an online environment: greater difficulties in enabling effective human interaction. Specifically, this proposal will test whether “Humanizing” a course—defined as efforts to help instructors to develop empathy, presence, and awareness, as well as pedagogies to improve instructor-student relationships and build classroom community—can help improve instructor-student and student-student interactions in online STEM courses, strengthen students’ sense of belonging and engagement, and increase learning outcomes in gateway online and hybrid STEM courses, particularly for URM students. Faculty, in partnership with instructional designers, will learn how to use free to low-cost digital tools and effectively apply them to the design and facilitation of their courses to foster instructor-student relationships.

The technology-enhanced pedagogical practices that are found to improve engagement and success for URM students will be scaled across the CCCs, CSUs, and UCs through the Humanizing Academy, which will be followed by a supportive course redesign period. Evidence-based practices will be shared publicly in the form of a “Humanizing Online STEM Courses” Practitioner Toolkit.

3.4. The Mechanics of Inclusion and Inclusivity in Mechanics

Region: Central Coast
Disciplines: Engineering, Physics
Grant Amount: Up to $1,300,000
Institutions: Cal Poly-San Luis Obispo, Allan Hancock College, UC Santa Barbara
Principal Investigators: Brian Self (Cal Poly), Dominic Dal Bello (AHC), Danielle Harlow (UCSB)
Co-Principal Investigators: Robert Jorstad (AHC), Brian Youngblood (AHC), Andrew Maul (UCSB), Geraldine Cochran (Cal Poly), Benjamin Lutz (Cal Poly), Laura Ríos (Cal Poly), Peter Schwartz (Cal Poly), Stamatis Vokos (Cal Poly)

Mechanics—the study of motion and of the action of forces on bodies—is a core topic in both physics and engineering that is rife with nonintuitive concepts and content that many undergraduates find challenging to master. In addition, though mechanics includes core topics across both engineering and physics, many faculty do not form strong connections between disciplinary treatments of these common principles in ways that might enhance performance, identity, belonging, and ultimately persistence in STEM.

To address these issues, "The Mechanics of Inclusion and Inclusivity in Mechanics" project seeks to eliminate equity and performance gaps in mechanics courses by (a) developing a suite of adaptive web-based tools that incorporate videos that illustrate why a topic is relevant to diverse professionals in the real world and adaptive tests, while (b) leveraging those cognitive tools and affective interventions to establish a sense of belonging, a strong STEM identity, and deep conceptual understanding. Parallel to these online efforts will be the implementation of evidence-based practices in the face-to-face classroom, such as the integration of Learning Assistants, implementation of hands-on, minds-on experiments, and development of a supportive, team-based learning environment, in which collaborative norms minimize microaggressions and toxic gendered interactions among team members.

To cultivate a sense of belonging and STEM identity, our work will target the development of coherent conceptual understanding as opposed to memorization (so that students feel that their own ideas contribute to the sense-making attempts of the group), situate problems within authentic scientific and engineering contexts (so that students see the relevance of what they learn to the needs of their communities), and highlight contributions by non-traditional scientists and engineers (so that students see themselves in them). The project will disseminate its resources, a framework for faculty development focused on both the instructional materials and the design of inclusive classrooms, and results of its research throughout the California educational system, online, as well as through professional conferences and publications.

3.5. Developing Student Identity and Self-Perception as Capable STEM Thinkers and Learners

Regions: Bay Area, North Coast
Disciplines: Chemistry, Math
Grant Amount: Up to $1,300,000
Institutions: College of Marin, Sonoma State University, Diablo Valley College, UC Berkeley
Co-Principal Investigators: Paul Daubenmire (COM), Hien Nguyen (COM), Jennifer Lillig-Whiles (SSU), Carmen Works (SSU), Cory Antonakos (DVC), Erin Palmer (DVC), L. Ellen Beaulieu (DVC), Angelica M. Stacy (UC Berkeley)

Pervasive narratives about scientific brilliance exclude many students from pursuing careers in science. These narratives suggest that what counts is innate talent, knowing lots of information, and being quick and correct. The traditional design of STEM courses perpetuates these narrow views, which disproportionately impact students historically underrepresented in STEM.

The goal of "Developing Students' Identity and Self-Perception as Capable STEM Thinkers and Learners" is to disrupt these narratives and misplaced assessments of what defines scientific brilliance. This project designs materials to help both instructors and students to see science as an expansive and inclusive set of practices. It explicitly defines scientific competence as participation in these practices. The diverse project team will use the results of research in the learning sciences and their collective expertise to:

1) Develop group-worthy equitable in-class activities and complementary social supports to empower students to recognize and develop their talents by practicing science; and
2) Empower faculty to build an inclusive classroom climate.

The activities for students center on providing data and information that foster thinking like a scientist by looking for patterns, generating rules, asking questions, and being open to ideas from teammates. The workshops and faculty engagement components offer supports for building a classroom environment that values the assets all students bring and that builds student talent. During the grant period, the project will use assessment tools to iterate and improve each online module developed. At the end of the grant period, the project will curate a library of online, transferable, data-driven modules that will be accessible to faculty across California, including Canvas Commons and through CSU Fully Online.

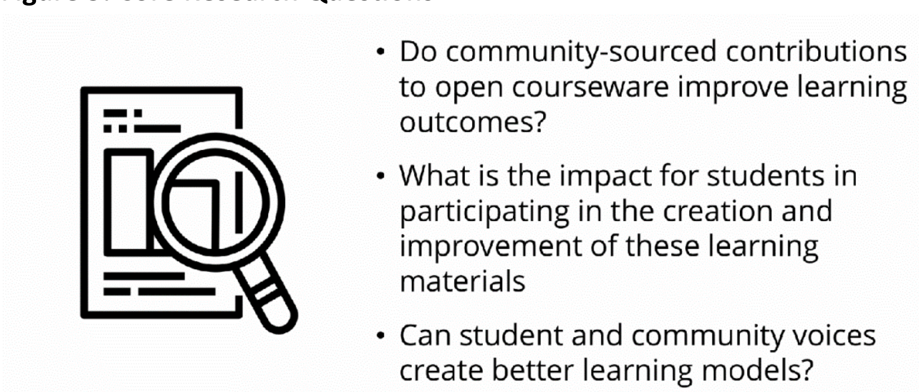
3.6. Community Sourced, Data-Driven Improvements to Open, Adaptive Courseware

Region: Orange County
Disciplines: Chemistry, Math, Engineering
Grant Amount: Up to $1,300,000
Institutions: Santa Ana College, CSU Fullerton, UC Berkeley
Co-Principal Investigators: Crystal Jenkins (SAC), Nina Robson (CSU Fullerton), Zachary Pardos (UC Berkeley), Lauren Herckis (Carnegie Mellon University)

"Community Sourced, Data-Driven Improvements to Open, Adaptive Courseware" will improve outcomes for STEM learners in targeted courses by deploying and improving open, adaptive courseware. This project builds on Open Learning Initiative (OLI) and Lumen Learning courseware that has been demonstrably effective in closing gaps and improving performance for underrepresented learners in STEM.

The project has two main thrusts: effectiveness and barriers. Effectiveness research will investigate the impact of multi-sourced data driven improvement on outcomes for targeted STEM learners, and barriers research will investigate the impact of this approach on faculty attitudes and culture. Improvements will be guided by analytic tools developed for this project that provide faculty, student, and crowdsourced feedback and participation. This approach ensures that student voices will play a central role in identifying areas of difficulty, evaluating materials and improvements, and recognizing student experience. Barriers research expands upon established protocols from Carnegie Mellon University, including embedding a cultural anthropologist who will use a mixed-methods approach to better understand barriers and facilitators for effective adoption of technology enhanced learning (TEL) innovations. This research complements and informs effectiveness research, employing a research-based approach to integrate these new tools into existing educational contexts.

Figure 5: Core Research Questions

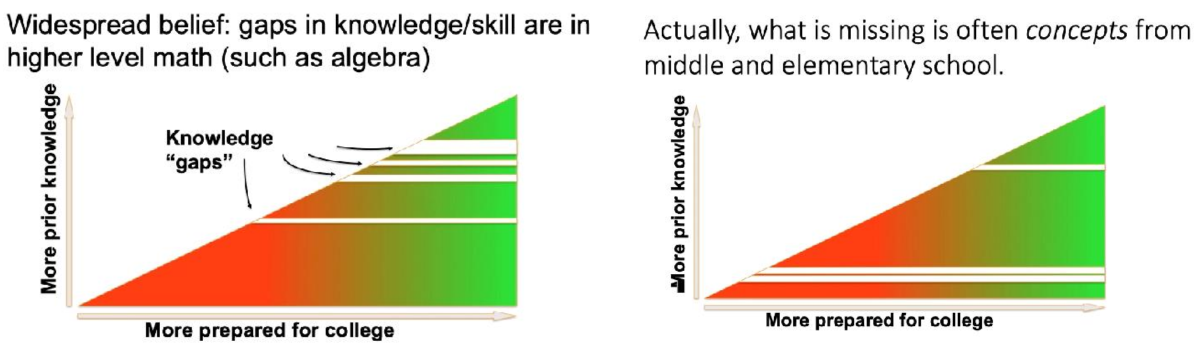


3.7. Building College-Level Number Sense with Adaptive Technology

Region: Inland Empire
Discipline: Math
Grant Amount: Up to $500,000
Institutions: CSU San Bernardino & Riverside City College
Co-Principal Investigators: Susan Addington (CSU San Bernardino) & Mary Legner (RCC)

"Building College-Level Number Sense with Adaptive Technology" will create content that helps students develop college level number sense, concentrating on foundational and advanced aspects of measurement and units, place value, and proportional reasoning, especially approximate mental calculation. These are thinking skills not just for the next math course, but for other courses needing quantitative methods (e.g., STEM, research methods in social sciences, business), as well as for careers, financial self-sufficiency, and for an educated citizenry. Though many math instructors presume that these thinking skills have been taught and learned in middle school, in fact they require practice at the adult level for mastery. Searches for good, conceptual curriculum at the college level in these areas turn up only traditional skills instruction. Some material is available at the middle-school level, and in curriculum for future elementary teachers, but none of this material is in a form appropriate for incoming college students.

Figure 6: Knowledge Gaps in College Level Math



The project team will develop materials, including video-based worked examples and virtual tutor simulations, that include culturally relevant situations and examples, featuring realistic scenarios that our diverse student body finds familiar, as well as aspirational situations (such as internships or jobs at the entry level in STEM fields). The project will also include interventions to help students develop a growth mindset, improve persistence and overcome stereotype threat. The materials developed under this proposal will be made available as Open Educational Resources.

3.8. E-Games for Active Training in Engineering Design

Region: Sacramento Metropolitan Area
Discipline: Engineering
Grant Amount: Up to $500,000
Institutions: UC Davis, American River College, CSU Sacramento
Principal Investigator: Angelique Louie (UC Davis)
Co-Principal Investigators: Jennifer Choi (UC Davis), Darnel Degand (UC Davis), Joshua McCoy (UC Davis), Will Davis (ARC), Hong-Yue (Ray) Tang (CSU Sacramento)

Students in engineering typically spend their freshman and sophomore years taking courses in mathematics, physics, chemistry, and fulfilling general education requirements. Major-specific training in engineering often does not begin until the junior year. A common complaint is that the first two years of engineering education are too abstract and students are unable to feel a connection between what they are learning and what a career in the discipline is like. Disillusioned students leave early in the curriculum, and underrepresented groups are disproportionately affected.

The project team believes it is critical in the first two years of education to allow students to apply their foundational knowledge to practice—to provide a more engaging introduction to engineering as an exciting and creative career option and to solidify student commitment to their selected engineering majors. Hands-on experience is well known to improve student success measures, and improved performance increases student desire to continue in their studies. Engineering design is an ideal topic to provide higher-level experiences to students, but engineering design courses can be expensive to deliver. It can also be difficult to fit another course into the already unit-heavy engineering curricula.

"E-Games for Active Training in Engineering Design" proposes to provide scalable, meaningful exposure to engineering design to lower division students by creating online game modules that will cover the basic steps of the engineering design process. The modules can be mix-and-matched for use in courses or offered to students for free play. The project team, which includes biomedical engineers, mechanical engineers, computer scientists, educators, game designers, social scientists and students, will harness online education and gaming products that they have made for undergraduate courses in Biomedical Engineering Design and Introduction to Research and create new gaming materials. Games offer an avenue for exploration that sparks student creativity, increases engagement with the material, promotes self-confidence, and allows us to implement "hands-on" design training at relatively low cost to students at California public institutions of higher learning. The project team will explore this adaptive learning tool and evaluate its impact on student learning and retention.

3.9. California Challenges in STEM Energy Education

Region: Central Valley
Discipline: Chemistry, Engineering
Grant Amount: Up to $500,000
Institutions: CSU Bakersfield, UC Merced, Bakersfield College
Principal Investigators: Marina Shapiro (CSU Bakersfield), Abbas Ghassemi (UC Merced), Stephen Waller (Bakersfield College)

"California Challenges in STEM Energy Education" seeks to reduce large educational equity gaps in STEM fields that are experienced by Hispanic and other underrepresented minority (URM) students who live in California's Central Valley. The California State University at Bakersfield (CSU Bakersfield), the University of California at Merced (UC Merced), and Bakersfield College, three academic institutions that are located in the valley and serve these students, will participate in this proof-of-concept project.

Equity gaps in Central Valley STEM education exist despite strong demand for STEM graduates in the local economy, which is largely based upon the energy and agricultural industries. Furthermore, when URM students enter STEM fields, they fail to see the connection between their studies and real-world problems because gateway courses in current curricula fail to make that connection explicit.

This project will introduce the concepts behind practical technical problems at the intersection of energy, water, and agriculture—problems relevant to the Central Valley—into gateway STEM courses. This will be accomplished via a novel combination of two pedagogies, flipped classroom and Process Oriented Guided Inquiry Learning (POGIL), which we call Flipped Classroom-Enhanced-Process Oriented Guided Inquiry Learning (FC-E-POGIL). The flipped classroom format involves pre-class student reading assignments and the enhanced POGIL format involves a highly structured in-class format, including assigned student roles and after class homework assignments.

Additionally, the team will work with vendors to develop adaptive online homework problems related to energy content, and develop an energy chemistry augmented reality application to enhance the learning experience. Co-PIs from all three institutions will work together to create videos for customized energy-related content, which will be implemented in gateway chemistry courses and a human centered research and design course at UC Merced.

4. Outreach Activities and Survey Results

Following the completion of Learning Lab's first RFP, Learning Lab staff engaged in two outreach projects to inform planning for subsequent Requests for Proposals. From late June through early July, staff surveyed unfunded applicants to understand their experiences of the RFP process and identify areas for improvement. Following this effort, staff also reached out to a broader community of STEM faculty to gauge professional development needs across the segments. The results of these surveys are discussed in the following two sections.

4.1. Applicant Survey

In order to better understand the experiences of applicants who participated in the Learning Lab's first RFP, Learning Lab staff solicited feedback from unfunded teams. Nine of 33 unfunded applicant teams responded to the call for feedback between June 27th and July 8th, 2019; seven applicant teams provided their feedback through semi-structured interviews with Learning Lab staff and two more teams offered input through an online survey.

Respondents generally had a positive impression of the RFP process. Most found the RFP document and the application process to be generally clear and well organized; several teams also mentioned that they appreciated the responsiveness of Learning Lab staff to inquiries and questions.

Applicant teams also provided constructive feedback, which has informed the design and organization of Learning Lab's RFPs for 2019-2020 (please Section 5.1 below). In particular, teams noted that the timeframe of the first RFP had been tight and had not provided opportunity for applicants to develop new partnerships with colleagues at other campuses and in the other segments of higher education. Most respondents agreed that they would have benefited from a more extended application timeline and that an extended timeline would have helped them to establish new relationships across segments.

Finally, respondents further agreed that they would have benefitted from additional clarity regarding the requirements of the RFP. Respondents suggested that their proposals would have benefited from better understanding of the RFP's expectations regarding the balance of research and implementation, the role of technology, and areas of emphasis. In part, this uncertainty stemmed from the fact that Learning Lab asked applicants to combine learning/education-based research and teaching practice, two areas that have traditionally been separate in disciplinary cultures. A lesson was that Learning Lab RFPs need to be more explicit regarding expectations for projects, particularly when those projects are bridging traditional disciplinary divisions. An additional lesson, further encouraged by applicant feedback, was to host additional online Q&A sessions with Learning Lab staff to provide additional information about Learning Lab's RFPs.

Notably, in addition to providing constructive suggestions, applicant feedback suggested that Learning Lab's RFP had succeeded in its goal of encouraging and strengthening intersegmental cooperation. Seven of the nine respondents reported that the RFP process encouraged them to strengthen or further develop existing intercampus and intersegmental partnerships. Three teams reported that they sought to develop new connections across the segments as a result of the RFP. One team suggested that the intersegmental team that developed in response to the RFP would not have come together otherwise; that team further related that they intended to continue collaborating and working together, even though they had not received funding from Learning Lab. Other teams agreed that Learning Lab's RFP encouraged intersegmental collaboration. According to one applicant team, "The RFP made it possible to accelerate connections and talk about partnership in a concrete way with others. It catalyzed the process [of building intersegmental partnerships]."

In other cases, the RFP further encouraged departmental recognition of the significance of the science of learning and of discipline-based education research. One team specifically mentioned that their department had not generally been supportive of education-based research. For that team, Learning Lab's RFP and the availability of grant funding to support teaching research demonstrated to their chair the importance of this area of research.

4.2. Professional Development Survey

During the first RFP review process, members of Learning Lab's Selection Committee noted that some proposed projects would have benefited from the inclusion of dedicated faculty professional development oriented toward pedagogical and curricular improvement. In order to inform the creation of a professional development component for future RFPs, Learning Lab developed a short survey (see Section 9) seeking educators' perspectives on professional development needs in STEM departments/disciplines and to learn about their experiences with effective approaches to professional development.

Between July 8th and July 24th, the California Education Learning Lab collected survey responses from STEM faculty and the greater STEM learning community in order to identify professional development needs across California's public colleges and universities and learn about effective approaches to professional development. Learning Lab disseminated a brief survey through its listserv and encouraged email recipients and the members of its Advisory Committee to share the survey broadly through their professional networks.

A total of 135 individuals responded to the Learning Lab's professional development survey. The respondents represented 50 institutions of higher education, coming primarily from California's Community College (41 percent) and CSU System (47 percent) followed by the UC system (7 percent). The participants served as tenured or tenure-track faculty (59 percent), lecturers with security (9 percent), contingent faculty (21 percent) and administrative staff (11 percent) at their institutions. Although the respondents were not fully representative of California STEM education, they nevertheless included perspectives from both two and four-year institutions and further included significant representation from contingent/non-tenure track faculty.

With respect to professional development needs, 49 respondents (36 percent) reported that they were interested in or saw need for professional development opportunities that would help them to integrate active learning principles into their classroom or adopt more effective pedagogical approaches generally. A slightly smaller share (36 respondents, or 27 percent of the total) reported that they were interested in resources that would help them to make their pedagogy and curriculum more inclusive. A number of respondents (17, or 13 percent) suggested that they would benefit from resources or programs that would help them learn to incorporate technology tools and/or online components more effectively into their courses.

Individual comments from respondents tended to emphasize the limited availability of professional development programs or resources for faculty, as well as the existence of departmental cultures that did not put a high value on professional development. Several respondents mentioned that their departments did not encourage faculty to pursue professional development opportunities related to pedagogical or curricular improvement or did not offer resources related to professional development. Some respondents also noted that their departments did not encourage collaboration or cooperation among faculty teaching different sections of the same course, or different elements of a course sequence. Other respondents mentioned a particular need for professional development support for contingent faculty.

In response to the question of which incentive strategies would best encourage faculty to participate in professional development activities, respondents suggested that time and money were, by far, the most important factors for incentivizing participation. These factors were distantly followed by tying PD participation to professional advancement. Encouragement from a department chair was slightly more valued as a means of incentivizing PD participation than encouragement from colleagues; however, neither of these strategies was highly ranked by most respondents.

5. Looking Ahead

For Fiscal Year 2019-2020, Learning Lab has allocated $9.5 million for three Requests for Proposals that will encourage the development and dissemination of pedagogical practices, learning resources, technological tools, courses, and course series that demonstrate success in improving learning outcomes and closing equity gaps, and contribute to the fundamental understanding of human learning.

In addition to commencing a new funding cycle that features an expanded number of funding opportunities, Learning Lab is also sponsoring convenings that aim to support the work of its current awardees and encourage collaboration and community building within the wider STEM faculty and learning communities. Furthermore, Learning Lab plans to engage students through a statewide student survey.

5.1. 2019-2020 Requests for Proposals

On September 16, 2019, Learning Lab issued three Requests for Proposals for 2019-2020, under the common title, "Using Research and Technology to Transform Undergraduate STEM Education." Through these grant opportunities, Learning Lab seeks to support curricular and pedagogical innovation and professional development for faculty in undergraduate STEM education. These RFPs are open to intersegmental faculty teams addressing courses in the life and biological sciences, engineering, computer science, information/data science, math and statistics, and the physical sciences (Including earth and environmental sciences).

For the 2019-2020 funding cycle, Learning Lab will award up to seven Innovation Grants ($7 million total), up to nine Seed Grants ($900,000 total), and up to eight Professional Development Grants ($1.6 million total). Since these grants are intended to support projects that are in different stages of development and operating at different scales, project teams may apply for only one of these funding opportunities:

1. Innovation Grants – For this RFP, up to $7 million will be provided from the Learning Lab to fund seven demonstration projects (approximately $1 million each) for 3 years to support curricular and pedagogical innovations that aim to improve learning outcomes, transform the culture of learning (both with regard to bridging divisions between learning/education-based research and teaching practice, as well as how students perceive the classroom or disciplinary learning culture), and close equity and achievement gaps in online and hybrid learning environments. Projects are encouraged to promote students' sense of belonging in STEM, students' STEM identity, and connections between STEM and students' lives, career aspirations and home communities, leveraging affective components of learning to reduce achievement gaps.

    These grants will support both projects that develop curricular and pedagogical innovations aimed directly toward students in lower-division STEM courses, and projects that indirectly support curricular and pedagogical change through the creation of innovative, large-scale faculty professional development programs that are closely related to improving learning outcomes or closing equity/achievements gaps in STEM fields. All projects, including professional development projects, must speak to the science of human learning, engage with discipline-based education research, utilize learning technology for purposes of data collection, and/or integrate learning research and teaching practice as core program elements.

2. Seed Grants – Seed Grants will provide initial funding for promising projects of curricular and pedagogical innovation that are still in early planning stages. For this RFP, up to $900,000 will provided from the Learning Lab to fund approximately nine seed grant projects (approximately $100,000 per project) for 1-2 years. Seed grants are intended to help teams design and develop projects that may compete for Innovation Grants in future RFP cycles.

   Like the larger Innovation Grants, Learning Lab Seed Grants are intended to support projects proposing curricular and pedagogical innovations that aim to improve learning outcomes, transform the culture of learning, and close equity and achievement gaps in online and hybrid learning environments within lower division STEM undergraduate curriculum. Seed grants, however, will provide support for project teams that are in earlier stages of project design or conceptualization and that would benefit from additional development or preliminary testing before proceeding to full-scale implementation. The goal of the seed grants is to provide projects with funding that will support initial project research and development and will lead to concrete deliverables, including, but not limited to, proof-of-concept testing, data collection and analysis, development of pedagogical/curricular resources, and/or development of a strong intersegmental team.

3. Professional Development Grants – For this RFP, up to $1.6 million will be provided for up to eight faculty professional development grant projects (approximately $200,000 each) for 1-2 years. Professional development grants will provide funding to intersegmental partnerships to support the creation or expansion of faculty professional development programs that contribute to improvement in learning outcomes or reduction in equity gaps in undergraduate STEM courses. These grants may be used to scale existing programs of faculty professional development, tailor existing programs in a local context, and/or as seed funding for the creation of new faculty professional development programs.

   The proposed program should include both online and in-person components for faculty in a particular STEM discipline or in STEM disciplines, and should be designed to address professional development needs with the goal of improving learning outcomes or closing equity/achievement gaps in STEM fields. Additionally, the proposed program should support understanding and incorporation of the principles of the science of human learning, discipline-based education research, learning engineering, and/or instructional design and assessment into STEM pedagogy and curricula..

These RFPs incorporate both applicant feedback and lessons learned from the 2018-2019 funding cycle. In their feedback, two applicant teams from 2018-2019 reported that they would have appreciated seed grant funding opportunities. These teams noted that they had understood that their projects were not fully mature when they applied and suggested they would have benefited from initial support for project design and for the development of a strong intersegmental team. This feedback, together with the Selection Committee's decision to recommend three of the 2018-2019 project teams for proof-of-concept awards, encouraged Learning Lab to make seed grants available in 2019-2020. Similarly, proposals for the previous RFP suggested that some applicant teams sought to expand professional development opportunities for faculty, as well as to design and implement curricular and pedagogical innovations. Recognizing this demand for professional development, Learning Lab introduced professional development grants so that teams may use funding to support faculty and indirectly improve learning outcomes and close equity gaps in STEM.

In addition, in response to feedback from the first RFP, application timelines have been extended and applicants have been given greater leeway in the particular structure of their proposals—rather than responding to distinct questions in their proposals, applicants for 2019-2020 grant opportunities are instead asked to provide narrative proposals that address key criteria within the overall context of the proposal. The RFPs also include additional framing language that aims to help applicants understand that Learning Lab seeks to support projects that both demonstrate success in improving learning outcomes and closing equity gaps and that contribute to fundamental understanding of human learning. The framing language for the RFPs explains that Learning Lab grants are intended to support projects that incorporate fully the following four project elements:

- Develop and implement curricular and pedagogical innovations;
- Demonstrate the effectiveness of those curricular and pedagogical innovations through a process of rigorous assessment and evaluation (and apply the results of that assessment through a process of iterative improvement);
- Utilize technology tools, including adaptive learning technology, in online or hybrid course environments to support learning outcomes and the collection of learning data for the purpose of advancing research into human learning; and
- Show clear potential for replication and dissemination, as well as capacity to affect positive pedagogical and/or curricular change at scale.

As with Learning Lab's first RFP, projects must be co-hosted by a faculty team representing a minimum of two public higher education segments in California. Collaboration with faculty from private independent/nonprofit institutions and non-faculty professionals is also welcome.

Selection Process
For the Innovation and Professional Development grant opportunities, awardees will be selected through a three-stage process involving: (1) submission of letters of intent to submit concept proposals (October 22, 2019); (2) submission of concept proposals (November 15, 2019); and (3) submission of full proposals, based on selected concept proposals, from which the final selection of awards will be made (February 3, 2020).

Seed grant awardees will be selected through a two-stage process involving: (1) submission of letter of intent to submit proposals (October 22, 2019); and (2) submission of proposals from which the selection of awards will be made (December 9, 2019).

As with the first RFP, an external Selection Committee will evaluate and recommend awards. At both the concept and full proposal stages, applications will be reviewed by members of the Selection Committee and by external reviewers. The Selection Committee will use a process consistent with National Science Foundation procedures for reviewing the proposals and making award recommendation. All reviewers and Selection Committee members will sign confidentiality and conflict of interest statements; Selection Committee members and external reviewers will not evaluate proposals where there is a conflict of interest.

Finally, in order to facilitate an application process that will include submissions for three distinct RFPs, and will likely include more proposal submissions than for Learning Lab's first RFP, Learning Lab contracted in August 2019 with a cloud-based grant management software provider to host an application management system for Learning Lab.

5.2. All Teams Meeting

In order to encourage collaboration and community building among Learning Lab awardees, Learning Lab hosted an All Teams Meeting for awardees on October 25th at UC Berkeley. This meeting provided an opportunity for grantees to share progress and challenges, discuss issues that are pertinent across all projects, and generally to engage with one another and with Learning Lab advisors. Members from all of the project teams participated in the event.

A principle goal for this convening was to create a sense of community across the Learning Lab's project teams so that they could look to each other for advice and support during the grant period, and beyond as they scale their projects. Sessions during the day focused on addressing shared questions and challenges and encouraging teams to work together to identify possible solutions to anticipated challenges. Topics of discussion included identifying what teams can learn from one another, identifying strategies and resources for using technology to change the culture of learning, and developing strategies and approaches for scaling and disseminating projects and innovations.

5.3. STEM Equity Conference

In conjunction with the All Teams Meeting, Learning Lab co-hosted a STEM Equity Conference on October 25th and 26th at UC Berkeley. Learning Lab co-sponsored this conference in collaboration with The Biology Scholar's "Expanding Undergraduate Success in STEM Project" at UC Berkeley and with the UC Systemwide Faculty Learning Community Project, both funded through grants received from the Howard Hughes Medical Institute. The conference focused on approaches to increasing institutional capacity to support the student success in STEM, especially the success of students from historically underrepresented backgrounds.

The STEM Equity Conference featured participation from more than 150 individuals, representing all three segments of California public higher education, and included faculty, administrators, and participants from the wider STEM learning community.

Panels featured presentations on undergraduate student experiences in STEM (presentations by current and recent STEM students), on STEM gateway courses (with a focus on inclusive practices that have demonstrated success in closing equity gaps in these courses), on STEM transfer students (with discussion of approaches for supporting STEM transfer students both on the pathway toward transfer and following their transfer to a 4-year institution), and on STEM advising, mentoring and academic support.
As with the All Teams Meeting, a goal of this conference was to encourage networking and community building among faculty with an interest in addressing equity gaps in STEM. Learning Lab grantees were encouraged to participate in this conference; the STEM Equity Conference offered an opportunity to interact with the larger community of faculty who are working to improve STEM pedagogy. All Learning Lab teams presented posters at the Equity Conference in order to showcase their projects to the wider STEM learning community and to benefit from discussing their projects with attendees.

5.4. Student Engagement Project

In addition to its outreach to STEM faculty, Learning Lab is also engaged in a STEM student engagement project in the form of a large-scale survey project to understand better undergraduate student experiences of STEM in California's segments of public higher education. This survey project consists of both a series of student focus groups as well as an online student survey.

Educational research has identified a number of factors—including opportunity gaps with regard to prior preparation, sociocultural factors, and traditional STEM pedagogy that can be ineffective and uninspiring—that contribute to low rates of retention in STEM disciplines, especially among underrepresented students. These studies are based, however, on national student populations and students at 4-year research universities. They do not provide insight into the relative weight of these factors for California's STEM students, nor do they address how barriers to student success and students' experience of STEM might differ among California's segments of higher education or in different parts of the state. Existing studies and research also do not examine how additional factors (like cost of living) may shape students experience of STEM in California or act as barriers to retention.

Learning Lab will develop a better understanding of how California students experience STEM education, and of the particular barriers to success in STEM that they face, through conducting a statewide STEM student survey. This student survey project asks students about their experiences in STEM undergraduate education and about their experiences of STEM courses and asks them what they perceive to be barriers to student retention and progression in STEM and what they think would help more students persist in STEM. It further seeks to understand how student experiences of STEM and perception of barriers to student success vary among the segments of public higher education in California.

Student focus groups constitute the first stage of Learning Lab's student survey project. During fall 2019, Learning Lab staff will conduct focus groups, consisting of STEM undergraduate students, at 6-7 California institutions of public higher education—three community colleges (American River College, Los Medanos College, Rio Hondo College), two California State Universities (CSU Fresno and CSU San Marcos), and two University of California campuses (UC Irvine and UC Davis). These focus group discussions will ask what STEM undergraduates in California's public institutions of higher education see as the key barriers to student retention and completion, as well as what they think could help support student success.

Volunteers for the focus groups will be recruited from participants in campus Math, Engineering, Science Achievement (MESA) programs at community colleges, from Louis Stokes Alliance for Minority Participation (LSAMP) programs at CSU campuses, and from other campus programs that aim to support students who are underrepresented in STEM. Learning Lab is particularly interested in hearing from students who are traditionally underrepresented in STEM fields and who have experience in campus programs that aim to promote inclusivity and student success in STEM. In addition, Learning Lab will recruit participants for additional focus groups at these campuses from the wider STEM student populations. The goal is to hear how experiences differ among students who are participants in programs that specifically aim to encourage student success and those who do not participate in such programs.

The focus group element of the survey project is currently under Institutional Review Board consideration at the Office of Statewide Health Planning and Development's Committee for the Protection of Human Subjects. Learning Lab will begin conducting focus group once IRB approval is confirmed.

The focus groups' responses will then help Learning Lab develop questions for the online statewide survey that will more broadly investigate students' experiences of STEM higher education in California. Learning Lab will conduct the online student survey on a pilot basis (starting with those institutions that were the site of focus group discussions) in late winter or early spring of 2020. The pilot survey will produce preliminary results and allow Learning Lab staff to validate questions before full-scale launch of the survey. The full-scale survey is planned for fall 2020, to provide time for thorough pilot testing and adequate outreach to encourage a high response rate.

6. Learning Lab Briefs

Learning Lab produced a series of three research briefs examining equity gaps in STEM undergraduate education in California. The first brief surveys data on enrollment and completion gaps for female, African American, and Latinx students in STEM fields in the UC, CSU, and CCC system. The second brief summarizes research identifying sources of enrollment and completion gaps. The third discusses approaches to closing enrollment and completion gaps and improving learning outcomes in STEM.

6.1. Enrollment and Completion Gaps in STEM Higher Education

This brief surveys the extent of enrollment and completion gaps in California's systems of public higher education and details the extent to which female, Latinx, and African-American students are underrepresented in UC and CSU STEM enrollment and among STEM degree recipients across the segments of California public higher education.

This review of UC and CSU STEM enrollment data shows that the number of female, Latinx, and African American students enrolled in STEM fields in California's segments of public higher education has grown considerably in the past decade, as has the number of baccalaureate degrees awarded to underrepresented students. The percentage of female, Latinx, and African American students majoring in STEM fields and earning STEM degrees is also growing; enrollment of female, Latinx, and African American students in STEM fields is, moreover, increasing at a faster rate than overall female and URM enrollment.

Yet the extent to which increased STEM enrollment among female, African American, and Latinx students has reduced enrollment gaps varies among fields, since STEM enrollment has also grown for men and non-underrepresented students. Despite improvement, especially for Latinx students, undergraduate STEM enrollment generally continues to display large gaps in female and URM enrollment. Tables 1 and 2 below summarize the extent of enrollment gaps in STEM overall and by STEM discipline in UC and CSU.[8]

[8] Enrollment data are not fully comparable between the UC and CSU systems, since the systems categorize broad disciplines differently—the UC system categorizes natural resources and conservation sciences and selected agricultural/animal sciences in the life sciences, while CSU groups these disciplines with non-STEM fields as interdisciplinary subjects. In addition, the two segments use different definitions when identifying students by race/ethnicity.

Table 1: Percentage of UC Undergraduate Enrollment Overall and by STEM Field that is Female, African American* or Latinx Fall 2008 and 2018

	Female	Female	African American	African American	Latinx	Latinx
	2008	2018	2008	2018	2008	2018
Total Enrollment	53.6	53.8	3.3	4.1	15.7	24.4
Total STEM Enrollment	44.0	45.8	2.5	3.0	12.7	21.0
Engineering/CS	19.8	24.9	1.8	2.1	12.0	17.2
Life Sciences**	59.0	65.0	2.9	4.0	13.0	24.9
Physical Sciences	43.0	42.1	2.2	2.2	13.3	19.5

Source: UC Infocenter, Enrollment at a Glance, https://www.universityofcalifornia.edu/infocenter/fall-enrollment-glance.
Notes: * For this and following tables: the number of students identifying as multi-racial has increased in the last decade, which may reflect changes in cultural and data definitions, as well as actual demographic change.
**In UC reporting, the life sciences include the biological sciences, conservation sciences, and selected agricultural sciences.

Table 2: Percentage of CSU Undergraduate Enrollment Overall and by STEM Field that is Female, African American* or Latinx, Fall 2008 and 2018

	Female	Female	African American	African American	Latinx	Latinx
	2008	2018	2008	2018	2008	2018
Total Enrollment	56.7	55.8	6.1	4.0	24.9	42.8
Total STEM Enrollment**	33.2	33.5	4.6	2.9	21.6	35.9
Biological Sciences	61.7	66.0	6.0	3.6	21.6	43.1
Engineering	13.7	18.6	3.4	2.3	22.8	33.8
Information Science***	16.2	17.9	5.3	3.1	15.6	28.6
Mathematics	48.3	45.2	4.0	2.4	28.3	44.3
Physical Sciences	44.8	44.9	4.5	3.1	19.0	39.2

Source: California State University Office of the Chancellor, Institutional Research and Analyses, Statistical Reports, https://www.calstate.edu/as/stats.shtml.
Notes: *CSU and UC employ different definitions for reporting race and ethnicity data, with particularly large discrepancies in enrollment reporting for students who identify as Black or African American. As a result, enrollment figures by student race/ethnicity for CSU and UC are not comparable.
**The total STEM calculation for CSU does not include conservation and agricultural science fields that are commonly classified as STEM.
*** The CSU broad discipline category of information science includes a small number of students in fields, including accounting information and management information systems, that are not commonly classified as STEM.

Similarly, the brief finds that even as more female, Latinx, and African American students earn degrees in STEM fields, notable completion gaps remain. Tables 3, 4, and 5 below illustrate the state of completion gaps in UC, CSU, and CCC. In relation to their share of all baccalaureate degrees awarded, female students, African American and Latinx students are generally underrepresented among degree recipients in STEM fields:

- In 2016-17, female UC students earned 54.1 percent of baccalaureate degrees, but (based on students' primary major) only 42.5 percent of baccalaureate degrees in STEM, down from 43.7 percent of STEM degrees in 2006-07.
- In 2016-17, female CSU students earned 57.7 percent of all baccalaureate degrees, but only 34.4 percent of bachelor's degrees in STEM, a figure that is slightly lower than the 34.6 percent of CSU STEM degrees that went to female students in 2006-07.
- The percentage of STEM degrees going to African American students decreased in both the UC and CSU systems between 2006-07 and 2016-17. The percentage of UC STEM degrees going to African American students fell from 1.5 to 1.3 percent and the share of CSU STEM degrees going to African American students fell from 3.0 to 2.0 percent. This decline in the African American share of STEM degrees is present across most STEM fields.
- Latinx students are also underrepresented among STEM degree holders, but the percentage of STEM degrees going to Latinx students increased substantially in the UC and CSU systems, doubling in many fields, and reducing the degree of Latinx underrepresentation in STEM. Between 2006-07 and 2016-17, the percentage of STEM degrees earned by Latinx students (increasing from 7.6 to 14.7 percent in UC and from 13.2 to 26.8 percent in CSU) grew more quickly than the percentage of baccalaureates overall earned by Latinx students.

As in the UC and CSU systems, female and URM students are underrepresented among community college STEM graduates, in comparison to their overall share of degrees received. Between 2006-07 and 2016-17, the level of underrepresentation among female and African American students earning associate degrees remained relatively constant while declining among Latinx students.

Table 3: Percentage of UC Bachelor's Degrees Overall and in STEM fields (by Primary Major) Awarded to Female, African American*, and Latinx Students, 2006-7 and 2016-17

	Female	**Female**	**African American**	**African American**	**Latinx**	**Latinx**
	2006-07	2016-17	2006-07	2016-17	2006-07	2016-17
All	54.8	54.1	2.8	2.2	12.8	20.9
All STEM	43.7	42.5	1.5	1.3	7.6	14.7
Biological and Life Sciences**	59.7	60.3	1.6	1.7	7.7	16.4
Engineering	18.9	22.8	1.3	1.2	6.7	14.9
Computer Science	13.1	19.1	1.7	1.0	5.7	8.5
Mathematics	40.6	43.2	1.8	0.5	11.1	12.2
Physical Science	43.7	36.1	1.4	1.3	8.4	16.7

Source: Integrated Postsecondary Education Data System (IPEDS).

Notes: *IPEDS uses different definitions for reporting race and ethnicity data than UC; these different definitions produce particularly large discrepancies in the reporting of enrollment and completion data for African American or Black students. As a result, these completion statistics are not comparable to the UC enrollment figures in Table 1.
**The Biological and Life Sciences in this table and in Table 6 include degrees in the following fields: Natural Resources (CIP 03.xxxx); Biological and Biomedical Sciences (CIP 26.xxxx); and selected agricultural/animal sciences (CIP 01.0000, CIP 01.0801, CIP 01.09 thru 01.9999, and CIP 30.1901).

Table 4: Percentage of CSU Bachelor's Degrees Overall and in STEM fields (by Primary Major) Awarded to Female, African American, and Latinx Students, 2006-7 and 2016-17

	Female	Female	African American	African American	Latinx	Latinx
	2006-07	2016-17	2006-07	2016-17	2006-07	2016-17
All	59.4	57.7	4.9	3.8	20.4	35.5
All STEM	34.6	34.4	3.0	2.0	13.2	26.8
Biological and Life Sciences	60.8	60.8	3.4	2.4	11.9	28.2
Engineering	16.0	17.1	2.8	1.6	14.1	25.9
Computer Science	16.4	13.2	2.9	1.8	10.0	22.0
Mathematics	46.8	43.5	1.9	2.0	20.7	34.3
Physical Science	40.2	39.1	3.3	2.4	12.0	27.4

Source: IPEDS.

Table 5: Percentage of Community College Associate Degrees Overall and in STEM Fields Awarded to Female, African American, and Latinx Students, 2006-7 and 2016-17

	Female	Female	African American	African American	Latinx	Latinx
	2006-07	2016-17	2006-07	2016-17	2006-07	2016-17
All Majors	62.5	60.0	6.5	5.2	25.5	43.6
All STEM	38.7	36.6	4.0	2.8	19.8	33.3
Biological and Life Sciences*	70.4	68.0	3.9	3.0	17.8	35.3
Engineering	16.8	21.1	3.5	2.5	23.9	37.1
Computer Science	27.5	18.7	6.3	4.6	18.6	28.4
Mathematics	27.8	30.2	3.1	1.8	23.2	33.7
Physical Sciences	44.6	38.1	--*	2.0	16.0	32.0

Source: IPEDS.
Notes: Percentages are not provided when fewer than 10 students received a degree for the year.

6.2. Sources of Enrollment and Completion Gaps in STEM Higher Education

The second brief surveys academic research and literature on the sources of the enrollment and completion gaps described in the first brief; it discusses the principal sources of enrollment and completion gaps in STEM higher education. Researchers have identified a number of factors that contribute to high rates of attrition among female and underrepresented minority (URM) students from STEM fields. According to researchers, these sources of equity gaps include:

1) **Opportunity gaps in K-12 education with regard to prior preparation for STEM fields**. Many URM students enter higher education less prepared for college-level STEM courses because of disparities in the quality of K-12 education and in access to advanced high school math and science courses. These disparities can also limit opportunities for underrepresented students to develop an interest in STEM.

2) **Traditional STEM pedagogy and curricula**. Students majoring in STEM confront a series of required introductory courses (e.g. math, chemistry, physics) in their first year, often with large enrollments. These courses typically feature instructional environments and standards that are very different from what students experienced in high school, and cover large amounts of material rapidly with limited individual support for students. In addition, the pedagogy and content of such introductory classes tends to be traditional and uninspiring, while the academic demands are high. These courses function as gateways to STEM fields, and they have a large impact on the attrition of all potential STEM students. Their impact is greatest, however, on students who have less preparation and/or who may have questions as to whether they can succeed and whether they are welcome in STEM. The effect of these factors tends to be greater on average for students from underrepresented groups compared to their non-underrepresented peers.

3) **Sociocultural factors**. Questions about whether they can succeed and are welcome in STEM are greater for female and URM students because of sociocultural factors. The classroom and disciplinary culture of STEM departments can be exclusive and unwelcoming to female and URM students. Cultural and disciplinary stereotypes about who is supposed or suited “to be a scientist” can negatively affect students’ experience of specific course settings, and can also have broader impacts, like deterring students from entering or continuing in fields. The lack of diversity in STEM fields, meanwhile, can deprive female and URM students of supportive communities and faculty role models.

The second brief surveys research relating to these different sources of enrollment and completion gaps in STEM. It also highlights research that demonstrates that approaches that address pedagogical and sociocultural sources of enrollment and completion gaps can help to close equity gaps even in the face of opportunity gaps related to prior preparation. This finding indicates that there is significant space for colleges and universities to improve STEM retention among female and URM students. Significantly, research into the sources of STEM equity gaps suggests that institutions of higher education can mitigate gaps in preparation by changing pedagogy and curricula and by addressing the sociocultural forces that inhibit persistence. Programs that build supportive communities for underrepresented students and that help to develop student identification with STEM disciplines have demonstrated significant success in fostering female and URM student persistence in STEM.

6.3. Addressing STEM Enrollment, Completion, and Performance Gaps in Higher Education

The third brief examines approaches to mitigating and closing STEM enrollment, completion, and performance gaps. Research indicates that well-constructed programs of student support and of pedagogical and curricular change can mitigate the impact of both opportunity gaps and of sociocultural barriers. In the words of one group of researchers focusing on STEM equity gaps, "[C]olleges and universities can make a significant difference in reducing racial disparities in science achievement and do not have to wait idly for high schools to send them more well-prepared students."[9] Institutions of higher education can provide underrepresented students with supportive communities, help those students better identify with the discipline that they are studying, and reshape pedagogy and curricula in ways that engage students more fully and improve learning outcomes.

The brief surveys the different approaches that colleges and universities have adopted to address equity gaps in STEM, including creating programs that provide cultural and academic support to underrepresented students, and implementing programs to improve or modify pedagogy and curriculum. It also discusses barriers that institutions and departments encounter in implementing these approaches and the limitations of these strategies for closing equity gaps. Education researchers observe that efforts to address STEM equity gaps through sociocultural support for students have generally proceeded separately from parallel initiatives to improve STEM pedagogy and curricula more broadly. This lack of integration between programs that are oriented, on the one hand, toward providing cultural support for underrepresented students and, on the other, toward reforming STEM pedagogy and curricula has tended to limit the full impact of both these approaches.[10]

The brief summarizes research that emphasizes the importance of integrating approaches to improving student-learning outcomes that have generally remained separate and distinct. This means addressing cultural and pedagogical sources of equity gaps simultaneously by encouraging faculty and departments to reshape traditional pedagogy and curricula at the same time as they seek to change traditional disciplinary cultures, and by integrating cultural and academic support with broad-based and sustained pedagogical and curricular improvements.

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[9] Mitchell J. Chang, et al., "What Matters in College for Retaining Aspiring Scientists and Engineers from Underrepresented Racial Groups," *Journal of Research in Science Teaching* 51, no. 5 (2014): 555-580, at p. 571.

[10] Mica Estrada, et al., "Improving Underrepresented Minority Student Persistence in STEM," *CBE—Life Sciences Education* 15(3) (Fall 2016), pp. 5-6. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5008901/; Adrianna Kezar and Elizabeth Holcombe, *Creating a Unified Community of Support: Increasing Success for Underrepresented Students in STEM—A Final Report on the CSU STEM Collaboratives Project* (USC Pullias Center for Higher Education, 2017), p. 7. Retrieved from: https://pullias.usc.edu/csustemcollab/#report.

In addition, the third brief discusses the role of educational technology in addressing equity gaps in STEM. Adaptive learning platforms and other educational technologies offer robust opportunities to collect and analyze student-learning data, thus supporting iterative improvement in teaching while also providing students a more personalized learning experience.[11] Studies and trials suggest that, in the context of ongoing efforts of STEM departments and institutions of higher education to address equity gaps, educational technologies can further facilitate improved learning outcomes when used as part of pedagogical strategies that encourage active learning and student engagement with the course and with course content.

[11] Candace Thille, "How Technology is Transforming Higher Education," in *Proceedings of the Aspen Institute Congressional Program—Challenges Facing America's Higher Education System* (Palo Alto, CA, October 4-7, 2013), https://assets.aspeninstitute.org/content/uploads/files/content/upload/2013_Education-Stanford-Cancelled-Notebook.pdf.

7. Learning Lab Advisors

7.1. Learning Lab Advisors

A distinguished panel of seven faculty members from across the higher education spectrum advised Learning Lab on its first year of operation and execution of its inaugural request for proposals. These seven advisors also served as Year 1 Selection Committee members, who reviewed and evaluated the 42 proposals submitted, and ultimately recommended nine projects which received Year 1 Learning Lab awards.

Candace Thille

Director of Learning Science and Engineering, Amazon.com, Inc.
Associate Professor, Stanford Graduate School of Education
Senior Research Fellow, Office of the Vice Provost for Teaching and Learning, Stanford University
Affiliate Faculty, Stanford Neurosciences Interdepartmental Program
Director, Stanford University Open Learning Initiative
Co-Director, Stanford Lytics Lab

Candace Thille focuses on applying the results from research in the science of learning to the design and evaluation of open web-based learning environments. Dr. Thille was the Founding Director of Carnegie Mellon University's Open Learning Initiative. Dr. Thille serves as a fellow of International Society for Design and Development in Education; on the technical advisory committee for the Association of American Universities STEM initiative; and on the advisory council for the National Science Foundation Directorate for Education and Human Resources. She served on the U.S. Department of Education working groups, co-authoring the 2010 and 2015 National Education Technology Plans and on a working group of the President's Council of Advisors on Science and Technology (PCAST) to write the "Engage to Excel" report for the Obama Administration on improving STEM in higher education.

Carl Wieman

Professor, Stanford Graduate School of Education
Professor of Physics, Stanford
DRC Chair, Stanford School of Engineering
Founder PhET Interactive Simulations

Carl Wieman has done extensive research in both atomic physics and science education. Along with Eric Cornell and Wolfgang Ketterle, Dr. Wieman was awarded the Nobel Prize for Physics in 2001 for creating a new ultracold state of matter, the so-called Bose-Einstein condensate (BEC). Dr. Wieman has over 100 publications on the design and comparative effectiveness of different methods of undergraduate science instruction, and on the adoption of research-based teaching methods. He established the Science Education Initiatives at the University of Colorado and the University of British Columbia which carried out unprecedented large-scale change in the teaching of undergraduate science at large research-intensive public universities. Having spent most of his career at the University of Colorado, he has been at Stanford University since 2013. He also served as Chair of the Board on Science Education of the National Academy of Sciences and as Associate Director for Science in the White House Office of Science and Technology Policy.

Carlos Gutiérrez

Distinguished Professor of Chemistry, Emeritus, Cal State LA
Founding Director, Cal State LA Minority Opportunities in Research Programs

Carlos Gutiérrez is founding director of the Cal State LA Minority Opportunities in Research (MORE) Programs, an association of efforts that share the goal of preparing minority undergraduates and masters students for success in science PhD programs (over 200 have earned the PhD and 150 are in graduate programs nationwide). He has directed research training programs for 40 years, including the campus MARC and RISE programs. Dr. Gutiérrez is a synthetic organic chemist whose research has focused on molecules for iron acquisition and transport in bacteria; and ligands for selective delivery of MRI contrast agents to anatomical targets. In 1996, Dr. Gutiérrez received the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring from former President William J. Clinton. He was named a 2005 U.S. Professor of the Year by the Carnegie Foundation for the Advancement of Teaching/CASE. Dr. Gutiérrez is a Fellow of the AAAS, and a Fellow of the American Chemical Society. He received a special Academy Award for a science educational film he and roommate Lewis Hall made as UCLA undergraduates.

Jessica Kuang

Professor of Mathematics, Oxnard College
OER Representative, Oxnard College

Jessica Kuang was trained as a theoretical ecologist and published many papers in ecology journals, including one in Nature, before she found her true passion for teaching and serving disadvantaged communities. Dr. Kuang moved to the U.S. when she was 17. She then attended City College of San Francisco and later received her Ph.D. from U.C. Davis. For the past 7 years, Dr. Kuang has been teaching math at Oxnard College. During this time, she served as the faculty chair for the Distance Learning Committee and participated in the ASCCC Open Educational Resources (OER) taskforce. Currently, Dr. Kuang is working on an OER project with faculty from around the state in order to bring high quality, free, instructional materials to low-income students.

John Matsui

Assistant Dean, Biological Sciences at UC Berkeley
Director, Biology Scholars Program at UC Berkeley

John Matsui grew up in a low-income West Berkeley household and was educated in both the California Community College and University of California systems. His personal background and life experiences drive him as Director and co-founder of the Biology Scholars Program (BSP), to make biology majors and related careers more accessible to all. Dr. Matsui's goal is to "level the playing field" for individuals who, like himself, do not fit the historical profile of success and to help them become leaders in their future science-related careers. For more than 25 years, he has learned from over 3,500 low-income and first-to-college BSP members how our colleges and universities can better train and support undergraduate and graduate students in biology. Dr. Matsui also serves on several national advisory committees to diversify STEM including the HHMI Inclusive Excellence Commission, the NSF Leadership Council for the Biology REU Initiative, and the NIH Advisory Committee to the Director for the Diversity Program Consortium Initiative. For his work, he received the 2014 SACNAS Distinguished Mentor Award and the 2015 NSF Presidential Mentoring (PAESMEM) Award.

Kimberly Tanner

Director, Science Education Partnership and Assessment Laboratory
Professor of Biology, San Francisco State University

Kimberly Tanner is a tenured Professor of Biology at San Francisco State University. Her laboratory – SEPAL: the Science Education Partnership and Assessment Laboratory – investigates what is challenging to learn in biology, how biologists choose to teach, and how to make equity, diversity, and inclusion central in science education efforts. As a Science Faculty with an Education Specialty (SFES), she is engaged in discipline-based education research, directs multiple K-16+ biology education reform efforts, and is deeply engaged in faculty professional development. Trained as a neurobiologist with postdoctoral studies in science education, Dr. Tanner is a proud first-generation college-going student.

Stephen Kosslyn

President and CEO, Foundry College
Founding Dean, Minerva Schools at the Keck Graduate Institute
Professor (Emeritus), Harvard University Department of Psychology

Stephen Kosslyn is an American psychologist, neuroscientist, and expert on the science of learning. Dr. Kosslyn is President and CEO of Foundry College, an online two-year college designed to help working adults develop skills and knowledge that will not be automated in the foreseeable future. Prior to starting Foundry College, he was Founding Dean and Chief Academic Officer of the Minerva Schools at the Keck Graduate Institute. He previously served as Director of the Center for Advanced Study in the Behavioral Sciences at Stanford University after having been chair of the Department of Psychology, Dean of Social Science, and the John Lindsley Professor of Psychology at Harvard University. Dr. Kosslyn's research has focused on the nature of visual cognition, visual communication, and the science of learning; he has authored or coauthored 14 books and over 300 papers on these topics. Dr. Kosslyn received his B.A. from UCLA and Ph.D. from Stanford, and was the first in his family to attend college.

7.2. Learning Lab Technical Advisor

Bror Saxberg

Vice President, Learning Science, Chan Zuckerberg Initiative (CZI)

As Vice President, Learning Science, Bror Saxberg is responsible for CZI's thinking about how to expand and apply learning science results and good learning measurement practice at scale to real-world learning situations across the full span of learning – pre-K, K-16, and beyond. Dr. Saxberg most recently served as Chief Learning Officer at Kaplan, Inc. where he was responsible for the research and application of innovative evidence-based learning strategies, technologies, and products across Kaplan's full range of educational services offerings. Dr. Saxberg received an Honors BA in Mathematics and a BS in Electrical Engineering from the University of Washington, an MA in mathematics from Oxford University, a PhD in electrical engineering and computer science from MIT, and an MD from Harvard Medical School.

8. Learning Lab Resources and Definitions

In addition to producing research briefs such as those highlighted above, Learning Lab has highlighted on its webpage the following publications on STEM equity gaps and research into approaches for addressing those gaps. New relevant resources are periodically added to the Learning Lab Resources webpage. Learning Lab has also defined key terms related to its grant opportunities.

8.1. Learning Lab Resources

Highlighted Publications

- STEM Attrition: College Student's Paths Into and Out of STEM Fields: Statistical Analysis Report – Xianglei Chen and Matthew Soldner (2013)
- Gender Imbalances in STEM Majors – Public Policy Institute of California (2018)
- Active Learning Increases Student Performance in Science, Engineering, and Mathematics – Scott Freeman, et al. (2014)
- Improving Underrepresented Minority Student Persistence in STEM – Mica Estrada, et al. (2016)
- Enhancing Diversity in Undergraduate Science: Self Efficacy Drives Performance Gains with Active Learning – Cissy J. Ballen et al. (2017)

STEM Participation and Equity Gaps

- Chen, X. and Soldner, M. (2013). STEM Attrition: College Student's Paths Into and Out of STEM Fields: Statistical Analysis Report. Washington, DC: National Center for Education Statistics.
- Johnson, H. (2018, June 21). Gender Imbalances in STEM Majors. Public Policy Institute of California (Blog Entry).
- National Science Board. (2018). Higher Education in Science and Engineering: Undergraduate Education, Enrollment, and Degrees in the United States. In Science & Engineering Indicators 2018. Alexandria, VA: National Science Foundation.

Understanding and Addressing Equity Gaps

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- Hurtado, S., and Carter, D. (1997). Effects of College Transition and Perceptions of the Campus Racial Climate on Latino College Students' Sense of Belonging. Sociology of Education, 70:4, 324-345.
- Toven-Lindsey, B., Levis-Fitzgerald, M., Barber, P.H., and Hasson, T. (2015). Increasing Persistence in Undergraduate Science Majors: A Model for Institutional Support of Underrepresented Students. CBE—Life Sciences Education, 14:2.

- Kezar, A., and Holcombe, E. (2017). Creating a Unified Community of Support: Increasing Success for Underrepresented Students in STEM. Available from USC Pullias Center for Higher Education, CSU STEM Collaboratives.
- Wang, MT, and Degol, J.L. (2017). Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. Educational Psychology Review, 29:1, 119-140.

Learning Science and STEM

- Ballen, C.J., Wieman, C., Salehi, S., Searle, J.B., and Zamudio, K.R. (2017). Enhancing Diversity in Undergraduate Science: Self Efficacy Drives Performance Gains with Active Learning. CBE—Life Sciences Education, 16:4.
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- Freeman, S., et al. (2014). Active Learning Increases Student Performance in Science, Engineering, and Mathematics. Proceedings of the National Academy of Sciences, 111:23, 8410-8415.
- Gasiewski, J.A., et al. (2012). From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses. Research in Higher Education, 53:2, 229-261.
- Haack, D.C., Hille Ris Lambers, J., Pitre, E., and Freeman, S. (2011). Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology. Science, June 3, 2011, 1213-1216.
- Huber, E. and Werner, A. (2016). Review of the Literature on Flipping the STEM Classroom: Preliminary Findings. In Barker, S., Dawson S., Pardo, A., and Colvin, C. (Eds.), Show Me the Learning. Proceedings ASCILITE 2016 Adelaide, 267-274.
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- Means, B., Peters, V., and Zheng Y. (2014). Lessons from Five Years of Funding Digital Courseware: Postsecondary Success Portfolio Review, Executive Summary. Menlo Park, CA: SRI Education.

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- Thille, C. (2016). What the Science of Learning Indicates We Should Do Differently. In Otte, G. and Goldstein M. (Eds.), Change We Must: Deciding the Future of Higher Education. New York, NY: Rosetta Books. Link to chapter in Google Books

Additional Works and Perspectives on Institutional Change

- Bush, S.D., Stevens, M.T., Tanner, K.D., and Williams, K.S. (2019). Evolving Roles as Scientists as Change Agents in Science Education over a Decade: SFES Roles beyond Discipline-Based Education Research. Science Advances, 5:6.
- Dolan, E.L., Lepage, G.P., Peacock, S.M., Simmons, E.H., Sweeder, R., and Wieman, C. (2016). Improving Undergraduate STEM Education at Research Universities: A Collection of Case Studies. Tucson, AZ: Research Corporation for Science Advancement. Available from Association of American Universities, Undergraduate STEM Education Initiative, Initiative Publications.
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- Smith, J. and Herckis, L. (2018). Understanding and Overcoming Institutional Roadblocks to the Adoption and Use of Technology-Enhanced Learning Resources in Higher Education. Available from: The Simon Initiative, Carnegie Mellon University.

Additional Institutional Initiatives of Interest

- California Community Colleges, California Virtual Campus – Online Education Initiative
- California State University, Course Redesign with Technology
- California State University, STEM Collaboratives Project
- University of California, Innovative Learning Technology Initiative
- University of California, STEM Faculty Learning Community
- Association of American Universities, Undergraduate STEM Education Initiative
- Association of American Universities. (2017). Progress Toward Achieving Systemic Change: A Five-Year Status Report on the AAU Undergraduate STEM Education Initiative. Washington, DC. Available from: Association of American Universities, Progress Toward Achieving Systemic Change.
- University of British Columbia, Carl Wieman Science Education Initiative
- University of Colorado - Boulder, Carl Wieman Science Education Initiative
- Carnegie Mellon University, Open Learning Initiative

8.2. Key Definitions

The following section defines key terms frequently used in Learning Lab's Requests for Proposals and broader work

Achievement Gap refers to "Any significant and persistent disparity in academic performance or educational attainment between different groups of students" (The Glossary of Education Reform).

Adaptive Learning is defined by statute to mean "a technology-mediated environment in which the learner's experience is adapted to learner behavior and responses." For the purposes of Learning Lab's RFPs, adaptive learning technologies will be considered in the broad sense of deploying technology to better understand learner experience/learner gaps and assets, and to modify learning environments, pedagogical approaches and/or available resources to be more inclusive of students most likely to leave the sciences (such as first-generation college-going students and underrepresented students in the sciences) and produce better learning outcomes across the broad range of students. The adaptive learning technology approach that is proposed will be considered in the context of all of the other elements in the proposal.

Equity Gap refers to disparities in educational access and attainment for historically underrepresented and underserved student populations that are the product of persistent social and institutional barriers to educational opportunities and educational success (Lumina Foundation and USC Center for Urban Education). From the perspective of the Learning Lab, this term is closely associated with achievement gap and opportunity gap. We can understand equity gaps, in part, as the achievement gaps that opportunity gaps created.

Learning Science is the study of how human learning takes place. It is interdisciplinary in nature, drawing from fields such as cognitive science, neuroscience, computer science, education, psychology, sociology, design studies and more (The Cambridge Handbook of the Learning Sciences). Learning science strives to understand how people learn, how to support learning, discipline-based learning, and the role of technology in enhancing learning and collaboration. This study of learning can cover how people process, gather, and interpret information; how they develop knowledge, skills, and expertise; or the extent to which social and physical context and design environments influence cognition (What Do We Teach When We Teach the Learning Sciences?). Scaffolding, inquiry or problem-based learning, collaborative learning, game and simulation-based learning, metacognition are all examples of how teaching methods and approaches to curriculum can be influenced by what we understand about learning. One of the principal goals of learning science and learning engineering is to create a positive feedback/continuous improvement loop between theories of learning and practice, which would result in improved student learning and advances the field of learning science (The Simon Initiative Learning Engineering Ecosystem).

Opportunity Gap refers to "The ways in which race, ethnicity, socioeconomic status, English proficiency, community wealth, familial situations, or other factors contribute to or perpetuate lower educational aspirations, achievement, and attainment for certain groups of students" (The Glossary of Education Reform).

9. Appendices

Learning Lab RFP #1 Feedback Survey

From late June through early July, staff surveyed unfunded applicants to understand their experiences of the RFP process and identify areas for improvement. Seven applicant teams provided their feedback through semi-structured interviews with Learning Lab staff and two more teams offered input through an online survey. The interview protocol and survey questions are below:

Online Survey Questions

RFP Process:

1. Team Member Name(s)
2. Project Title
3. What was your overall impression of the Learning Lab's first RFP process? (1-5 scale + optional comment box)
4. We understand that the timing of the RFP posed a major challenge for applicants. What is the ideal time for you to begin an application process for an RFP like the one Learning Lab released? (Checkbox: August, September, October, Other)
5. In order to put together a strong application, how much time do you need between the RFP Launch and the Concept Proposal due date? Between the notification of finalists and the Full Proposal due date? (Comment box)
6. Were there aspects of the RFP process, other than timing, that posed major challenges for your project team or that you wish had been organized or managed differently? (Comment box)
7. How would you rate your experience of assembling an intersegmental team? (1-5 scale)
8. Were you easily able to find project partners? (Y/N)
9. Were you able to build off existing partnerships to assemble your project team? (Y/N)
10. How would you rate the experience of incorporating learning scientists, social scientists, or discipline-based researchers into your team? (1-5 scale)
11. Would you have benefited from introductions to potential partners including learning scientists, social scientists, or discipline-based researchers? (Y/N)

Contents of the RFP:

12. Did the instructions in the RFP adequately communicate the information that the Learning Lab and the Selection Committee expected at each application stage and for each proposal section? (Y/N)
13. What do you think the Learning Lab could have done to communicate expectations and directions more effectively? (Comment box)
14. Were there any aspects of the RFP instructions that were particularly challenging for your project team? (Comment box)
15. Did you think the summary feedback aligned with expectations and requests for information stated in the RFP? If not, why? (Y/N + comment box)

16. For future RFPs, do you think Q&A sessions with Learning Lab staff and Selection Committee members would be helpful for clarifying questions about proposal requirements and contents? (Y/N)
17. Would it have been helpful for you if we asked project teams to structure their proposals along narrative lines, or had given you more leeway in organizing your proposal (while still responding to key questions/criteria)? (Y/N)

Selection Process:

18. Do you feel that selection criteria for grant awards were clear, and that the selection process was understandable and timely? (Y/N + comment box)
19. Do you think it would be helpful for future project teams to be able to include multimedia components or demonstration technology in their proposals? (Y/N)
20. If there was other additional information you would have liked to have presented in your proposal or have made available to the Selection Committee, please describe. (Comment box)

Future RFP Opportunities:

21. How could Learning Lab grant funding best help you, as a STEM educator, improve learning outcomes for your students and address equity and achievement gaps? (Comment box)
22. Did this RFP encourage you to develop closer ties and working relationships with faculty from other segments of California higher education? (Y/N)
23. Do you think the intersegmental partnerships that you forged for this RFP will continue into other projects or collaborations? (Y/N)
24. Was there anything about the RFP process that you found particularly helpful and that you suggest we continue to do during the next RFP? (Comment box)
25. Is there any other feedback you would like us to take into consideration? (Comment box)

Interview Protocol for Follow-up with Applicant Teams

Thank you for your participation in the California Education Learning Lab's first Request for Proposals, "Improving Equity, Accessibility and Outcomes for STEM Gateway Courses." We appreciate the time and effort you put into your proposal(s).

In order to improve upon our RFP process and content, we are soliciting your feedback through the following questions. We intend to take your feedback and suggestions into consideration as we plan for our next grant round.

We appreciate your commitment to improving learning outcomes for California's students and to closing achievement and equity gaps in undergraduate STEM education.
Questions for Feedback:

RFP Process:

[Note: We understand that the timing of the RFP posed a major challenge for applicants and would-be applicants – both the time of year during which the RFP was released, as well as the turnaround times for submitting letters of intent and proposals.]

a. What were your overall impressions of Learning Lab's first RFP process?
b. What is the ideal timing for you to participate in an RFP like the one Learning Lab released?
c. Were there aspects of the RFP process, other than timing, that posed major challenges for your project team or that you wish had been organized or managed differently?
d. What was your experience of assembling an intersegmental team? Were you able to build off existing partnerships to assemble your project team, and/or were you able to find potential partners to put together your team?
e. What was your experience of incorporating learning scientists, social scientists, or discipline-based researchers into your team? Would you have benefitted from more time or introductions to potential partners?
f. Was there anything about the RFP process that you found particularly helpful and that you suggest we continue to do during the next RFP?

Contents of RFP:

a. Were the contents of the RFP clear? Did you feel that the instructions in the RFP adequately communicated the information that the Learning Lab and the Selection Committee expected at each application stage and for each proposal section?
b. Were there any aspects of the RFP instructions that were particularly challenging for your project team? What do you think the Learning Lab could have done to communicate expectations and directions more effectively?
c. Did you think the summary feedback aligned with expectations and requests for information stated in the RFP? If not, why not?
d. For future RFPs, do you think Q&A sessions with Learning Lab staff and Selection Committee members would be helpful for clarifying questions about proposal requirements and contents?
e. Would it have been helpful for you if we asked project teams to structure their proposals along narrative lines, or had given you more leeway in organizing your proposal (while still responding to key questions/criteria)?

Selection Process:

a. What was your overall impression of the selection process?
b. Do you feel that selection criteria for grant awards were clear, and that the selection process was understandable and timely?
c. Was there additional information that you would have liked to have presented in your proposal or have made available to the Selection Committee that you were unable to because the structure of the RFP? For instance, would you have liked to include videos or demonstration technology to show your project in action? Do you think it would be helpful for future project teams to be able to include multimedia components in their proposals?

Future grant opportunities from the Learning Lab:

a. How could Learning Lab grant funding best help you, as a STEM educator, improve learning outcomes for your students and address equity and achievement gaps?
b. And, as a follow-up: Did this RFP encourage you to develop closer ties and working relationships with faculty from other segments of California higher education? Do you think the intersegmental partnerships that you forged for this RFP will continue into other projects or collaborations?
c. Is there any other feedback you would like us to take into consideration?

Learning Lab Professional Development Survey

1. Institutional Affiliation(s) (textbox)
2. Department/Field (textbox)
3. Title/Position (optional textbox)
4. Category (Checkbox: Tenure Track Faculty, Lecturer with Security, Contingent Faculty, Administration, Other)
5. Please describe the professional development needs in your department/field. (Comment box)
6. What would best motivate and/or enable you or your colleagues to take a professional development workshop or participate in a formal professional development program? (Ranking of time, money (funding or stipend), encouragement from department chair, encouragement from department colleagues, mandatory requirement, tie to advancement/promotion track, other)
7. If other, please specify (Comment box)
8. What is an example of a positive professional development experience you have had? What has been the best resource for helping you to improve your teaching? (Comment box)
9. Is there any other information or input you would like to offer the Learning Lab as we consider grants for professional development? (Comment box)

Learning Lab Request for Proposals 2018-2019

(See below.)

State of California
Governor's Office
Office of Planning And Research

EDMUND G. BROWN JR
Governor

KEN ALEX
Director

California Education Learning Lab

REQUEST FOR PROPOSALS 2018-19:

"Improving Equity, Accessibility and Outcomes for STEM Gateway Courses"

Revised on February 8, 2019, with Full Proposal Instructions in Section IV. F, pages 7-10. Other changes have been highlighted.

MILESTONES	DATE
Request for Proposals Announced	Wednesday, December 12, 2018
Letter of Intent to Submit a Proposal Due	Monday, January 7, 2019
Concept Proposals Due	Tuesday, January 22, 2019
Notification of Finalists	Tuesday, February 5, 2019
Full Proposals Due	Friday, March 15, 2019 Friday, March 22, 2019 (new date)
Selection Committee Meeting (brief public meeting, followed by closed session deliberation)	Monday, April 15, 2019 (venue TBD)
Awardees Announced	Monday, April 8, 2019 (estimated) Wednesday, April 24, 2019 (new estimated date)
Projects Commence	June 1 or July 1, 2019
Duration of Projects	36 months
Funding	For 6-9 projects, approximately $1 million to $1.5 million total per project (including indirect costs[1]).

I. *California Education Learning Lab*

[1] See Item VI.

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Assembly Bill 1809 (Chapter 33, Statutes of 2018) established the California Education Learning Lab ("Learning Lab") as a competitive grantmaking program for intersegmental faculty teams[2] to incorporate learning science and adaptive learning technology into their curriculum and pedagogy, with the express purpose of increasing learning outcomes and closing equity and achievement gaps in STEM and other disciplines. The Learning Lab is housed in the Governor's Office of Planning and Research, with an annual budget of $10 million. Initial calls for proposals will focus on lower-division online and hybrid courses in STEM. In later years, other disciplines may compete for funds and funds may be used to support professional development and a curated resource library.

II. Learning Science and Adaptive Learning Technologies

"The goal of learning sciences is to better understand the cognitive and social processes that result in the most effective learning, and to use this knowledge to redesign classrooms and other learning environments so that people learn more deeply and more effectively." -- R. Keith Sawyer, Washington University

Learning science is the study of how human learning takes place. Interdisciplinary in nature, drawing from fields such as cognitive science, neuroscience, computer science, education, psychology, sociology, design studies and more,[3] learning science strives to understand how people learn, how to support learning, discipline based learning, and the role of technology in enhancing learning and collaboration.[4] Learning science can cover how people process, gather, and interpret information; how they develop knowledge, skills, and expertise; or the extent to which social and physical context and design environments influence cognition.[5] Scaffolding, inquiry or problem-based learning, collaborative learning, game and simulation-based learning, as well as metacognition are all examples of how teaching methods and approaches to curriculum can be influenced by what we understand about learning. Additionally, strategies linked to social psychology and multicultural education emphasize the importance of attending to students' identity and culture when addressing achievement gaps.

One of the goals of learning science is to create a positive feedback/continuous improvement loop between theories of learning and practice, which results in improved student learning and advances the field of learning science.[6] For the purposes of the Learning Lab, as public higher education strives

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[2] "Intersegmental faculty teams" refers to a team of faculty from more than one segment of public higher education, e.g., University of California, California State University, California Community Colleges.

[3] Sawyer, R.K. (2006). *The Cambridge Handbook of the Learning Sciences*. Cambridge, U.K.: Cambridge University Press.

[4] Sommerhoff, D., Szameitat, A., Vogel, F., Chernikova, O., Loderer, K. & Fischer, F. (2018). What Do We Teach When We Teach the Learning Sciences? A Document Analysis of 75 Graduate Programs. Journal of the Learning Sciences, 27:2, 319-351. https://doi.org/10.1080/10508406.2018.1440353.

[5] Ibid.

[6] The Simon Initiative Learning Engineering Ecosystem at Carnegie Mellon University emphasizes: 1) building and leveraging cognitive models of expertise to inform the design of effective student-centered instructional materials; 2) collecting rich data on student interactions and learning

to educate more students with diverse backgrounds in a rapidly changing world, leveraging, increasing and applying our knowledge of human learning is a challenge we must embrace.

Adaptive learning is defined by statute to mean "a technology-mediated environment in which the learner's experience is adapted to learner behavior and responses." For the purposes of this RFP, adaptive learning technologies will be considered in the broad sense of deploying technology to better understand learner experience/learner gaps and assets, and to modify learning environments, pedagogical approaches and/or available resources to be more inclusive of students most likely to leave the sciences (such as first-generation college-going students and underrepresented students in the sciences) and produce better learning outcomes. The adaptive learning technology approach that is proposed will be considered in the context of all of the other elements in the proposal.

III. Demonstration Projects - Summary

For this RFP, up to $9 million will be provided from the Learning Lab to fund six to nine demonstration projects to support curricular and pedagogical innovations that aim to increase learning outcomes, transform the culture of learning, and close equity and achievement gaps in online and hybrid learning environments within lower division STEM undergraduate curriculum. In order to have the potential for large scale impact, this call will be open to lower-division "gateway" courses in the following disciplines: biology, chemistry, physics, engineering and computational sciences, including computer science, mathematics and statistics. Within the available funds, approximately $1 million to $1.5 million will be available to each awarded demonstration project. Projects are encouraged to develop pedagogical innovations that promote students' sense of belonging in science, students' science identity and connections between science learning and students' personal lives, career aspirations and home communities, leveraging affective components of learning to reduce achievement gaps.

Projects must be co-hosted by a faculty team representing a minimum of two public higher education segments in California. (Example: a faculty member from the California Community Colleges must collaborate with a faculty member from the University of California OR the California State University. Faculty collaboration across all three segments is welcome and encouraged.) Other faculty from private independent/nonprofit institutions and nonfaculty (i.e., professionals operating in a nonfaculty role for the purposes of the project) may participate in the project as well. A strong project will engage many stakeholders iteratively and throughout the duration of the project, as well as lay the foundation for sustainability of innovations and institutional culture change.

Demonstration projects will be selected through a three-stage process involving: (1) submission of letters of intent to submit concept proposals; (2) submission of concept proposals; and (3) submission of full proposals, based on selected concept proposals, from which the final selection of awards will be made. A selection committee will make recommendations for final awards. After

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outcomes; 3) data analysis via state-of-the-art machine learning and analytic methods; 4) data-informed iterative improvement of the instructional materials; and 5) leveraging these assets to drive fresh insights in learning science. https://chronicle-assets.s3.amazonaws.com/5/items/biz/pdf/SimonLearningEngineeringEcosystem.pdf.

awards are announced, Learning Lab will work with awardees to establish an agreement governing the award period, including concrete metrics and goals to track the progress of the demonstration projects, and provide technical assistance.[7]

IV. Applications

A. Application process

Stage 1: Letter of intent to submit a concept proposal (**DUE: Monday, Jan. 7, 2019**)
Applicants should submit a brief letter of intent. The letter should note the expected host institutions and co-principal investigators, provide a (tentative) title of the proposal and a tentative total budget. The letter should also include a brief description of the proposal and characterize the discipline-specific problem that co-PIs are trying to solve and/or investigate. Please provide institutional data disaggregated by course and student characteristics (e.g., ethnicity, gender, socio-economic status, first-generation college going) on existing campus-, school- or department-specific equity issues that your project is designed to address.

Stage 2: Institutional cover letter and concept proposal (**DUE: Tuesday, Jan. 22, 2019**) Applicants should submit institutional cover letters and short concept proposals; see sections C and D below.

Stage 3: Full proposal (DUE: Friday, ~~March 15, 2019~~ March 22, 2019)
The selection committee selected a subset of submitted concept proposals to move onto the full proposal stage. (21 proposals were invited to the full proposal stage.) For the finalists advancing to this next stage, instructions for submission of the full proposal is in Section F (beginning on page 7). The selection committee will recommend between six and nine final projects for this grant cycle. The Governor's Office of Planning and Research (OPR) will approve and announce the final funding decisions.

For questions, please see the FAQ document or contact **learninglab@opr.ca.gov**, or go to our webpage (opr.ca.gov/learninglab). Please join our email distribution list to recieve updates directly by sending an email to **learninglab@opr.ca.gov**.

B. Eligibility

1. Applicant teams must include faculty co-principal investigators (PIs) from at least two public higher education segments. Representation from all three public higher education segments is encouraged. Additional partnerships, such as with private independent/nonprofit institutions and/or industry partners, are also encouraged. All faculty teams must commit to teaching and evaluating the codeveloped or jointly redesigned curriculum or innovative pedagogy during the grant period.

[7] Contracting entity will be the Governor's Office of Planning and Research.

2. Demonstration projects should aim to improve learning outcomes and close equity/achievement gaps for STEM undergraduate students in lower division course series[8] where the mode of learning is online or hybrid, i.e., makes use of both online and in-person interactions as part of the formal course environment or requirements.

C. Institutional Cover Letter (to be submitted with the Concept Proposal)

For each faculty team application, the relevant departments/schools/institutions should provide answers for Section C1, C2 & C3, in a brief (limit one page); minimum Arial 11 font; 0.5 inch margins; no appendices.

Host institutions: Identify the institutions that are submitting the proposal and will be responsible for receipt/administration of the grant funds, if awarded.

Institutional focus: Describe each department/school/institution's commitment (e.g., faculty release time, funding, administrative support) to the proposed demonstration project. (Each participating institution should sign the cover letter. Additional demonstration of institutional commitment will be highlighted in the full proposals stage.)

Principal investigators: Identify the investigators who will serve as faculty (co-)PIs. Please briefly describe each PI's capacity, including any previous and/or current grant funding received, strength of faculty and student engagement activities, and history of successful intersegmental partnerships.

Authorized submission: The Institutional Cover Letter (C1-C3) and the concept proposal (section D) should be submitted electronically to learninglab@opr.ca.gov by the signatories, which must include the department chair AND either the dean, vice chancellor/vice president of research or the provost or equivalent.

D. Concept Proposal

For each application, please provide answers for Section D in a short Concept Proposal: maximum two pages for questions 1-7; maximum 1 page for questions 8-10; minimum Arial 11 font; 0.5 inch margins; no appendices.

1. How will your proposal measure or define success?: Describe what problem you are trying to solve. Please include data/metrics to highlight the problem and elaborate on the description and data provided in your letter of intent. Describe how your proposed project will improve understanding of learning science and/or assessments, and/or effectiveness of pedagogical methods and/or adaptive learning technologies. What will you measure? (For example: increased retention or increased proficiency and performance with STEM; increased conceptual understanding/higher order thinking or passion for STEM careers; increased communication skills, leadership, and teamwork capabilities of STEM students; increased self-efficacy/ability to learn independently; increased facility with the scientific method; increased faculty impact; or reduction

[8] High school dual enrollees may also be captured as part of this population.

of a particular pain point experienced by faculty or students.) How will you evaluate students? How will you evaluate faculty?

2. Project plan: Describe the components and timeline of your proposed project (specific aims and research strategy).

3. Data and adaptive learning technologies: Each proposal should demonstrate its commitment to the use of robust data and technology tools, including adaptive learning technology (see definition above). Please describe how your proposal will use real-time learning outcomes data and adaptive learning technology and other technology tools to improve the pedagogy and/or curriculum.

4. Learning science: Describe how you will use evidence-based pedagogical approaches supported by research from a variety of disciplines. What is innovative about your approach? How will you take an existing approach and experiment with achieving broader scale?

5. Student engagement: Describe your approach to student engagement, potentially including engagement of students who may not identify as STEM proficient. Examples: How might your approach increase students' sense of belonging, and encourage students' help-seeking behavior from faculty, teaching assistants, other students, technology resources, etc. Will your approach include engagement through active learning, applied learning through a career or workforce pathway lens, and/or highly contextualized learning? How might students drive their own learning and/or the learning of their peers? Will your proposal individualize learning or use metacognition? How often will students receive meaningful and timely feedback, whether through a technology-mediated environment or face-to-face?

6. Culture: How will your proposal impact traditional "classroom" and disciplinary culture? In particular, how will your approach address aspects of classroom or disciplinary culture that are barriers to student learning and to their sense of belonging? How might it encourage a strengthening-assets or growth-oriented approach to student learning and how might it help establish a classroom context in which all students can succeed? How might your proposal take advantage of under-represented communities' cultural strengths to increase their achievements in STEM?

7. Scalability and value analysis: Describe how your work could be scaled, afforded, replicated and/or modified through an open educational resources model? What other dimensions of value can be evaluated in your project? With whom will you partner to do the analysis, what data will you analyze, etc.?

8. Project team: Provide a brief description of the co-PI(s), team, and key collaborators. Describe the nature and strength of any existing collaborations among project team members, and how you will use the expertise of all involved to create a well-balanced collaboration. Describe also how the project team may use external expertise and/or stakeholder input to iterate over the course of the project.

9. Budget overview: Briefly outline how Learning Lab funds (approximately $1 million to $1.5 million)

will be used and how other resources may be leveraged including any outside funds or institutional funds. How will you maximize existing structures or resources? Will your innovations place any costs on users? If so, how will these be minimized?

Note: Learning Lab funds are intended to be used exclusively in California. If the project necessitates the use of Learning Lab funds outside of California, provide a brief justification and estimate of the funding that will leave the state. The amount of funds that can leave the state will be subject to the final award agreement.

10. Common data-sharing/technology platform: Please discuss the potential for using a common data-sharing platform to deliver the course or course series.

Submission: Concept proposals, including the institutional cover letter, must be submitted electronically as a single PDF to learninglab@opr.ca.gov by 5:00pm PT on Tuesday, January 22, 2019.

E. Full Proposal-NEW

Of the 42 concept proposals that the Learning Lab received, 21 have been invited to submit full proposals. Please provide answers for Section F in your Full Proposal: maximum 15 pages total, not including appendices or institutional cover letters; minimum Arial 11 font; 0.5 inch margins.

Please note that the questions below are modified versions of the questions contained in the Concept Proposal section. Please read the questions below carefully, using the page length maximums (indicated in parentheses) to expand on your answers from the Concept Proposal and address any new requested or suggested content.

Please include in your Full Proposal submission:

1) Institutional Cover Letter(s) included in your Concept Proposal, updated for content and/or signatories;
2) Full Proposal responses;
3) Appendices, as follows:
    a. Information on additional team members, i.e., statement of qualifications, not covered under Question 8 (maximum 3 pages total);
    b. Budget information (maximum 2 pages total);
    c. Bibliography of key sources (maximum one page total);
    d. Any other supporting documents (maximum 3 pages total);
    e. Any brief letters of support from additional faculty colleagues who are interested in being part of the scaling efforts related to Question 7 below. (Maximum 5 pages for all additional indications of support. This can be a single letter with signatories or individual letters. Please identify name, title and contact information for signatories.)

Updated rubric and suggested templates for additional institutional cover letters (any added since the submission of your Concept Proposal) and Appendix B will be available on March 1, 2019, at http://www.opr.ca.gov/learninglab/.

All submissions are due in full by Friday, March 22nd, 2019, by 5pm. Please email your entire submission in a single PDF to learninglab@opr.ca.gov. If you have any questions, please contact learninglab@opr.ca.gov

General Notes: When responding to the questions below, to the extent possible please describe students and faculty from an asset-based perspective (i.e., building on strengths), rather than a deficit-based perspective (i.e., cataloging what is "wrong" with learners or faculty that needs to be "fixed). Please be as clear as possible about what learners and faculty will do differently based on this project, in both academic and other domains (social, emotional, etc.).

As stated in the "Demonstration Projects – Summary" (Section III), projects are encouraged to develop pedagogical innovations that promote students' sense of belonging in science, students' science identity and connections between science learning and students' personal lives, career aspirations and home communities, leveraging affective components of learning to reduce achievement gaps. A strong project will engage many stakeholders iteratively and throughout the duration of the project, as well as lay the foundation for sustainability of innovations and institutional culture change.

A strong proposal will describe the project as succinctly and clearly as possible, contrasting how it differs from the status quo, or what is currently the norm in the discipline or course. (½ page)

1. How will your proposal measure or define success?: Describe what problem you are trying to solve. Please include data/metrics to highlight the problem**.** What will you measure? (For example: increased retention or increased proficiency and performance with STEM; increased conceptual understanding/higher order thinking or passion for STEM careers; increased communication skills, leadership, and teamwork capabilities of STEM students; increased self-efficacy/ability to learn independently; increased facility with the scientific method; increased faculty impact; or reduction of a particular pain point experienced by faculty or students.) How will you evaluate students? How will you evaluate faculty? Will your project improve understanding of science of learning and/or assessments, and/or effectiveness of pedagogical methods and/or adaptive learning technologies? A strong proposal will describe the learning outcomes to be measured, over what time period, and the validity of these outcome measures with clarity. (1-1½ pages)

2. Project plan: Describe the components and timeline of your proposed project (specific aims and research strategy). A strong proposal will describe in detail the steps to be undertaken and by whom. (1-1½ pages)

3. Data and adaptive learning technologies: Each proposal should demonstrate its commitment to the use of robust data and technology tools, including adaptive learning technology (see definition above). Please describe how your proposal will use real-time learning outcomes data and adaptive learning technology and other technology tools to improve the pedagogy and/or curriculum. (1 page)

4. <u>Science of learning</u>: Describe how you will use evidence-based pedagogical approaches supported by research from a variety of disciplines. What is innovative about your approach? How will you take an existing approach and experiment with achieving broader scale? A strong proposal will demonstrate knowledge of and grounding in the literature of the science of learning, and connect the different parts of the project/interventions to the research cited. If relevant, a strong proposal will describe how the project furthers existing research and/or addresses the gaps in our understanding of human learning, with an explicit hypothesis, analytic framework, research design and evidence gathering. (1 page)

5. <u>Student engagement:</u> Describe your approach to student engagement, potentially including engagement of students who may not identify as STEM proficient. Examples: How might your approach increase students' sense of belonging, and encourage students' help-seeking behavior from faculty, teaching assistants, other students, technology resources, etc. Will your approach include engagement through active learning, applied learning through a career or workforce pathway lens, and/or highly contextualized learning? How might students drive their own learning and/or the learning of their peers? Will your proposal individualize learning or use metacognition? How often will students receive meaningful and timely feedback, whether through a technology-mediated environment or face-to-face? (1 page)

6. <u>Culture</u>: How will your proposal impact traditional "classroom" and disciplinary culture? In particular, how will your approach address aspects of classroom or disciplinary culture that are barriers to student learning and to their sense of belonging? How might it encourage a strengthening-assets or growth-oriented approach to student learning and how might it help establish a classroom context in which all students can succeed? How might your proposal take advantage of under-represented communities' cultural strengths to increase their achievements in STEM? (1 page)

7. <u>Scalability and value analysis:</u> Describe how your work could be scaled or replicated; made affordable for users; and/or modified through an open educational resources model. What other dimensions of value can be evaluated in your project? With whom will you partner to do the analysis, what data will you analyze, etc.? A strong proposal will describe the depth and breadth of institutional support for making successful practices normative within the discipline(s), and how faculty will be encouraged or incentivized to adopt successful practices. A strong proposal will include a proposed plan for broad dissemination and lasting impact. (1–1½ pages)

8. <u>Project team:</u> Provide a brief statement of qualifications of the co-PI(s), team, and key collaborators. Describe the nature and strength of any existing collaborations among project team members, and how you will use the expertise of all involved to create a well-balanced collaboration. Describe also how the project team may use external expertise and/or stakeholder input to iterate over the course of the project. A strong project will demonstrate collaboration with social scientists, behavioral scientists, instructional designers, and/or others with relevant expertise outside of the discipline to be impacted. A strong proposal will also demonstrate meaningful, balanced, near equivalent contributions across the segments represented in the proposal, from design to implementation to evaluation. (1-1½ pages)

9. Budget overview: Briefly outline how Learning Lab funds (approximately $1 million to $1.5 million) will be used and how other resources may be leveraged including any outside funds or institutional funds. How will you maximize existing structures or resources? Will your innovations place any costs on users? If so, how will these be minimized? (1 page, with more detail allowed as Appendix B, template to be provided by March 1. Please see http://www.opr.ca.gov/learninglab/)

   Note: Learning Lab funds are intended to be used exclusively in California. If the project necessitates the use of Learning Lab funds outside of California, provide a brief justification and estimate of the funding that will leave the state. The amount of funds that can leave the state will be subject to the final award agreement.

10. Common data-sharing/technology platform: Please discuss the potential for using a common data-sharing platform to deliver the course or course series. A strong proposal will discuss the robustness of technology approach and interoperability with other systems. (1 page)

11. Information requested by the Selection Committee. Please respond to the request for information in the **individualized summary feedback you received on February 8, 2019**, from the Learning Lab. (1–1½ pages)

12. Accessibility. Please describe your plan for ensuring access for students with disabilities, compliant with your institution's policies. (½ page)

V. Selection

Selection Committee: Learning Lab has recruited an advisory committee, which shall serve as the selection committee to recommend awards. External readers will be recruited to score proposals. Readers may be recommended by the Legislature, public solicitation or academic referral. Selection committee members shall not be deemed to be interested in any contract including any award of Learning Lab funds and will be screened for conflict of interest consistent with National Science Foundation procedures. The names of selection committee members will be provided on the Learning Lab webpage on OPR's website (OPR.ca.gov). The selection committee will use a process consistent with National Science Foundation procedures for reviewing the proposals and making award recommendations. Learning Lab will use a process consistent with National Science Foundation practices to ensure proposals are evaluated in a manner that is fair, equitable, timely and free of bias.

Selection criteria: Section 65059.1 of the Government Code sets forth the following selection rubric, which may be augmented by the Learning Lab and the selection committee:

- "The potential for reducing achievement and equity gaps in the particular discipline that is the subject of the call for proposals."
- "The depth and breadth of expertise in the particular discipline and deployment of learning science or adaptive learning technologies across the proposal's team members."

- "The prospects for increasing equity and accessibility in quality STEM education and other disciplines that show high initial failure or dropout rates, including scaling access to a newly developed or redesigned course or course series in the future."
- "The potential to incorporate real-time learning outcome data to improve the curriculum."
- "The potential to utilize a common technology platform to deliver the course or course series."
- "The representation of all three public higher education segments on the proposal's faculty team."[9]
- "The inclusion of career education and workforce pathways in the proposal."
- "Opportunities to leverage nonstate funding."
- "The quality of the concrete metrics and goals identified in the proposal."

The Selection Committee will also consider additional factors in reviewing the proposals, such as:

- The degree of innovation in the concepts, approaches or methodologies, assessments, or interventions to improve learning outcomes or reduce equity/achievement gaps.
- The feasibility of the project (can the project plan be achieved within the proposed timeline).
- The quality and extent of student engagement and faculty engagement.
- Approaches to protect privacy and personal information.
- Robustness of technology approach and interoperability with other systems.
- Sharing data across institutions.
- Where the project is located in California in order to balance geographic equity of awards, and diversity of awarded institutions.
- Diverse expertise and background of team members, including complementary expertise from social or behavioral scientists that can contribute to design of the proposal and evaluation.
- The degree to which a clear path to broad dissemination and adoption is envisioned and planned.
- Overall impact to advance learning science and learning outcomes.

Results: Applicants that are selected for award will be notified ~~in early to mid-April~~ late April (estimated notification date is April 24). Applicants who are not selected for award will receive a summary statement with perceived strengths and weaknesses of the proposal to inform future submissions for subsequent requests for proposals.

VI. Post-Award Agreements.

Applicants of proposals that are selected will be asked to enter into an agreement with the Governor's Office of Planning and Research. The Learning Lab will administer the agreement,

[9] The representation of all three public higher education segments is not an eligibility requirement, but the selection committee will weight proposals that span across all three segments, i.e., UC, CSU and community colleges.

which will address project implementation, including the following:

a) **Indirect Costs:** Up to 8 percent in indirect costs are allowed. Total costs (direct plus indirect) are to be within the $1 million to $1.5 million total per project.
b) **Open Educational Resources:** Agree to terms and conditions that require course and course series and technology/platforms enabled with Learning Lab funds to be available as open educational resources.
c) **Start Date:** Initiate work within 30 days of signing the agreement.
d) **Reporting:** Submit progress reports at agreed-upon intervals, including tracking of milestones and expenditures, participate in conference calls and convening activities, and seek technical assistance from the Learning Lab Advisory Committee or Learning Lab staff. All post-award expectations will be specified in award agreements.
e) **Use of Data:** Investigators and demonstration teams are expected to share data and research findings consistent with academic standards.
f) **Protection of Privacy and Personal Information:** Investigators and demonstration project teams are expected to follow state and federal law to protect privacy and personal information.