A Synthesis of Grantee FINAL EVALUATIONS

Successes, Challenges, and Lessons Learned
# TABLE OF CONTENTS

I. Introduction 3

II. 2018-19 Cohort: Improving Equity, Accessibility, and Outcomes for STEM Gateway Courses 7

III. 2019-20 Cohort: Using Research and Technology 13

IV. 2019-20 Cohort: Institutional Change 21

V. 2020-21 Cohort: Calculus Grand Challenge 25

VI. Common Issues and Lessons Learned 28

VII. Conclusion 30

VIII. Appendices 33
I. INTRODUCTION

In 2018, Assembly Bill 1809 established the California Education Learning Lab (Learning Lab) in order to improve learning outcomes and close equity gaps across California’s three public higher education segments—California State University (CSU), University of California (UC), and California Community Colleges (CCC)—particularly in the Science, Technology, Engineering, and Math (STEM) disciplines. Housed in the Governor’s Office of Planning and Research (OPR) and administered in partnership with the Foundation for California Community Colleges (FCCC), Learning Lab funds innovative, intersegmental, faculty-led projects that leverage technology tools and the science of human learning to foster student success in online and hybrid learning environments. Learning Lab’s team operates in consultation with OPR leadership and an advisory board1 and is supported by the FCCC’s administrative structure.

The Learning Lab’s early vision to incentivize teaching and learning approaches vis-a-vis online and hybrid educational formats was in step with evolving technology and changing student demographics, with increasing numbers of students engaging in online learning. This vision proved to be prescient in unexpected ways, as the landscape of higher education in California and the world over changed dramatically as a result of the COVID-19 (referred hereafter as COVID) pandemic just two years after the grantmaking program was created, driving the imperative for educational transformation. Inequities among students had become more pronounced during COVID, while increased demand for alternative teaching formats and approaches surfaced.

It was within the three-year period roughly between FY 20192 and FY 2022 that 28 Learning Lab-funded projects received initial funding, with implementation periods generally ranging between two to three years. This group was the first among Learning Lab grantees to formally conclude and submit final evaluations3, a required deliverable for all awards.

During this timeframe, faculty witnessed a significant surge in demand for new tools and pedagogical approaches to engage students in online instruction, accompanied by faculty’s own needs for community and support during and after pandemic shelter-in-place restrictions. Most projects faced unprecedented challenges to project implementation, especially data collection. Overall, all grantee teams tested new approaches to teaching and learning, created Open Educational Resources (OER) (student- and/or faculty-facing) and gained valuable lessons from their efforts to improve student learning. The following section explains Learning Lab’s grant award criteria and provides additional context for understanding report findings.

Footnotes
1 Learning Lab’s Advisory Board is comprised of seven to eight members reflecting disciplinary and institutional leadership from the three segments of California higher education and beyond. Learning Lab’s current advisory board has seven members.
2 Learning Lab’s inaugural class of projects were awarded with funds from FY 2018-2019. Award cycles from development to grant agreement typically take up to one year, with projects officially launching at the end of the fiscal year or the beginning of the next fiscal year.
3 Note: one project, Mechanics of Inclusion and Inclusivity in Mechanics from the 2018-2019 Improving Equity, Accessibility, and Outcomes for STEM Gateway Courses cohort, submitted a final evaluation but has not formally closed at the time this synthesis report was prepared. The project team was granted an extension until August 2024. It is currently conducting additional demonstration and data collection activities and will produce an addendum to their final evaluation.
Background

Persistent equity gaps in STEM success among underrepresented minority (URM) students have created demand from various higher education stakeholders (e.g., campus/system leadership, policymakers, philanthropy) for pedagogical and curricular innovation as well as institutional change. To face California’s 21st-century challenges related to climate change, health care, and crisis management, for example, the state’s workforce depends upon diverse students succeeding in STEM to contribute as agile problem solvers, collaborators, and connectors within an evolving cultural and social environment.

As outlined in AB 1809 (2018), Learning Lab’s primary vehicle to achieve its mission to improve learning outcomes and close equity and achievement gaps, particularly in STEM, is through grantmaking. Learning Lab awards grants to faculty teams affiliated with CCC, CSU, and UC campuses through competitive application processes.

Through development of Request for Proposals (RFPs), Learning Lab incentivizes and supports faculty to creatively pursue alternative teaching approaches that hold potential for evidence-based effectiveness and scaling. The overall focus of the Learning Lab’s initial RFPs had a strong emphasis on “gateway” courses; these are courses that are foundational but are also a major barrier to entering STEM career pathways. More than one RFP focused on mathematics, as mathematics courses are early requirements for many other science, technology, and engineering majors. Math instructors were also adjusting to institutional changes instigated by California Assembly Bills 705 (2017) (and later AB 1705 (2022)), which functionally eliminated placement testing and strongly restricted community colleges’ option to offer remedial courses in math and English. Additionally, Executive Orders 1100 and 1110 in the California State University system required CSU campuses to maximize the likelihood that an incoming student would complete college-credit-bearing math and quantitative reasoning courses within their first year. This increased the sense of urgency to innovate teaching methods. Practices employed by Learning Lab projects have included active learning, group and project-based work, culturally responsive pedagogy, restructuring curriculum, and utilizing adaptive learning technology to scaffold learning among students with varied educational experiences. Approaches have also included cultivating student-centered learning environments that promote a sense of belonging and STEM identity.

Footnotes

4 Note: this often refers to historically underrepresented demographic groups in STEM higher education, including Black, Latinx, Native American, some Asian American subgroups, Pacific Islanders, and women, but there is not a universal definition of this term and not all project teams defined “URM” in the same way. Learning Lab’s RFPs requested applicants to provide student demographic data as part of building their case for serving URM students, while project teams were allowed flexibility to use the term at their discretion. Similarly, not all grantees used the same term to describe their students of Latin American origin or descent; grantees variously used the terms Latinx, Latine, Latino, and Hispanic. For the purposes of this report, the term “Latinx” will be used consistently to refer to students of Latin American origin or descent.

5 A subset of projects from one calculus-focused RFP, the Calculus Grand Challenge Prototype awards, are included in this report, but the majority of calculus-focused projects will be included in a subsequent report due to the timing of those projects’ end dates.
Grant Award Criteria

Guided by statutory requirements and incorporated into respective criteria for Learning Lab’s various RFPs, all 28 funded projects included in this report were required to:

- Be co-hosted by a minimum of two public higher education segments in California,
- Articulate potential to improve learning outcomes and/or close equity gaps in online and hybrid course environments for lower division undergraduate students,
- Integrate the science of human learning and adaptive learning technology tools where appropriate,
- Apply data toward achieving objectives,
- Demonstrate potential for scalability, and
- Make all materials developed with Learning Lab funds available as open educational resources (OER).

In their proposals, project teams were required to make a compelling case for the need for the project; demonstrate how the project design and strategies were grounded in education research; and explain how assessment and data would be used to iterate/improve project implementation and be incorporated into final project evaluations. These criteria together were intended to incentivize projects that not only offered student-centered and responsive teaching but also cultivated adaptive, flexible, and inclusive learning environments among faculty working across systems to support their students, many with transfer goals toward achieving undergraduate degrees.

Critical Context: COVID and its Impact

As mentioned above, these grant cohorts were awarded just prior to or during the COVID pandemic, which affected higher education broadly, but learning environments in particular. Challenges faced by grantees varied depending on the project’s design, rapidly evolving grading and institutional policies, team member circumstances, and other factors. For example, while many projects had proposed activities intended for online environments, there were others that intended to hold in-person activities or in-person courses as control groups; such projects had to adjust the delivery of their interventions to accommodate fully online modalities. This required unexpected increases in time and energy devoted to modifying, planning, and coordinating activities. Some projects that had planned to begin with in-person activities managed to engage in in-person activities towards the end of the project duration instead, but in a greatly reduced capacity. This necessitated revising final evaluation approaches. In many cases, there was a shift towards greater reliance on qualitative survey data than originally anticipated; for example, several projects originally planned to track retention rates, course drop, fail, and withdrawal (DFW) rates, student outcomes/GPAs, and similar measures. These data points were not reliable due to myriad unforeseen variables created by COVID circumstances, such as students being given the option to take all of their courses credit/no credit, which impacted student outcomes and measures.

Budget cuts were also put into effect across many campuses during this time, which had an impact on administrative support and general capacity to implement new structures and projects. A small number of projects began just before shelter-in-place policies were enacted, and these cases offered a rare opportunity to observe the impact of the shift to online learning in real time. While these observations are valuable, insights and conclusions from these cases cannot be extrapolated to online learning as a whole, as remote learning environments forced into being by crisis are markedly different from remote learning environments that are designed as such from the ground up.

Additionally, both instructors and students faced numerous personal challenges. There was a significant increase in demand for remote learning resources and professional development, but at the same time, faculty exhaustion and burnout with trainings impacted recruitment and overall enthusiasm for engagement.
Some faculty were wary of taking on too many changes at once and did not have capacity to implement, for example, new curricula on top of working out remote learning logistics, which depressed faculty participation levels in some cases. Students also experienced increasing burnout, mounting external pressures and responsibilities, and survey fatigue, which similarly affected their engagement. As a result of shifting project designs, project teams had to adjust expectations for faculty and student participation as data collection efforts continued to be impacted by changing conditions (see Learning Lab’s report, *Class Interrupted: Faculty Needs in the Time of COVID*, for more insight into these challenges). These unforeseen variables created by the pandemic led to limited data sets, making pre-/post-intervention comparisons and drawing direct causal relationships between interventions and outcomes more difficult.

Considering the relative timeframes and environmental conditions impacting project implementation described above, it is important to view the findings as a point-in-time snapshot of longer-term efforts to create and sustain more equitable learning environments for students. In the short term, these 28 projects reported benefits for students and faculty across California public higher education, impacting more than 3,400 faculty and over 49,000⁶ students in research-based, equity-driven teaching and learning approaches and creating open teaching and learning resources in multiple formats. While it is necessary to acknowledge the limitations of interpreting findings given the broader context of learning environments, funded projects advanced efforts to test or improve teaching methods as well as initiated methods for measuring the success/effectiveness of such interventions (e.g., developing rubrics or observation protocols for planned adoption/expansion). Several project teams have expressed commitment to continue tracking and analyzing available data to measure longer-term impacts of their interventions.

The proceeding four sections present an analysis of each grant cohort, detailing the types of interventions undertaken, measurements of success, and barriers to and mechanisms of success. This is followed by a summary of issues commonly reported by grantees and lessons learned overall. This report concludes with an overview of outcomes and produced assets and steps Learning Lab is taking to continue supporting its community and encourage adoption and iteration of grantee-produced innovations and educational materials. One-page summaries of all formally closed projects can be found in Appendix C.

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**Footnote**

⁶ These figures exclude impact numbers from one project, *Increasing Student Flow and Success Along Intersegmental STEM Program Pathways* (2019-2020 Institutional Change cohort), due to this project’s unique emphasis on building an interactive web tool to assist in student transfers from CCCs to CSUs and UCs, as opposed to direct faculty engagement or impact on student learning outcomes.
Under this inaugural RFP, the Learning Lab sought demonstration projects on curricular and pedagogical innovations for online and hybrid learning environments with a focus on lower division STEM fields. Up to $1.3M over the course of three years was awarded to each grantee team focused on promoting learner sense of belonging in science, science identity, connections between science learning and personal lives, career aspirations and home communities, and leveraging affective components of learning. Nine innovation projects, including three demonstration projects, in the fields of mathematics, computer science, engineering, physics, chemistry, and interdisciplinary STEM were awarded. The projects are listed by their abbreviated project titles in the tables below. Full project titles and more project information are included in Appendix C.

Innovation Grants

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
<th>HOST INSTITUTION</th>
<th>PROJECT AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better Book Project</td>
<td>UCLA</td>
<td>Develop, implement, and continuously improve an online interactive textbook for introductory statistics.</td>
</tr>
<tr>
<td>Mechanics of Inclusion</td>
<td>Cal Poly SLO</td>
<td>Develop suite of adaptive web-based tools with videos and adaptive tests and leverage cognitive tools and affective interventions.</td>
</tr>
<tr>
<td>Community Sourced DDI</td>
<td>Santa Ana College</td>
<td>Deploy and improve open, adaptive courseware and open tools to support data-driven improvement of courseware.</td>
</tr>
<tr>
<td>GOALS in CS</td>
<td>CSU San Marcos</td>
<td>Implement an iterative design and development education research process to create innovative hybrid offerings of the introductory computer science sequence.</td>
</tr>
<tr>
<td>Developing Students’ Identity</td>
<td>College of Marin</td>
<td>Develop group-worthy, equitable in-class activities and complementary student social supports; and empower faculty to build an inclusive classroom climate.</td>
</tr>
<tr>
<td>Humanizing Academy</td>
<td>Foothill-De Anza Community College District</td>
<td>Implement large-scale, collaborative online professional development program to enable effective human interaction.</td>
</tr>
</tbody>
</table>

Demonstration Grants

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
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<th>PROJECT AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-Games</td>
<td>UC Davis</td>
<td>Create online game modules that cover basic steps of the engineering design process to provide scalable, meaningful exposure to design.</td>
</tr>
<tr>
<td>Building Number Sense</td>
<td>CSU San Bernardino</td>
<td>Create college-level number sense content, concentrating on foundational and advanced aspects of measurement and units, place value, and proportional reasoning.</td>
</tr>
<tr>
<td>Energy Education</td>
<td>CSU Bakersfield</td>
<td>Introduce concepts behind practical technical problems relevant to the Central Valley into gateway STEM courses and utilize flipped classroom and Process Oriented Guided Inquiry Learning (POGIL) approaches.</td>
</tr>
</tbody>
</table>

Footnote

7 Note: while this project submitted a final evaluation, it is not formally closed. The project team was granted an extension until August 2024. It is currently conducting additional demonstration and data collection activities and will produce an addendum to their final evaluation.
Interventions for this cohort had two broad targets: the development of student-facing materials; and faculty professional development and guidance (with some projects covering both aspects). The student-facing initiatives variously aimed to improve subject matter understanding; increase interest in STEM; foster STEM identity, confidence, and self-efficacy; and increase student engagement. Faculty-oriented actions and materials broadly aimed to build community; create onboarding experiences and guidance documents to train faculty on new curricular materials and associated technological tools; and foster an equity mindset and understanding of culturally responsive pedagogy.

By design, the awarded projects under this RFP were highly varied in approaches and outputs. The majority of interventions took the following forms:

- Subject-focused course materials
  - Interactive technologies to augment subject matter content
- Faculty guidance materials
- Outreach/engagement and developing communities of practice/learning communities
- Professional development opportunities

Additionally, one project (Energy Education) developed a new service-learning course in the discipline, and one other project (Mechanics of Inclusion) implemented a learning assistants program for foundational mechanics (introductory physics, statics, and dynamics) and developed curricular materials specifically for these learning assistants.

Subject-focused course materials produced by these grantee teams were creative and wide-ranging, implementing strategies for deep conceptual learning, active learning, and culturally responsive instruction and student support. Learning through experiential activities and metacognitive skills development were emphasized by several projects. Building Number Sense developed nonstandard problems (such as qualitative questions, asking traditional problems in a backward fashion, and asking students to analyze example work from fictional students) that focused on honing metacognitive and reasoning skills in students, as opposed to focusing on getting a correct answer; Community Sourced DDI leveraged learning-by-teaching methods, having students participate in developing adaptive learning resources also focusing on metacognitive skills development (including teamwork, collaboration, effective conflict management strategies, and self-regulated learning). Mechanics of Inclusion developed adaptive learning modules utilizing multiple response items and inquiry-based learning activities, integrated with multimedia and simulations. Developing Students’ Identity created modules focused on data analysis and critical thinking, with non-linear, group-worthy tasks designed to employ experimentation and/or modeling and socialize students into new ways of participating in science and develop their sense of STEM identity. Energy Education deployed Process Oriented Guided Inquiry Learning (POGIL) and flipped classroom strategies.

Some grantee teams leveraged interactive technologies in various ways to augment instruction or deliver subject matter content. For E-Games, this was the project’s primary goal; the grantee team created two new online games aimed at engaging students in experiential engineering design and teamwork in engineering. Energy Education worked with external contractors to develop an augmented reality (AR) app as a supplement to other course materials. Community Sourced DDI developed a suite of interactive courseware, while the Better Book Project enhanced an entire interactive, online textbook for statistics. E-Games and the Better Book Project also developed faculty guidance materials to supplement their subject matter content. E-Games created a toolkit for instructors with example activities, quizzes, survey instruments, assessments, while the Better Book Project created Jupyter notebooks for in-class lesson plans (both student-facing and complete versions for instructors).
Several projects developed entire curricular packages that specifically emphasized culturally relevant pedagogy and affective dimensions of learning. Building Number Sense developed modules with culturally responsive content, including explanatory text, examples, and solutions for 10 different math topics. These modules were integrated into learning management systems (LMSs) for Early Start Math, algebra, and math methods courses. Mechanics of Inclusion also developed a new curriculum for mechanics (pulling together content from introductory physics, statics, and dynamics) that integrated motivational videos highlighting student reflections about mechanics topics and relevance of these ideas to other areas outside of the classroom (such as hobbies or extracurricular activities). These videos were developed from a thematic analysis of a student survey conducted on utility value interventions (UVIs). The curriculum developed by GOALS in CS aimed to improve students’ social-emotional success, emphasizing confidence, self-efficacy, and problem-solving skills.

Outreach and engagement activities were primarily geared towards faculty. Building Number Sense held information sessions to introduce their material to interested instructors. Formal communities of practice (CoPs) with various forms of continuous engagement were implemented by the Better Book Project, Humanizing Academy, GOALS in CS, and Mechanics of Inclusion. The Better Book Project also created an engagement framework built around an R&D model to involve researchers, designers, developers, and instructors in the scaling and continuous improvement of their online textbook. Developing Students’ Identity was the only project to create a learning community geared towards engaging and supporting students.

Professional development opportunities were also primarily aimed towards faculty. Several grantees conducted workshops to familiarize and train faculty on new subject matter content and approaches. The Better Book Project created a layered approach to professional development, with study groups, a dedicated Slack channel, and daily office hours in addition to hosting workshops. Community Sourced DDI also held office hours to support faculty in addition to over 100 professional development workshop sessions on their courseware. Two project teams created professional development activities focused specifically on inclusivity and culturally responsive teaching. Humanizing Academy’s primary project objective was creating a six-week professional development course with eight research-based inclusive design elements on culturally responsive teaching and decentering whiteness in the classroom. Developing Students’ Identity created a series of faculty workshops focusing on the impacts of implicit bias on student outcomes, redefining what it means to do science and who is perceived of as a scientist, exploring the role that “smartness” plays in making vulnerable students feel excluded from learning processes, and giving guidance for faculty on implementing more equitable instructional practices, how to bring about shifts in student mindset, and how to enhance a sense of belonging in STEM. Energy Education’s new engineering service-learning course for students incorporated professional development workshops.

The Mechanics of Inclusion project was unique in its strong focus on developing a learning assistant program. Beyond simply implementing learning assistants into the discipline, they conducted a study to understand learning assistant epistemological development and evaluate best practices, which informed the creation of curricular materials specifically for learning assistants.

Footnote

8 “Whiteness” in education and society as a whole refers to how the standard to which all other groups are compared, and often viewed as deficient or “abnormal” in relation to, is rooted in the culture, beliefs, and experiences of white people and white racial identity. To “decenter whiteness” in the classroom is to focus on building a more equitable educational environment that does not take whiteness as the foundational norm.
Defining and Measuring Success

As the projects themselves were highly varied, assessment methods were accordingly diverse. Grantee teams used both qualitative and quantitative measures, though the small sample sizes and multiple confounding variables caused by the COVID pandemic made results from quantitative analysis inconclusive in several cases.

The most fundamental measure of success for most projects was the production of educational and/or professional development materials, their continued use and improvement, and expansion of the user base. The majority of grantee teams met this goal. One project, Mechanics of Inclusion, was not able to complete their intended subject content modules within the formal grant period and were approved to continue working on the project until deliverables were completed. Mechanics of Inclusion did, however, successfully develop support materials for learning assistants and implemented a full learning assistant program. E-Games completed development of not just one game as originally proposed, but two games and accompanying guidance materials, but struggled to recruit engineering faculty to use the games in their courses. In contrast, Better Book Project not only completed content development to improve an interactive, online textbook, it had undergone several revisions leveraging both instructor and student feedback (and was on Version 5 at the time of reporting, from a start point of Version 1). The content has been iterated into six textbooks (three for college use and three for high school use) with complete sets of Jupyter notebooks for in-class lessons, quizzes, and student projects, and the material has been adopted by 23 institutions of higher education nationally and abroad.

“Through this work we aimed to create a replicable R&D model that engages researchers, designers/developers, and instructors in the hard work of scaling the innovation, and of continuous improvement of the book and its implementation. By implementing a process of continuous improvement, we aimed to iteratively improve outcomes and reduce gaps among groups of students over time, making a bigger difference for students’ success in the long run.”

- Better Book Project

Community Sourced DDI had 32 faculty pilot and evaluate 14 adaptive STEM courses, with nine faculty ultimately participating in improving materials. Over 20 learning activities created by students themselves were developed and iteratively refined, as well as workflows and open-source scripts to analyze the quality and utility of this student-generated content.

Several grantee teams aimed to establish communities of practice and peer/community-based support structures for students. For these projects, degree of engagement and sustained support were important measures of success, and all grantee teams for whom this was a priority achieved this goal. The Better Book Project continued to have instructors reach out to the team, establish “study groups” to familiarize themselves with the material, and serve on panels of experienced instructors to guide new instructors through the process of adopting the materials. Humanizing Academy’s CoP remains engaged, with six program alumni continuing to conduct regular meetings. Mechanics of Inclusion developed a community of learners and hosted a symposium where instructors shared ideas and established mentoring/guidance connections between junior and senior faculty. The community of learners continues to be active and, at the time of reporting, was planning a 2023 symposium. Developing Students’ Identity created a comprehensive student support structure, with an embedded tutor program, a peer mentor program, and a formal STEM Learning Community (LC). The Learning Community has been institutionalized and integrated into the student campus culture at
College of Marin, with a dedicated Learning Community Coordinator position given full funding. The LC has collaborated with other student learning communities and hosted virtual STEM LC events.

The majority of projects collected qualitative data in the form of pre- and post-intervention surveys. Some projects also conducted focus groups, interviews, and ethnographic observations in addition to surveys. Qualitative data gathered from students had a wide variety of purposes. Improving project materials was a common objective, and student surveys gave feedback to guide revisions on project materials and perspectives on usefulness of, usability of, and satisfaction with project materials. Qualitative data was also gathered to gauge student mindset, content understanding, and affective dimensions of learning, such as confidence, ability to solve problems, attitudinal constructs, content understanding, accessibility, anxiety, engagement levels, STEM identity, and sense of belonging. Some projects, such as Humanizing Academy and GOALS in CS, also conducted faculty surveys for instructor perspectives on issues such as confidence in teaching online, perceptions of the role of the instructor in closing equity gaps, willingness to accommodate student differences, dimensions of self-awareness, effectiveness in facilitating active student learning, and ability to recognize signs of students struggling.

Quantitative data collection primarily focused on student outcomes, such as GPAs or assessments measuring content understanding, DFW rates, and retention rates. Some projects took additional quantitative measures such as student engagement as indicated by time spent with the project materials (E-Games), numbers of participants in programming (Humanizing Academy), and quantitative measures derived from interviews (Mechanics of Inclusion).

Qualitative measures indicated positive impacts on students. Student feedback reflected overall satisfaction, utility, and effectiveness of project materials. For example, in the Energy Education project, Pearson Correlation tests showed statistically significant differences in attitudinal constructs, intellectual accessibility, and emotional satisfaction, and analysis of open-ended survey response items resulted in themes such as “really useful” and “made it easier to learn.” Humanizing Academy’s student surveys reported high levels of satisfaction with sense of belonging, instructor-student relationships, teaching presence, social presence, and attitudes towards online learning. Some data on satisfaction and utility were mixed; for example, with E-Games, student feedback indicated increases in student confidence/ability to solve problems and students felt the game was inclusive and enjoyable to play; however, there were no indications of the game improving confidence in ability to communicate with teammates or give instructions to teammates, which was one of the primary practice activities of one of the games. While Energy Education showed statistical differences overall in attitudinal constructs, intellectual accessibility, and emotional satisfaction, there were variations when data were broken down: there were significant differences for first-generation and Hispanic/Latinx students, but no differences were found overall following implementation of the flipped classroom enhanced POGIL curriculum; and under the implementation of the flipped classroom enhanced POGIL AR curriculum, significant differences were obtained overall across all students, but no differences were found when evaluating for first-generation and Hispanic/Latinx students.

Qualitative data on affective dimensions of learning also showed positive impacts on students. Surveys from Better Book Project showed declines in fixed student mindset and anxiety from the beginning to the end of the term. GOALS in CS demonstrated increased sense of self-efficacy and engagement for students enrolled in classes with GOALS in CS interventions implemented compared to non-GOALS in CS classes, especially for students of color and women. Mechanics of Inclusion showed improved sense of belonging and STEM identity; similarly, qualitative data from Developing Students’ Identity also reflected increased sense of student belonging, as well as confidence and ability to understand difficult concepts. Qualitative data collected from faculty showed a significant increase in confidence in teaching online, perceptions of the role that an instructor plays in closing equity gaps, awareness of the differences students bring to a class, willingness to intentionally accommodate student differences and be more flexible with course policies and grading (Humanizing Academy), and increased perceived effectiveness in facilitating active student learning,
recognizing early warning signs for students who struggle, adopting meaningful culturally relevant content, and offering appropriate interventions to help students excel (GOALS in CS).

Implications from quantitative data were mixed. E-Games and Mechanics of Inclusion reported that they did not have enough data points to draw conclusions on the impact of their interventions on retention or DFW rates. Mechanics of Inclusion also reported that there was no statistical difference in student learning outcomes/performance between students in classes with the intervention implemented and other/control sections; however, it was also noted that dips in performance immediately after new curricula or resources are implemented are not uncommon, as there is often an adjustment period and thus a lack of difference is possibly a positive outcome. In contrast, Energy Education and Developing Students’ Identity both reported decreases in DFW rates and improved learning outcomes. For Energy Education, the decrease in DFW rates had a higher impact on women who took the Human Centered Research and Design course, and there were higher mean scores for oxidation-reduction topics that were covered in the project’s AR app activity. In the Developing Students’ Identity project, there were reduced GPA differences between underserved minority (USM) and non-underserved minority (NUSM)9 students, DFW rates of USM students decreased by 13% at Sonoma State University, and retention rates and success rates (grade of A, B, C, or passing) increased at Diablo Valley College. Though it was too early at the time of reporting to determine the outcomes conclusively, preliminary findings show students using materials from Developing Students’ Identity in introductory chemistry did relatively well in their immediately subsequent chemistry course.

GOALS in CS showed higher learning outcomes and retention rates, but not at statistically significant levels (though these results are possibly confounded by COVID-related variables). Better Book Project tracked performance outcomes and transfer performance (the ability to apply learned concepts to more advanced problems not directly learned from material), finding that student performance did not decline with the transition to remote instruction (somewhat surprisingly, it increased for CC and UC students) and overall high levels of transfer performance (with more than half of students giving completely correct responses on transfer questions). Community Sourced DDI tracked student performance analytics within the Gradebook platform of the LMS over five semesters and found increases in learner engagement over the semesters and improved performance in several Chemistry, Statics, Statistics, and Biochemistry courses.

Barriers and Mechanisms of Success

There were several common mechanisms contributing to project successes. Collaborating across disciplines, campuses/segments, and sectors (i.e., between researchers and practitioners) was repeatedly cited as a major factor in project progress, though the logistics of doing so was often complicated. Related to this, establishing strong communication protocols and holding regular meetings was also seen as crucial. Active, intentional networking, such as at conferences, helped several project teams recruit participants and connect with others who would “champion” their work. Having mechanisms for student feedback was valuable for several grantee teams in revising and improving their project materials. Finally, building a framework to support instructors in implementing new content and strategies helped to ensure continued use of project outputs.

Several institutional factors outside of the control of grantees hindered project progress. Administrative burdens were a commonly cited incumbrance. Required community college Board approvals for curricular changes, for spending award funds, and other issues caused significant delays. IRB approvals were sometimes a major cause of delay; establishing IRB approvals across institutions was logistically difficult, and in one case (San Joaquin Valley College, with the Energy Education project), it delayed collecting data on that campus for an entire year. Differing institutional budget guidelines and varying deadlines increased time and effort.

Footnote
9 In this project, underserved minority students (USM) were defined as those who identify as Black, Latinx, or Native American. Non-underserved minority students (NUSM) consists of all other students.
required to complete administrative tasks. Additionally, the CCCs, CSUs, and UCs do not have standardized collection methods for student data, and only the CSUs collect information specific to first-generation students, making it difficult to compare impact of interventions across segments. The degree of instructor autonomy also varies across campuses, which influences recruitment. For example, Building Number Sense reported that instructors at Riverside City College struggled to add content on number sense, as their courses were already overloaded with content required for transfer to other institutions, while instructors at CSU San Bernardino had more flexibility.

There were several issues specific to circumstances at the time and grantee decisions that hindered progress. As with many other projects from this time period, low interest levels and difficulties recruiting participants, along with certain IRB requirements for opt-in consent, led to small sample sizes, often preventing more comprehensive statistical analyses. General delays caused by COVID slowed project development and in some cases prevented project teams from enacting the full extent of user testing and feedback that they intended. Finally, having ill-defined roles on teams at the start of the project also led to communication issues and delays. While teams eventually overcame many of these difficulties, these issues often took more time and resources than initially anticipated.

III. 2019-20 Cohort: Using Research and Technology

For the 2019-20 grant cycle, Learning Lab issued a request for proposals titled “Using Research and Technology to Transform Undergraduate STEM Education.” Under this RFP, Learning Lab sought projects that would not only develop and implement curricular and pedagogical innovations, but assess, evaluate, and iterate improvements, utilize technology tools to support learning outcomes and advance research in human learning, and show potential for replication and scaling. Projects under this grant cycle fell into three categories: Innovation, Seed, and Professional Development. The creation of subcategories under this RFP was in direct response to the feedback received from the inaugural RFP to appeal to faculty at different stages of the innovation development process, with support from Learning Lab’s advisory council to provide this more scaffolded opportunity. This section focuses on the Seed and Professional Development grants. Innovation grants are not included in this analysis, as these projects recently concluded and final evaluations are ongoing.

Seed Projects

Seed grants sought to support intersegmental teams in the early stages of designing and developing promising pedagogical and curricular innovations. These grants were intended to help teams plan, design, and develop projects that could compete for Innovation Grants in future RFP cycles. Six project teams were offered $100,000 each over the course of two years. These projects spanned multiple disciplines, including mathematics, biology, chemistry, computer science, and data science, and are summarized in the table below and on the next page. Please note that projects are listed by their abbreviated titles. Full project titles and more project information are included in Appendix C.

<table>
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<tbody>
<tr>
<td>Equity and Access in Discrete Math</td>
<td>San José State</td>
<td>Develop and pilot group-worthy tasks and team-based adaptive learning for discrete math learning.</td>
</tr>
<tr>
<td>Coding Community</td>
<td>Chico State</td>
<td>Develop and implement an online, inclusive, and hands-on tool for coding classes that connects a diverse population of students across different campuses.</td>
</tr>
<tr>
<td>Social Online Tools</td>
<td>Stanislaus State</td>
<td>Create and pilot collaborative curriculum interventions and leverage online tech tools for students in Introductory Biology courses.</td>
</tr>
<tr>
<td>SHORTENED PROJECT NAME</td>
<td>HOST INSTITUTION</td>
<td>PROJECT AIM</td>
</tr>
<tr>
<td>------------------------</td>
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</tr>
<tr>
<td>STEM Success</td>
<td>Butte College</td>
<td>Develop and assess two virtual lesson series with short, interactive and adaptable videos on the biology of learning and applying the science of learning to inform successful studying strategies.</td>
</tr>
<tr>
<td>Pathways to Computing</td>
<td>UC Riverside</td>
<td>Create a sequence of courses in Data Science (DS) that includes online modules that aim to build bridges between DS and the physical sciences, social sciences, humanities, and the arts, modeled on established pedagogical approaches like Project Based Learning.</td>
</tr>
<tr>
<td>Supporting Student Learning</td>
<td>UC Riverside</td>
<td>Design effective online formative assessments for online simulations presenting content about fundamental introductory chemistry concepts.</td>
</tr>
</tbody>
</table>

**Intervention Types**

As this funding was meant to facilitate the planning and initial development of what could potentially become larger projects, building collaborative implementation teams, institutional channels, and project foundations intentionally designed towards future scaling were priorities for this Seed grant cohort. Other overarching goals included fostering active and collaborative learning; improving learning outcomes; and improving student sense of belonging, self-efficacy, and other affective dimensions.

Activities carried out by these grantees were primarily focused on developing, piloting, and refining new student-facing course materials, with some projects also developing supports to guide instructors in using the new materials. One project, *Equity and Access in Discrete Math*, took additional steps to analyze a broader picture, making efforts at state-level policy reform in order to build "scaffolds" that would support systemic change. Three of these Seed projects received additional awards to expand their work, and two are involved in larger “Grand Challenge” projects (Calculus and Data Science) awarded by Learning Lab.

The course content for learners developed by the Seed grantees were diverse in both content and form, with active learning materials such as team-based learning activities, project-based assignments, adaptive learning lessons, simulation-based instructional content, and work problems utilizing real world data developed for remote and in-class settings. Two grantees, *Coding Community* and *STEM Success*, focused on inclusive audiovisual media, developing video instructional materials to communicate subject matter. *Coding Community* emphasized representation by featuring students from underrepresented backgrounds to demonstrate course concepts in ways related to their lives and interests, coupling videos with applied, interactive coding problems (Figure 1 below depicts an example).

![Figure 1](https://example.com/figure1.png)
STEM Success's videos were designed to foster growth mindsets, sense of belonging, science identity, and self-efficacy among students. Other projects, such as Creating New Pathways to Computing and Social Online Tools, designed and implemented inclusive curriculum and culturally relevant teaching models.

Several projects developed assessments to closely align with new teaching content. One project, Supporting Student Learning, specifically prioritized the creation of formative assessments and testing the impact of different kinds of feedback strategies on student outcomes, along with corresponding model simulations of molecular structures to reinforce subject matter understanding. Some grant teams, such as Supporting Student Learning, Coding Community, and STEM Success integrated all project outputs into cohesive, interactive online learning modules. Guidance materials for instructors were also created by some grantees, such as teaching notes to go along with lecture- and simulation-based instructional content and other instructor learning opportunities. In one project, Equity and Access in Discrete Math, the creation of instructor support materials was not initially a priority, but it became one as PIs realized over the course of their work that some instructors were willing or interested but not ready to make instructional changes. These instructors in particular needed more support and scaffolding to recruit them into adopting new frameworks, and this discovery informed the project’s subsequent scaling efforts.

The Equity and Access in Discrete Math team also realized in the early stages of their project that the state’s Course Identification Numbering System (C-ID) impacted innovation on instruction in unexpected ways. Because the C-ID defines what a course must teach in order for it to be transferrable between institutions (such as from a community college to a CSU) it tends to specify very long lists of topics to be covered in a course. This often leaves little room for flexibility or time for instructors to explore more innovative pedagogical strategies. Because of this, the Equity and Access in Discrete Math team sought ways to reform the C-ID for discrete mathematics to help facilitate and sustain pedagogical changes, drafting a streamlined C-ID that will be proposed in upcoming state-level C-ID revision discussions. Figure 2 below shows the project team’s Q-sort process, across three sub-teams and extensive discussions and negotiations, to identify the intersection (overlap in the center), representing core topics. This core contains only topics common to both existing C-ID collections for discrete mathematics and discrete structures that are also in the collection from the guidelines for discrete mathematics/structures produced by the Association for Computing Machinery (ACM; the largest professional society for computing in the United States). Three examples are highlighted in the Q-sort: a core topic, ideas from set theory (intersections and unions, appearing in all three collections); and two topics outside the core, quantifiers (fine-grained, appearing in two of the three collections), and tautologies (very fine-grained, appearing in only one collection, the discrete math C-ID).

![Discrete Math Curriculum Venn Diagram](image)

**Figure 2.** Q-sort produced by the Equity and Access in Discrete Math team, with core topics (at the center intersection) and extraneous topics.
Defining and Measuring Success

Grant teams primarily used qualitative measures to assess degrees of success of project outcomes. As the Seed grant was to fund the design and initial development of technology-mediated teaching innovations, the degree of collaboration and communication between team members, completed production of intended instructional materials embodying pedagogical innovations, and their use by faculty and students were primary indicators of success at the most basic level. Some grantees also took measures to assess the usability of the new materials, surveying students on ease of engagement and relevance of the content in order to make improvements.

Other qualitative measures included surveys and other assessments on changes in student sense of belonging, self-efficacy, inclusivity, student mindset and other affective dimensions, learning gains and degree of understanding of subject matter pre- and post-intervention, overall learning experience with new active learning activities and materials, perspectives on the pacing of new lesson material, and values and motivations. For example, Coding Community conducted a student needs assessment at the beginning of their project to identify potential learning applications that would be relevant to and align with student interests and daily lives. Instructors and team members were also surveyed on their perspectives on implementation of the interventions, the level of student understanding relative to years prior, and willingness to continue using the developed materials. When available, quantitative student learning outcomes (such as DFW rates), numbers of enrolled students in relevant classes or majors/minors pre- and post-intervention, and the demographic composition of these students were also observed in some projects.

Some grantees took additional steps to gauge the overall sustainability and robustness of their interventions. For example, Equity and Access in Discrete Math, in efforts to intentionally plan for future scaling, conducted a full feasibility study using surveys, interviews of faculty and students, and observations of class sessions to gauge feasibility along four dimensions: technical; organizational; support; and usability factors. Findings were converted to a numeric score with a high of 3 and a threshold for feasibility of 2.4 or higher. Out of the measured dimensions, organizational feasibility was above threshold, while others were below. They also conducted document review and analysis of team reflections, student-facing materials, instructor roadmaps, and student artifacts created during lessons. STEM Success conducted a mixed-methods research study to assess the direct impact of the produced videos on student success and equity gaps, creating seven experimental sections and five control sections outside of the classroom, conducting qualitative interviews with 32 students, and gathering data on science identity, self-efficacy, study practices, metacognition and motivation, and fixed and growth mindset.

Overall, these measures indicated high levels of student satisfaction and engagement with the developed materials and positive changes in student growth mindset, inclusivity, self-efficacy, and other affective dimensions. Direct impact of interventions on learning outcomes was more difficult to discern across projects. Some projects, such as STEM Success, had data sets that were too small to draw conclusions on the direct impact of the interventions on learning outcomes, and they were not able to disaggregate data on DFW rates in order to run robust statistical analysis though qualitative analysis (via questionnaires) showed positive changes in student study habits. Supporting Student Learning also had inconclusive results in regards to the closing of equity gaps among underrepresented minority students due to the experiment’s small sample sizes. However, beyond the scope of their experiment, materials from Supporting Student Learning were subsequently implemented in classes at CSU Northridge, where pre- and post-intervention measures indicated statistically significant learning gains and student response was overwhelmingly positive.

Some projects had clear indications of broader or institutional changes. For example, in the wake of the Creating New Pathways to Computing project, a new data science minor was established at Cal Poly Pomona, a new second course in the sequence was created at UC Riverside, and Riverside City College’s new course was adopted by two other community colleges. A Broadening Participation Committee was established in
the computer science department at UC Riverside, which evaluates retention and graduation rates of women and URM students, and an Undergraduate Learning Assistant program for lower division classes was also established. Overall, quantitative indicators on enrollment have shown a greater diversity of students either switching majors to data science, taking more data science courses, or intending to pursue the new data science minor.

Materials were also generally well received by peers. For example, Coding Community reported they received a good deal of positive feedback at conferences, and 29 instructors at other institutions and other departments within their own institution and as well as the open educational resource repository Runestone Academy indicated interest in adopting their content. Supporting Student Learning conducted significant outreach to primary school educators, and their materials are now being used by high school teachers.

Barriers and Mechanisms of Success

Several trends emerged across this cohort in regards to elements that helped or hindered project progress. Communicating and collaborating broadly was perhaps the biggest common contributor to success. Not only did intersegmental collaboration foster productivity, grantees reported that cross-departmental collaboration helped to develop real world, applied content and additional insights that improved the relevance and value to students of course content, and intentional networking with potential adopters helped to identify needs for future scaling and recruitment strategies.

Several factors outside of the direct control of grantees hindered success. The COVID pandemic and subsequent policy changes significantly impacted the ability to collect course performance data, recruit participants, and conduct in-person piloting for comparisons. Student survey fatigue was high (and to a large extent, remains high), as was faculty burnout, resulting in sample sizes too small to run the statistical analyses that several grantees originally planned. Classroom sizes and the degree of autonomy for faculty to implement new ideas meant that some campuses were more willing to adopt materials than others; for example, Social Online Tools stated that the CSU’s and UC’s, with class sizes that often run in the hundreds, tended to have more rigid structures and less room to deploy new material, while community college campuses with smaller class sizes tended to adopt new materials at a higher rate. Across the board, grantees struggled to varying degrees with administrative and institutional barriers. The logistics of establishing sub-contracts, following complicated campus protocols for billing and invoicing, and gaining IRB approval across segments was a challenge, particularly for faculty that were new to the PI position and on smaller campuses that do not have dedicated grants administration staff. STEM Success stated they were met with organizational resistance at nearly every step, and there was an overall lack of departmental and institutional will to support and sustain structural changes and intersegmental collaboration.

Finally, certain elements of project design impacted success for some grantees. Student-facing instructional materials were generally well developed but guidance for utilizing the materials (for both instructors and students) needed strengthening. For example, Supporting Student Learning reported that the online simulations they developed to demonstrate molecular structures likely needed some scaffolding on how to deploy and interact with them, which could have affected student engagement with the tool. They also determined that their experimental design was perhaps not ideal for student participation; test sessions were in controlled settings outside of class and long in duration (up to two hours). Recruitment of student volunteers was especially difficult, and the project team had to pivot from the original plan to gather group data to scheduling student participants individually; hence, recruitment methods, sample size expectations, and data collection had to be continually adjusted. As previously mentioned, Equity and Access in Discrete Math ultimately determined that the next phase of their project will require improved instructor supports in order to increase readiness and willingness to adopt curricular changes.
Professional Development Projects

The Professional Development grants aimed to support intersegmental partnerships in creating new or modifying/expanding existing faculty professional development programs that contribute to improvement in learning outcomes or reduction in equity gaps in undergraduate STEM courses, covering the costs of development and/or dissemination of programs on best practices and supporting communities of practice among participating faculty. Five project teams were offered $200,000 each over the course of two years. *Deeper Math Learning* and *BAM-C* were focused on mathematics, *Closing Equity Gaps in Intro Bio* was focused on biology, and *Teaching Experiment Academy* and *Building Community and Facilitating Active Learning* were interdisciplinary projects. These projects are summarized in the table below. Please note that projects are listed by their abbreviated titles. Full project titles and more project information are included in Appendix C.

### Professional Development Projects

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
<th>HOST INSTITUTION</th>
<th>PROJECT AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEA/Teaching Experiment Academy</td>
<td>UC Irvine</td>
<td>Create a cohort-based faculty development program that supports STEM faculty in redesigning their courses using guidance from the mastery learning model and employing specifications grading to encourage a growth mindset for student success.</td>
</tr>
<tr>
<td>Building Community and Facilitating Active Learning</td>
<td>UC Irvine</td>
<td>Develop an online synchronous faculty development program that leverages evidence-based teaching practices aimed at building students’ sense of belonging.</td>
</tr>
<tr>
<td>Closing Equity Gaps in Intro Bio</td>
<td>UC Berkeley</td>
<td>Develop a community of practice to boost student achievement and narrow observed equity gaps via faculty professional development in active, student-centered teaching practices.</td>
</tr>
<tr>
<td>BAM-C</td>
<td>CSU East Bay</td>
<td>Restructure the traditional (C-ID aligned) Precalculus Course, clustering the standard concepts into a “Big Ideas” structure to add coherence and deeper meaning to central course concepts.</td>
</tr>
<tr>
<td>Deeper Math Learning</td>
<td>CSU Chancellor’s Office</td>
<td>Support math faculty to participate in an intensive, networked, Reading Apprenticeship professional learning program focused on apprenticing students into advanced mathematics literacies.</td>
</tr>
</tbody>
</table>

### Intervention Types

The activities undertaken by these five projects fell under two broad categories: creating training and information dissemination/sharing opportunities for instructors; and the development of student-facing materials (note: these were not mutually exclusive; grant teams did not necessarily conduct one category of activities at the expense of the other).

Interventions geared towards instructors had a long-term goal of training instructors on student-centered pedagogical frameworks and guiding them into adopting and institutionalizing these new philosophies, practices, and strategies. Programming took several forms, including workshops, working groups, courses, webinars, conferences, showcases, collaborations with instructional designers, and formalized communities of practice. Communities of practice themselves also took many forms, from regularly scheduled meetings with project teams and participating faculty, to BAM-C’s “nested” partnership network, wherein each partner institution had one member serving on a central Steering Committee, and each committee member worked to recruit faculty at their home institution and develop localized working groups. In all forms, CoPs created communication pathways for the sharing of knowledge and tools and space among peers to familiarize themselves with new instructional strategies and materials, ask questions, voice and discuss concerns, get/give feedback, and practice implementing new teaching approaches.
These interventions covered varied aspects of student-centered pedagogical theory. Some projects, such as Closing Equity Gaps in Intro Bio, created workshops and seminars on fostering a growth mindset about student learning, understanding the sociocultural characteristics of diverse learners, culturally relevant/responsive teaching, and cultivating student sense of belonging or community. These interventions sought to build awareness and understanding of cultural and affective dimensions of learning and achievement. Others, such as the Teaching Experiment Academy, held trainings on mastery learning, specifications grading, generating peer interaction among learners, developing group-based activities, and other active learning strategies to give instructors sets of tools and strategies to modify their approaches in teaching students. Some project teams, such as BAM-C, also created distributable written and/or media resources around these topics to provide guidance beyond the workshops and trainings and encourage sustained adoption. A portion of BAM-C’s Pre-Calculus Course Guide is depicted in Figure 3 to the right.

Interventions aimed towards the development of materials and strategies for students sought to impact learning outcomes more directly. Project teams re-designed course structures and created new instructional content, activities, and/or assessments to facilitate more student-oriented learning processes and environments. Activities included the implementation of learning assistants for online classes to encourage engagement and create opportunities for guided peer learning, elements that are generally lacking in remote learning contexts (Building Community and Facilitating Active Learning); reorganizing curricula, grouping and resequencing subject matter content in more coherent, connected ways and creating tightly aligned activities and assignments to help students build essential conceptual knowledge (BAM-C); developing corresponding course guidance to assist faculty in implementing new curricula (BAM-C); and coordinating feedback cycles, wherein instructors could pilot new course content in classes and, based on student feedback, workshop the material with other instructors, find areas of improvement, and revise the content accordingly (Deeper Math Learning).

Defining and Measuring Success

Outcomes were primarily assessed with qualitative data, drawn from surveys on participating faculty and students. For interventions focused on training and information dissemination/sharing for instructors, success was measured according to the degree of faculty participation and engagement with the new pedagogical frameworks. Faculty surveys gathered data on a variety of metrics, such as satisfaction with professional development programming; level of faculty understanding of content from trainings; faculty mindset change; and degree of interaction among community of practice members after training periods. Deeper Math Learning conducted additional surveys on the designers and providers of the professional development content to get their perspective on implementation success, and Building Community and Facilitating Active Learning also analyzed post-intervention impact in the classroom by measuring shifts in faculty use of student-centered language in syllabi. This gave insight on the extent to which faculty applied the knowledge and theory following the interventions and the extent to which it persisted beyond the grant period. Interventions focused on the development of materials for students were measured by student feedback on piloted content. One project, Deeper Math Learning, was also able to compare student outcomes with historic data (grades, pass rates, course completion, and demographics) and student performance in subsequent classes.
BAM-C collected data on student outcomes in courses with implementation of the Big Ideas Framework in comparison to courses without implementation. Student surveys gathered data on the numbers of impacted students; pre- and post-intervention sense of belonging, self-efficacy, and growth mindset; and perspectives on faculty impact. Closing Equity Gaps in Intro Bio also measured alignment of student perspectives with faculty perspectives on content implementation.

Overall, these measures indicated positive shifts in faculty mindset on student learning, increased understanding of students, and successful implementation of strategies/knowledge acquired in professional development programs for all projects. However, the degree of persistence in continued use beyond the term immediately following the completion of intervention activities and continued engagement in communities of practice was mixed; for example, TEA reported continued application of specifications grading in classes beyond the grant program, while Building Community and Facilitating Active Learning did not have all of the participating faculty commit to re-teach their courses due to scheduling conflicts that were out of faculty members’ control. This suggests that sustained engagement is mixed and remains a major concern. For students, there were increases in content understanding, confidence in performance, and growth mindset, though most projects were unable to collect data that would measure student outcomes as directly linked to interventions. Some projects, such as Closing Equity Gaps in Intro Bio, could not draw firmer conclusions from some of their survey data; their student-faculty alignment surveys were inconclusive due to low response rates, with some classes having as few as five student respondents and some faculty not responding to all questions in the survey. As mentioned above, only one project was able to compare with historic data or track student performance in subsequent classes. For the BAM-C project, a higher average GPA and more positive distribution of grades was observed in courses with Big Ideas Framework implementation compared to those without implementation.

Barriers and Mechanisms of Success

Projects generally suffered from delays caused by bureaucratic complications within and across segments and lack of support (both financial and institutional) beyond the grant period. While the onset of the COVID pandemic increased demand for professional development and pedagogical guidance overall, the impact of participant levels varied across projects; for example, TEA and BAM-C were quite successful in their project recruitment, and they reported the unprecedented pandemic context likely influenced this. Deeper Math Learning also reported that the unfamiliar situation positively impacted their engagement levels, as it “made everyone a learner.” In contrast, Closing Equity Gaps in Intro Bio could not measure equity gaps as they originally intended and, as previously mentioned, their small sample sizes meant they could not draw firm conclusions on student-faculty alignment. Across all projects, it was clear that successes were bolstered by the involvement of “auxiliary” experts such as learning assistants, peer coaches, master trainers, and instructional designers, who helped distribute the labor of implementing new learning and teaching methods. Robust, formalized management of communities of practice, with regularly scheduled meetings, frequent communication, and structures of accountability also contributed to success and increased longevity of interventions.
IV. 2019-20 Cohort: Institutional Change

Learning Lab issued an additional request for proposals in the 2019-20 cycle, “Enabling Institutional Change in Undergraduate STEM Education.” This RFP sought projects that would address institutional barriers to student success and retention in STEM and establish institutional contexts and environments that enable greater student success and faculty engagement. Projects were required to demonstrate an innovative approach to institutional-level change that would improve learning outcomes and/or reduce equity gaps, demonstrate potential for sustainable, institution-wide impact across the partner campuses, demonstrate potential to directly or indirectly improve learning outcomes and/or close equity gaps in online and hybrid course environments for lower division undergraduate students, and integrate the science of human learning and adaptive learning technology tools and make robust use of data and technology. Learning Lab issued five grants of $500,000 to $650,000 over the course of two years. One project, Implementing and Testing Adaptive Learning Software for Introductory Physics, Chemistry and Engineering Classes, has not yet closed and is excluded from this report. The four grants from this cohort that have formally concluded are listed in the table below by their abbreviated project titles. Full project titles and additional project details are included in Appendix C.

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
<th>HOST INSTITUTION</th>
<th>PROJECT AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity in STEM</td>
<td>CSU Chancellor's Office</td>
<td>Engage STEM faculty in a community of practice that supports the adoption of culturally relevant and high-intensity active learning techniques in online and remote environments.</td>
</tr>
<tr>
<td>Increasing Student Flow</td>
<td>Bakersfield College</td>
<td>Expand the existing Program Pathways Mapper (PPM) system to facilitate transfer between community colleges and UC campuses.</td>
</tr>
<tr>
<td>Reorienting Formative and Summative Assessment</td>
<td>UC Berkeley</td>
<td>Promote an institutional pivot towards mastery learning by developing and deploying paradigm-based question generators (PQGs) for high-demand STEM courses.</td>
</tr>
<tr>
<td>Hybrid Approach</td>
<td>CSU Dominguez Hills</td>
<td>Develop and assess hybrid, lab-based courses.</td>
</tr>
</tbody>
</table>

Projects in this cohort broadly aimed to engage with, empower, and build community for instructors to make structural change and target broader institutional structures. Improving student engagement and pedagogical shifts towards active and mastery learning were also major aims. Interventions conducted by this cohort fell into three broad categories: development of new course content and instructional tools; distribution of project materials; and developing community and networking opportunities for faculty.

Three projects developed, tested, and implemented course content and instructional tools. Increasing Student Flow created a new course for transfer students, the UC Transfer Experience. Reorienting Formative and Summative Assessment developed and deployed paradigm-based/parameterizable question generators (PQGs), computer code that can generate a moderate to large number of questions from a single template representing a particular skill and give instant feedback, to facilitate a shift towards mastery learning in computer science. PQGs take the burden of developing more practice problems and providing more opportunities for summative assessment and automate a process that would otherwise require significant instructor effort, both to create the materials and give students feedback. The grantee team eventually implemented an “F’s for None” policy and subsequently an “A’s for All” grading policy, wherein if students took an assessment and received a grade they found unsatisfactory, they were allowed to continue to work...
and take re-assessments until they achieved the grade they wished. Hybrid Approach designed and implemented hybrid course-based undergraduate research experiences across three colleges, redesigning courses to integrate collaborative, scaffolded, and data-driven curricula in such a way to accommodate heavy teaching load contexts and reduce instructor burden.

Two projects made distribution of materials a primary focus. Equity in STEM created an online, accessible repository of text-based activities related to metacognitive conversations about disciplinary texts and active, culturally responsive teaching. Increasing Student Flow’s main objective was to improve and expand a free, mobile-adaptive, and interactive visual map of the path to a degree, called the Program Pathways Mapper (PPM). Statewide templates, transfer maps, a guidebook for hosting effective convenings, and an intersegmental collaboration guide were also created. The PPM aimed to eliminate disparities in the knowledge of students and makes visible the “hidden curriculum” of how to successfully navigate college. An example of the final output for a degree program in the PPM is depicted in Figure 4 below.

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**Figure 4.** An example of the final output in the PPM for a kinesiology associate degree.

All four Institutional Change grantee teams implemented community or networking opportunities in some capacity. Equity in STEM created several learning communities—STEM Instructors Learning Community, Facilitator Learning Community, and Learning Community of Practice—and conducted active outreach through team members’ existing networks to sustain and expand into “spin-off” workshops and communities. They also developed a 10-month professional learning course and an Apprenticing Students into STEM
Thinking workshop. *Increasing Student Flow* hosted three convenings of faculty to develop buy-in, get feedback, and held training opportunities for faculty on the requirements of developing major pathways. *Reorienting Formative and Summative Assessment* engaged in high visibility presentations, outreach, conference presentations, and onboarding workshops for faculty and student assistants, and *Hybrid Approach* held a faculty symposium to brainstorm ideas and expand outreach.

## Defining and Measuring Success

The most elemental measure of success was the completion and sustained use of project materials. *Increasing Student Flow* successfully developed and deployed the PPM, with plans to expand its reach. Through persistent external engagement and connecting with Central Valley Higher Education Consortium (CVHEC), the *Increasing Student Flow* team gained a strong supporter in the CVHEC, which eventually resulted in $25 million in new funding from the state to support the scaling of intersegmental program pathway mapping. *Reorienting Formative and Summative Assessment* had a goal of developing at least 100 PQGs; by the end of the reporting period, the grantee team developed over 2,000 PQGs for 13 courses and received feedback from 40 student teachers (original goal was to receive feedback from 20 student teachers). *Hybrid Approach* aimed to redesign 15 courses; they eventually redesigned 14 courses.

Beyond completion of project materials, grant teams used both qualitative and quantitative measures to gauge project progress. Qualitative data primarily took the form of surveys and qualitative analysis of interviews and written materials. Student pre- and post-intervention surveys measured student engagement; sense of community and belonging; changes in confidence; self-efficacy; instructor familiarity; and gains in experience with research and writing. Faculty surveys focused on issues such as degree of student engagement, instructor knowledge about equity and culturally relevant pedagogies, and mindset on being change agents. One project team, *Equity in STEM*, commissioned an external evaluation report based on the Value Creation Framework (which gauges an intervention's immediate value; potential value; applied value; realized value; and transformative value). Quantitative data gathered by project teams include numbers of transfer students and website analytics for project sites (*Increasing Student Flow*); pass rates (*Reorienting Formative and Summative Assessment*); and student retention (*Hybrid Approach*).

These measures indicate varying degrees of success. For *Equity in STEM*, evaluation using the VCF Framework showed a robust sense of community was developed, instructors were changing their approach in teaching practices, with substantial and meaningful changes to their use of text in their courses and more active learning sustained. Most participants (63%) reported the program had transformed their practice to a large or very large extent, and that faculty were more likely to be confident in their ability to implement culturally responsive teaching practices such as addressing power dynamics. Overall, the project team engaged 144 faculty members from 21 CSUs and 40 CCCs from 23 STEM disciplines. *Reorienting Formative and Summative Assessment*’s PQG’s received a high degree of interest, expanding to four courses outside of pilot program to include data science, statistics, and other STEM courses. All students who aimed to pass the pilot course, CS10, did so, demonstrating that students welcomed the “A’s for All” grading approach.

> “I think it’s an amazing initiative! As a 4th year student I truly wish some of my other classes would have implemented this because often it’s not that students don’t know the material, it’s just that courses are so fast paced it’s hard to do well on exams”

–Survey response from student participating in *Reorienting Formative and Summative Assessment*’s “A’s for All” approach
After the implementation of the PPM under the Increasing Student Flow project, there has been a sustained increase in the number of transfer students. The initial bump in transfer students was too early to be directly tied to the PPM, but the project team noted that “the shared focus on clarifying transfer pathways and holding convenings among a wide array of discipline faculty from UC Merced, Merced College, and Bakersfield College affected the overall transfer receptivity of the UC Merced campus over a period of time leading up to the launch of the Program Pathways Mapper, creating in practice clarified, intentional, supportive pathways to UC Merced even before the maps themselves were widely available.” Hybrid Approach aimed to increase student retention in the major, but at the time of reporting, they had not yet collected sufficient data to determine the outcomes in this regard.

Barriers and Mechanisms of Success

Administrative burdens posed a significant challenge to several grant teams. Some experienced difficulties in processing grant funds and distributing stipends, causing delays. The effort required to change grades, a crucial point for the Reorienting Formative and Summative Assessment project, was a considerable obstacle. Administrative staff turnover also caused major delays. The differences in staffing levels and compensation rates across campuses made coordination difficult, and also possibly impacted participant recruitment (as lower compensation rates were likely a deterrent).

Relatedly, strong financial support for participants was cited as a crucial factor in project success. Having the support of external experts, such as counselors, advisors, and other administrative staff, helped to alleviate some of the labor burden, and two grantee teams specifically cited support from the Learning Lab in providing guidance, connections, and backing as being a major benefit. General institutional support and instructor autonomy gave instructors the freedom to try new strategies and implement new course material. Finally, like many other grantees, the Institutional Change cohort stated that collaborating widely, across departments, segments, campuses, and fields, was a valuable tool for working out problems and gaining insights that would otherwise be overlooked on less expansive project teams.
V. 2020-21 Cohort: 
Calculus Grand Challenge

In 2020-21, Learning Lab launched its first Grand Challenge RFP, “Overcoming the Calculus Barrier to STEM Success.” The RFP was focused on this field given that the calculus sequence often poses considerable barriers for prospective and existing STEM students. Retention and degree completion gaps are especially prevalent for women and students from underrepresented backgrounds. Learning Lab solicited proposals for the development of innovations that would transform the calculus sequence and/or reimagine the role of calculus in STEM majors where calculus is a prerequisite. Applicant teams were required to represent at least two of the three segments of public higher education in California (CSUs, UCs, and CCCs) to develop and implement innovations that would improve overall student success and reduce existing equity gaps.

The competitive RFP resulted in four project awards between $1.2 million and $1.4 million each and an additional grant award of $500,000 for a cohort facilitator to foster collaboration among the Grand Challenge cohort over a three-year period. All five grants being implemented are slated to conclude in summer 2024. Due to the pervasiveness of the calculus barrier and broad potential for innovation, Learning Lab invited select applicants with projects that had not received full awards yet with evidence of success to apply for $100,000 prototype grants to develop and pilot an aspect of their proposed calculus innovations. Four prototype awards were made to intersegmental teams to implement their projects over roughly a year and a half. The evaluations for these prototype grants are included in this report and are summarized in the table below. Please note that projects are listed by their abbreviated titles. Full project titles and more project information are included in Appendix C.

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Calc-Boost</td>
<td>CSU San Marcos</td>
<td>Increase pass rates in Calculus II via an inter-semester bootcamp, with particular focus on supporting students who received a B- or lower in Calculus I.</td>
</tr>
<tr>
<td>Grading for Growth in Calc</td>
<td>CSU Monterey Bay</td>
<td>Implement Standards Based Grading (SBG) in the calculus curriculum and create aligned Canvas materials and professional learning to support SBG.</td>
</tr>
<tr>
<td>Realistic Tasks in Calc</td>
<td>CSU Long Beach</td>
<td>Develop homework tasks rooted in community-relevant real-world data and embed the tasks in an open source online learning platform.</td>
</tr>
<tr>
<td>Mobile Friendly Calc</td>
<td>Bakersfield College</td>
<td>Create an openly licensed, mobile-friendly online calculus course shell that would include active learning and humanizing approaches.</td>
</tr>
</tbody>
</table>

In addition to improving calculus success and persistence, projects also sought to reduce gender and racial equity gaps at their institutions, and in some cases, improve associated measures such as confidence and sense of belonging. The four funded innovations were all designed to respond to known sources of STEM success and/or persistent inequity at the participating institutions, all of which are federally recognized as Hispanic Serving Institutions in which 25% or more of the full-time undergraduate population identify as Hispanic/Latinx and 50% qualify as low-income. Calc-Boost responded to data showing that women and students from underrepresented backgrounds at their schools pass calculus at significantly lower rates than non-URM students and men, that men advance in the calculus sequence at higher rates irrespective of performance, and that students with lower grades in Calculus I were less likely to pass Calculus II. Grading for Growth was based on research that showed that Standards Based Grading leads to increased success across all groups, particularly URM students. At the partner institutions collaborating on Realistic Tasks in Calculus,
Intervention Types

All interventions included a curricular component as well as professional development to support faculty implementation. Calc-Boost modules included problem-sets and group activities designed to both cover math content and support affective domain components such as study skills, understanding of how we learn, and growth mindset. Problem sets were developed by faculty to cover the concepts their students needed the most support with. Grading for Growth included standards, assessment plans and grading schemes, aligned assessments, teaching resources, syllabi, and a Canvas shell. The teaching resources included a Canvas module introducing students to SBG and its relationship with equity, modules for each concept/textbook chapter, and an interactive checklist of learning outcomes. Realistic Tasks in Calculus included homework activities created in the web-based math homework system, WeBWorkK. Mobile Friendly Calculus included a course shell, a faculty resource module, and “just-in-time” faculty development supporting equity practices throughout the course. Components of the course included 10 mobile-friendly calculus modules with guidelines for how to adopt in either eight-week or 16-week courses, 19 culturally-responsive videos for students, and 10 just-in-time professional development videos. The Mobile Friendly Calculus course design was in part based on focus group interviews with students and faculty that examined how mobile devices were used by students for their classes and what student and faculty needs were.

Across all four funded projects, curricular materials were piloted with students. In addition to the curriculum itself, Calc-Boost participants also had trained peer tutors and follow-up peer mentoring during Calculus II.

Defining and Measuring Success

Both quantitative and qualitative measures were used to gauge student success after participating in classes using curricula developed through these grants and to gain insight on student perceptions and attitudes. Quantitative measures of success from pilot studies included:
- Pass rates of student participants (Calc-Boost, Mobile Friendly Calculus),
- GPA and mastery of learning targets from student participants (Grading for Growth), and
- Quantitative data derived from survey measures of attitudes and perceptions related to real-world and future relevance of calculus, and overall enjoyment of the calculus course for student participants (Realistic Tasks in Calculus).

Some projects formed focus groups to gather information on the perceptions of mobile learning (Mobile Friendly Calculus) and student perceptions of the real-world relevance of calculus, experiences and perceptions of learning calculus through modeling and applied contexts, student understanding of how to apply calculus to real-life contexts, and student understanding and enjoyment of calculus (Realistic Tasks in Calculus). Calc-Boost also conducted interviews with student participants and peer educators.

Overall, these measures showed mixed outcomes. There were issues with recruitment for some projects. Calc-Boost's small number of pilot participants versus non-participants made it challenging to interpret intervention effectiveness. The project also found that students who had not taken Calculus I the semester immediately before taking Calculus II had low pass rates regardless of whether or not they participated in Calc-Boost, further contributing to the difficulty in drawing conclusions on the intervention’s impact. Pass rates between
Calc-Boost participants and non-participants were not statistically different. Notably, however, all 10 students who participated in Calc-Boost at CSUSM and received B or C grades in Calculus I passed Calculus II, a positive outcome given that the project team was particularly interested in improving Calculus II outcomes for students who received grades between a B- and C-. At Calc-Boost’s partner institution, only one of the four students who had participated in Calc-Boost and passed Calculus II was a student who had received a B- or C- rather than a higher grade in Calculus I. Participant qualitative feedback however was positive overall, though students indicated a desire for a longer program. Mobile Friendly Calculus also struggled with recruitment. The project only had partial implementation of their curricular materials in pilot classes, as it was reported that finding faculty who could implement the curriculum was difficult and, in some cases, faculty were only able to implement certain components of the course. The pass rate for calculus courses where the Mobile Friendly Calculus intervention was implemented at the host institution was not statistically different than the college’s overall pass rate. However, at one partner institution, San Diego City College, all 18 students in the pilot passed Calculus I, while the typical college success rate is 35%.

Grading for Growth’s data was more conclusive. Grades were significantly higher for students in Calculus I sections using SBG compared to past grades during in-person semesters. This remained true when disaggregating based on gender, URM, first generation status, and math preparedness. However, while all students had higher grades, existing equity gaps based on gender, URM, first generation status, and math preparedness did not narrow either in grades or standard achievement. Of note, this pilot implementation inspired a great deal of interest in SBG implementation; fifteen other faculty members have implemented SBG and there is interest in expanding to other STEM disciplines. Survey data for Realistic Tasks in Calculus’s outcomes were also more conclusive. Their survey data indicated overwhelmingly positive response from students in the utility and value of the tasks in helping them see how calculus topics can be used for understanding the world and envisioning using the concepts learned in their everyday life. The positive response was particularly notable given that both pilot and non-pilot students agreed that the realistic application tasks were harder than other calculus tasks. Students believed though these tasks were more difficult, they deepened their understanding of the concepts and were more memorable.

“For many students, the perception changed from ‘I cannot learn or excel’ to ‘I need to find my own learning pace to excel and achieve greater learning’. That shift made it possible for students to seek more feedback in a low stake environment and created opportunities for growth in an atmosphere that promotes equity and inclusion in the classroom.”

– Grading for Growth in Calculus Final Evaluation Report

Barriers and Mechanisms of Success

Across all funded projects, grantees pointed to collaboration as one of the most valuable elements in the design and implementation of these innovations, including collaboration across institutions and collaboration between faculty, administration, instructional designers, and students. Professional development initiatives, such as communities of practice, had positive impacts on faculty understanding of and engagement with equity as it applied to classroom practices.

Particularly notable was the importance of having student and faculty input before or during curriculum design. In the case of Calc-Boost, project leaders highlighted the role of peer tutors, who tested the curriculum and gave feedback before it went out to bootcamp participants. The Mobile Friendly Calculus team found student and faculty focus groups to be valuable not just to their own course design process, but also to the field of mobile-course design more broadly. While wide collaboration was highlighted as an extremely positive component of the grant process, it could present challenges, such as increased...
development time when different technologies or learning management systems were used on different campuses. More than one project also noted the importance of having faculty who would implement curriculum be involved in the development of curricular materials, but challenges were noted including the time intensive nature of course development and the fact that Calculus I instructors are often not full-time faculty.

Finally, while all projects made an effort to use openly-licensed platforms and textbooks, this could present an obstacle to implementation and adoption. At some institutions, textbooks are chosen at the department level and thus selection of materials is out of the control of individual faculty, and in some cases, faculty needed components of a previously used online platform that were not available in the openly licensed platform.

VI. Common Issues and Lessons Learned

Taken all together, several trends and lessons can be gleaned from the Learning Lab’s first set of concluded projects. Nearly all grantee teams stated that collaborating widely—across segments, disciplines, and with external experts—strengthened their projects. It contributed not only to the creation of stronger course content and communities of practice, but it increased understanding of the institutional contexts and student populations in other segments. However, because the logistical and administrative burden of doing so was high, additional guidance and strategies for promoting buy-in, gaining administrative support, and building upon existing campus and community partnerships and resources would be helpful for grantees.

Related to this, variations in institutional policies and practices created some complications for intersegmental teams. Differences in degree of instructor autonomy sometimes influenced recruitment, as some instructors were interested in adopting new approaches or materials but either did not have the capacity to (in the face of pressure to cover a large amount of content) or could not due to the fact that materials required departmental or institutional approval. Variations in course formats (quarters vs. semesters, the integration of labs or teaching support/assistance or lack thereof, and class sizes) created additional considerations and alterations when adopting curricular content to other campuses.

Differing IRB requirements (and total lack of on-campus IRB offices and other research support for most of the CCCs) created confusion and added to administrative and logistical delays. To better understand and provide useful guidance to grantees about the IRB approval process, Learning Lab commissioned an IRB research brief from SRI International, an independent nonprofit research institute, which will include identification of issues that create barriers for Learning Lab-funded grant projects. This brief is forthcoming, but some of the key issues and recommendations based on the preliminary findings are summarized in the table below.

<table>
<thead>
<tr>
<th>COMMONLY CITED ISSUES WITH IRB</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reconciling differences between institutions; lengthened administrative time</td>
<td>Learning Lab could take initiative to build IRB relationships across the state to implement improvements, convening research officers from the UC, CSU, and CCC systems to build relationships and discuss ways to potentially have common agreements about IRB expectations and processes.</td>
</tr>
<tr>
<td>Difficulties with data collection and data collection requirements</td>
<td>Data sharing across California’s higher education systems should be enabled. Over time, Learning Lab could position itself as a hub with a multi-institutional data sharing agreement in compliance with proper privacy protection principles for study subjects.</td>
</tr>
</tbody>
</table>
COMMONLY CITED ISSUES WITH IRB

<table>
<thead>
<tr>
<th>COMMONLY CITED ISSUES WITH IRB</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of preparation and knowledge of IRB process</td>
<td>Learning Lab could provide IRB guidance, training, and supports for awardees who have no knowledge about, or experience with, IRB. This includes clear parameters about IRB purposes and expectations for projects, such as which partners must pursue IRB, and suggestions about how to navigate if all institutional partners require IRB approval.</td>
</tr>
</tbody>
</table>

In executing their projects, several grantee teams cited more clearly defined roles, stronger organizational and planning structures, and stricter routines and meeting schedules from the beginning would have been beneficial. Some grantee teams expressed the great utility of a dedicated project manager or administrative assistant, or a wish that they had they hired one to help alleviate the burden of labor. Similarly, communities of practice were consistently characterized as productive and crucial for supporting faculty that are often overburdened and burned out, but developing these required significant concerted effort, robust planning, clear targets, and structures of accountability. In terms of recruitment, which was a concern for most projects, early and multifaceted planning across varied communication pathways was highlighted as crucial.

Providing scaffolding, support, and more thorough explanations of expectations for students was also noted by several grantee teams. Students are not always receptive to active learning or other classroom strategies that are unfamiliar to them. Clearly setting up expectations for students around new material can assist in ameliorating this wariness. Several projects also implemented peer learning structures (student teachers, embedded tutors, and learning assistants) along with new course material, which saw great success. Sustained support and institutionalization of these programs would help students transition into new classroom approaches and benefit students overall.

Providing robust scaffolding and support for faculty is also essential. Several grantee teams stated that they encountered fellow instructors who were interested or wanted to improve their teaching practices, but were not necessarily ready to do so, were uncomfortable with certain pedagogical innovations, or needed help with the “how” and pragmatic guidance on where to start. Workshops can help train faculty, but sustained engagement, knowledge sharing, and step-by-step scaffolding on how to implement changes can assist in recruiting faculty that are initially resistant but interested.

How to sustain programs beyond the grant term is a common concern. For example, while stipends encourage initial participation in faculty professional development programming, continued engagement remains an issue. Professional development is required “work” for faculty, but they are not necessarily recognized or rewarded for it, experimenting with new teaching methods is often not encouraged, and faculty are generally pressed for time. Faculty incentives also function differently between the segments; faculty are rewarded for research at the UCs, while the CSUs and CCCs are teaching-centric. Differing levels of compensation for research or professional development activities between the segments (often higher at the UCs than at the CSUs and CCCs) is an equity concern that can cause lower levels of engagement at institutions with weaker financial support. Course release time, structured institutional supports, and dedicated collaborative time could help encourage continued engagement.
VII. Conclusion

Range of Outcomes and Assets

Results from the majority of these 28 projects were generally positive and promising in terms of student and faculty response to materials and overall improvement in outcomes. In some cases, results were variable across institutions, or there was no clear evidence of whether there had been any impact on student outcomes or narrowing of equity gaps. The extent of impact of confounding variables related to COVID on these uncertain outcomes and conclusions is not fully understood. The table below shows a summary of selected project outcomes; these examples were chosen to illustrate a representative range of outcomes (from clearly positive to mixed), educational segments, and geographies.

<table>
<thead>
<tr>
<th>SHORTENED PROJECT NAME</th>
<th>OUTCOME TYPE</th>
<th>EVIDENCE OF OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAM-C</td>
<td>Positive</td>
<td>As the implementation level of the project’s Big Ideas Framework increased, so did student grades; Big Ideas Framework positively made an impact on student outcomes for all students, with more positive outcomes for URM students than non-URM students.</td>
</tr>
<tr>
<td>Creating Pathways in Computing</td>
<td>Positive</td>
<td>More diverse students have either switched their major to data science (DS), decided to take more DS courses, or are planning to pursue a DS minor.</td>
</tr>
<tr>
<td>Increasing Student Flow</td>
<td>Positive</td>
<td>Large, durable increase in community college transfer students to UC Merced; continued growth of numbers in access of the project’s PPM tool/website.</td>
</tr>
<tr>
<td>Reorienting Formative and Summative Assessment</td>
<td>Positive</td>
<td>Percentage of students who would have otherwise failed had they not been allowed to re-take assessments was higher for URM students than for women, and higher for women than for majority-group students; significant gains in student learning outcomes for URM students, with every URM student group achieving a 3.0/B-average for the first time in the history of the class. An increase in Latinx student enrollment upon offering PQGs was observed, from 9% to 24%, as well as women student enrollment, from 52% to 72%.</td>
</tr>
<tr>
<td>GOALS in CS</td>
<td>Mixed/inconclusive</td>
<td>In the 5 semesters where outcomes for GOALS in CS was tracked, students experienced higher academic success and retention rates, but not at statistically significant levels.</td>
</tr>
<tr>
<td>STEM Success</td>
<td>Mixed/inconclusive</td>
<td>Quantitative data indicated that the intervention shifted students away from a fixed mindset and positively impacted the studying behavior of over 70% of students in the experimental sections; however, analysis on DFW rates was limited due to small numbers of participants.</td>
</tr>
<tr>
<td>Supporting Student Learning</td>
<td>Mixed</td>
<td>Pre- and post-intervention measures were taken to gauge student spatial skills and learning gains. Results showed little to no difference. However, this project could not implement the originally designed experiment due to various factors and statistical analysis was underpowered due to small sample sizes. Outside of the project’s experiments, the developed materials were implemented in classes at CSU Northridge, where the results were improved.</td>
</tr>
</tbody>
</table>

Learning Lab-funded projects are required to produce resources and materials that will be accessible as OER, as noted previously in this report. Across all 28 projects, OER assets were wide-ranging, including assets such as: Canvas course shells with student-facing curriculum; Canvas professional development course shells or modules; Jupyter coding packages; online instructional toolkits; course modules in other formats;
new curriculum featuring group-worthy tasks, collaborative activities, and project-based activities; interactive videos; interactive simulations; an augmented reality application; mobile and web-based games; faculty guidance on pedagogical strategies and best practices for CoPs; and more. Further, this was complemented by publications in professional journals and presentations at nationwide higher education conferences over the past few years. Learning Lab’s website currently includes links to many of such assets on respective project pages.

Looking Ahead

Learning Lab is taking several steps to support sustained adoption, sharing, and scaling of produced assets and encourage further iteration. Learning Lab is currently developing an online database repository to house and allow retrieval of project assets for the Learning Lab community and beyond. This repository, called the Learning Lab Asset Database (LLAD), will allow for the tagging and classification of discrete curricular assets and easy searchability and navigation of materials to cater to diverse use-cases for faculty, instructors, and potentially students, while adhering to the principles of OER.

To build upon the momentum of project accomplishments and the leadership of faculty teams, Learning Lab subsequently released the competitive “Scaling Success” RFP in 2021. The overall goal of this RFP was to advance the projects with the most evidence of success and scaling potential to expand the positive impact and benefit for all students pursuing or interested in pursuing STEM education and careers. Seven Learning Lab grantee teams received between $200,000 and $700,000 to support the design and implementation of scaling efforts, and activities are currently ongoing. The Scaling projects are summarized in the table below.

<table>
<thead>
<tr>
<th>INITIAL GRANT</th>
<th>INITIAL GRANT AMOUNT</th>
<th>SCALING SUCCESS GRANT</th>
<th>SCALING SUCCESS GRANT AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing Students’ Identity and Self-Perception as Capable STEM Thinkers and Learners</td>
<td>$1,300,000</td>
<td>Shifting Faculty Mindsets to See ALL Students as Capable STEM Thinkers and Learners</td>
<td>$650,000</td>
</tr>
<tr>
<td>Eliminating Equity Gaps in Online STEM Gateway Courses through Humanized Instruction</td>
<td>$1,300,000</td>
<td>Scaling Humanized Online Teaching in STEM</td>
<td>$700,000</td>
</tr>
<tr>
<td>Bay Area Math Collaborative</td>
<td>$200,000</td>
<td>EMAP: Equitable Math Assessment Project</td>
<td>$385,000</td>
</tr>
<tr>
<td>Reorienting Formative and Summative Assessment Towards Mastery Learning for Learner Success, Student Equity, and Institutional Resilience</td>
<td>$650,000</td>
<td>As’s-for-All (A4A): Scaling Mastery Learning Through Technology, Advocacy, Policy, and Partnerships</td>
<td>$650,000</td>
</tr>
<tr>
<td>Social Online Tools to Support Collaborative and Inclusive Learning in Biology</td>
<td>$100,000</td>
<td>Social Tools for Bio: Communities of Practice</td>
<td>$400,000</td>
</tr>
<tr>
<td>Equity and Access in Discrete Mathematics</td>
<td>$100,000</td>
<td>Expanding Equity and Access in Discrete Mathematics</td>
<td>$650,000</td>
</tr>
<tr>
<td>Increasing Student Flow and Success Along Intersegmental STEM Program Pathways</td>
<td>$500,000</td>
<td>Clarifying and Communicating Engineering and Computer Science Transfer Pathways</td>
<td>$350,000</td>
</tr>
</tbody>
</table>
The initial 28 projects funded by Learning Lab were undertaken during a time of unprecedented upheaval and challenges in the educational landscape. Grantee teams adapted to changes and faced them with determination and fortitude, pivoting in creative ways to address unanticipated educational contexts. These projects impacted thousands of instructors and students, tested new approaches to teaching and learning, advanced efforts to improve teaching methods and measure the effectiveness of these interventions, and created student- and faculty-facing Open Educational Resources. Valuable lessons have been uncovered from these efforts to improve student learning, which will continue to inform future Learning Lab projects and Learning Lab’s efforts to support instructors and students across the state.
Appendix A: Learning Lab RFP Descriptions

**Innovation grants** supported projects that proposed to develop curricular and pedagogical innovations aimed at students in lower-division STEM courses.

**Demonstration projects** applied for Innovation grants, but received a lesser award based on their perceived state of readiness.

**Professional Development grants** supported the creation, refinement, or expansion of faculty professional development programs that aimed to improve learning outcomes and close equity gaps in undergraduate STEM courses.

**Seed grants** supported project teams in the early stages of project design. Examples of concrete deliverables from these grants include, but are not limited to, proof-of-concept testing, data collection and analysis, or development of pedagogical/curricular resources.

**Institutional Change grants** supported efforts to reduce institutional barriers and/or foster institutional contexts to advance undergraduate STEM success, improve online and hybrid course environments, and close equity gaps for students.

**Grand Challenge Prototype awards** were granted to applicant teams that submitted promising Calculus Grand Challenge proposals but did not receive a full award. These teams submitted revamped, condensed proposals to develop a prototype of their project for which they could receive a lesser award over one year. Projects were aimed at contributing important knowledge and understanding of how to support student success in the Calculus course sequence for STEM majors.

Appendix B: Terms and Definitions

**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.” In order to have the potential for large-scale impact, Learning Lab understands adaptive learning technologies 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 produce better learning outcomes across the broad range of students.

**Equity Gap** refers to racial and gender 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, we can understand equity gaps, in part, as the achievement gaps that opportunity gaps created. Our preferred term is to use equity gap, rather than achievement gap, in order to keep the focus on the multiple barriers to educational success, rather than on student performance alone.
Host Institution refers to the college or university that will act as grantee and fiscal intermediary for purposes of grant administration. The host institution will enter into a grant agreement with the Foundation for California Community Colleges for receipt and management of grant funds and will distribute funds to the partner institutions based on sub-award agreements. The designation of an institution as “host” is for grant administration purposes only. Learning Lab expects awarded projects to exhibit meaningful, well-balanced collaboration among partner institutions, i.e., all the institutions involved in the project.

Online/Hybrid Learning Environments. Learning Lab also 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. Hybrid courses or blended courses are those that use both “online” and in-person interactions as part of the formal course environment or requirements. Hybrid courses allow some component of the course to be available or accessible in an online environment. For the purposes of this RFP, a course does not have to be officially designated by the institution or department as “hybrid” to be eligible for Learning Lab grant funding, so long as it conforms to the definition above.

Science of human learning, also referred to as 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 more10, 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 collaboration11. 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 learning12. Scaffolding, inquiry or problem-based learning, collaborative learning, game and simulation-based learning, and 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 equity gaps—we view such equity gaps as invitations to apply the science of learning in new or improved ways.

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. For the purposes of Learning Lab, as public higher education strives 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.

Appendix C: Project Summaries

Note: Mechanics of Inclusion and Inclusivity in Mechanics (from the 2018-2019 Improving Equity, Accessibility, and Outcomes for STEM Gateway Courses cohort) submitted a final evaluation but has not formally closed at the time this synthesis report was prepared. The project team was granted an extension until August 2024. It is currently conducting additional demonstration and data collection activities and will produce an addendum to their final evaluation. Because of this, it has been excluded from the project summaries that follow. Additionally, Learning Lab does not require the submission of raw evaluation data. Relevant quantitative figures, such as sample sizes or the number of respondents to surveys, are included below when available in grantee final evaluation reports.

Footnotes
12 Ibid.
### The Better Book Project

**Shortened Project Name:** Better Book Project  
**Host Institution:** UCLA  
**Partner Institution(s):** CSU Los Angeles & LA Pierce College  
**Award Amount:** $1,300,000

#### PROJECT GOAL(S)

Develop, implement, and continuously improve an online interactive textbook for introductory statistics, based on learning science theories of how people develop deep understanding in complex spheres of knowledge; to develop flexible and transferable knowledge—i.e., deep understanding—in all students.

#### INTERVENTIONS

- Improved online interactive statistics textbook to increase engagement with students on deep conceptual structure of statistical modeling with heavy emphasis on simulation, randomization, and bootstrapping as tools for both doing data analysis and understanding statistical ideas.
- Created replicable R&D model engaging researchers, designers/developers, and instructors in scaling and improvement of the book and its implementation.
- Provided PD programming, onboarding, and developed CoP: on-going support of instructors using curriculum, study groups, workshops, daily office hours, and a Slack channel.
- Created implementation guides: Jupyter notebooks for in-class lesson plans, both student facing and complete versions.

#### IMPACT/OUTCOMES

- Content development/improvement and professional development: started at Version 1.0, now on Version 5.0 and with six iterations of the textbook (3 for college, 3 for high school), with complete set of curated Jupyter notebooks for in-class lessons, quizzes, and student projects.
- Improved student performance across all partner institutions; improved transfer performance (see below).
- Improved student mindset.
- Materials are now being used at 23 colleges and universities in the US and abroad and the numbers are increasing each year; also being used at 20+ high schools.
- See methods section below for additional data.

#### DATA COLLECTION / EVALUATION METHODS

- Collected data on student performance/outcomes in piloted courses (based on percent correct of end of chapter questions and transfer performance, i.e., the ability to apply learned concepts to more advanced stats problems not directly learned from material): data indicated differences across institutions, with UC students outperforming CSU and CC students, though performance in all three groups showed decline as topics become more advanced; in transition to remote learning during COVID shelter-in-place orders, performance at UC and CC increased, performance decreased at CSU; high scores for transfer performance, with 53% of students giving completely correct responses on assessment questions.
- Survey data on student mindset (over 2,500 participants): concerns about understanding concepts, lack of prior knowledge, performance, and time management, fixed mindsets and anxiety declined from the beginning to the end of the term.
**Community Sourced, Data-Driven Improvements to Open, Adaptive Courseware**

**Shortened Project Name:** Community Sourced DDI  
**Host Institution:** Rancho Santiago Community College District  
**Partner Institution(s):** CSU Fullerton & UC Berkeley  
**Award Amount:** $1,300,000

### PROJECT GOAL(S)

Improve outcomes for STEM learners in targeted courses by deploying and improving open, adaptive courseware (e.g., Open Learning Initiative (OLI), Lumen Learning) that has been demonstrably effective in closing gaps and improving performance for underrepresented learners in STEM.

### INTERVENTIONS

- Integrated adaptive learning tools, learner-driven improvements, and faculty support.
- Implemented learning-by-teaching: students participated in developing and improving STEM learning resources.
- Developed open, adaptive STEM courseware and tools, improved using data to target underrepresented learners; included teamwork, collaboration, and effective conflict management strategies, self-regulated learning and other metacognitive skill development techniques within the courseware.
- Piloted interventions to improve uptake and effective implementation.

### IMPACT/OUTCOMES

- Held over 100 professional development workshops to train faculty on adoption, use, improvement, and customization of open, adaptive courseware; held office hours.
- Gradebook analytics showed increase in learner engagement over the semesters, improved performance in several chemistry, statics, statistics, and biochemistry courses.
- Development of courseware and tools: 32 faculty used and evaluated 14 courses, 9 faculty participated in improving materials; materials adopted by 32 faculty in chemistry, biology, physics, math, and engineering.
- Created 20+ learner-sourced activities, workflows, and open-source analysis scripts to assess the student-generated content.

### DATA COLLECTION / EVALUATION METHODS

- Collected data from observations, focus groups, interviews, surveys to identify barriers and facilitators for sustained adoption and effective use of innovations, insights into how data-driven improvement approaches can support or hinder learning.
- Conducted learning curve analysis using Gradebook analytics (of 3,210 students total) to help identify areas in need of improvement, assess engagement, and track student performance (instructors worked with learning engineers to analyze learning curves).
# Giving Ownership of Active Learning to Students in Computer Science

**Shortened Project Name:** GOALS in CS  
**Host Institution:** CSU San Marcos  
**Partner Institution(s):** MiraCosta College  
**Award Amount:** $1,038,048

## PROJECT GOAL(S)

Address the low passing rates of students in introductory Computer Science (CS) classes by implementing 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.

## INTERVENTIONS

- Conducted skill mapping; developed hybrid curricula integrating active learning and culturally responsive content, refined, and implemented.  
- Created faculty learning community (FLC).  
- Built a variety of student-focused and selectable modules in the Open Learning Initiative (OLI) framework that are adaptive to students' personal characteristics, background contexts, and learning experiences.  
- Implemented online modules with learning goals assigned and assessed throughout the week.  
- Included weekly face-to-face lab activities that engaged students in project-based learning and helped students navigate and better understand the discipline of CS.

## IMPACT/OUTCOMES

- Experienced higher academic success and retention rates over the 5 terms in which outcomes were tracked, but not to statistically significant degrees; results possibly confounded by COVID policies (diminished use of letter grades, increased options for pass/no-pass).  
- Increases in student self-efficacy, engagement, and validation compared to non-participants, especially for students of color and women.  
- Increases in faculty effectiveness in facilitating active student learning, recognizing early signs of warnings for students who struggle, adoption of meaningful culturally relevant content, and offering appropriate interventions to help students excel; high retention rates in FLC.

## DATA COLLECTION / EVALUATION METHODS

- Collected faculty survey data: gauging effectiveness in facilitating active student learning, recognizing early signs of warnings for students who struggle, adoption of meaningful culturally relevant content, and offering appropriate interventions.  
- End of semester surveys administered to students in the re-designed courses (351 students total) and non-redesigned courses (45 students total) to assess student social-emotional success; conducted Pearson's chi-square analysis to gauge significant patterns.  
- Collected ethnographic fieldnotes, qualitative interviews to assess faculty effectiveness; conducted Dedoose qualitative analytics and quantitative analysis of data.  
- Tracked data on FLC retention rates and engagement/attendance in sessions.  
- Conducted SPSS analysis to compare averages of success and retention rates across all the GOALS in CS participants versus non-participants.
**Developing Students’ Identity and Self-Perception as Capable STEM Thinkers and Learners**

**Shortened Project Name:** Developing Students ID  
**Host Institution:** College of Marin (COM)  
**Partner Institution(s):** Diablo Valley College (DVC), Sonoma State University (SSU), UC Berkeley  
**Award Amount:** $1,300,000

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<th>PROJECT GOAL(S)</th>
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<td>Design materials to help both instructors and students see science as an expansive and inclusive set of practices; utilize project team’s collective expertise and research in the learning sciences to: develop group-worthy equitable in-class activities and complementary social supports to empower students to recognize and develop their talents by practicing science; and empower faculty to build an inclusive classroom climate.</td>
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<th>INTERVENTIONS</th>
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| - Developed STEM Learning Community (LC).  
- Developed collection of content modules and Data Tasks grounded in data analysis and critical thinking, with group worthy practice centered tasks.  
- Developed faculty workshops to demonstrate how to bring about shifts in student mindset, enhance a sense of belonging in STEM, and improve student learning outcomes in authentic scientific practice. | - At SSU: reduced GPA differences between USM and NUSM students; USM DFW rate decreased by 13%, no trend in the DFW rate for NUSM students.  
- At DVC: increases in retention rates and success rates (A, B, C, or passing).  
- At COM: STEM LC Coordinator position given full funding by district; STEM LC institutionalized and integrated into the student campus culture.  
- Across institutions: increases in student confidence and ability to understand difficult concepts, intellectual courage, sense of belonging; increased faculty understanding of achievement gaps in the classroom and systemic inequities, faculty willingness to change pedagogy by incorporation of the student-focused modules; preliminary indicators show students using these materials in intro chemistry did relatively well in an immediately subsequent chemistry course.  
- Across institutions: 250+ students enrolled and participated in in-person and digital learning support activities; 80 students signed up and participated in one-on-one mentoring with STEM LC support faculty; network of 23 faculty piloting the curriculum reached over 1,300 students.  
- Across institutions: collaborated with other LCs; embedded tutor program and peer mentors program launched; fostered faculty support/buy-in (faculty participation at events, positive student referrals); hosted virtual STEM LC events. |

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| - Collected data on student learning outcomes: DFW rates, GPA, and retention rates (for 88 students at SSU, 2,535 students at DVC).  
- Student reflections and mindset survey data: Science Skills Development Tracker (SSDT) to gauge ability to bounce back from setbacks, diligent skepticism, intellectual courage, collaboration, making connections, and team pulse; final course reflection assignment; pre- and post-semester surveys to gauge sense of belonging; self reports/reflection of STEM capability; changes in career/academic majors.  
- Data on faculty perspectives and mindset: gathered via self-assessment surveys before and after professional development program and Quality Learning and Teaching Instrument (QLT) survey. |
## Eliminating Equity Gaps in Online STEM Gateway Courses Through Humanized Instruction

**Shortened Project Name:** Humanizing Academy  
**Host Institution:** Foothill-DeAnza Community College District  
**Partner Institution(s):** Humboldt State University, Modesto Junior College, UC Irvine  
**Award Amount:** $1,300,000

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<td>Implement 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; to explore 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 underrepresented minority students.</td>
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| • Developed, piloted, revised 6-week PD course with subsequent scaling/expansion; course blended culturally responsive teaching with eight research-based inclusive course design elements (liquid syllabus; humanized homepage; getting to know you survey; warm, wise feedback; self-affirming ice-breaker; wisdom wall; bumper video; microlectures); shared materials.  
• Created CoP. |

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| • 90 participants applied from 8 schools: 81 signed up, 79 completed (98% success rate).  
• Faculty show a significant increase in: confidence in teaching online, perceptions of the role that an instructor plays in closing equity gaps, awareness of the differences students bring to a class, willingness to intentionally accommodate student differences, self-awareness, efficacy in supporting students, satisfaction with PD and digital fluency, flexibility with course policies and grading, and intentionality about being approachable.  
• Students reported high levels of satisfaction with sense of belonging, instructor-student relationships, teaching presence, social presence, attitudes towards online learning.  
• Continuation of CoP and application of concepts: 16 alumni have regular meetings; participants reported using elements from Academy in their courses.  
• Materials shared to Canvas Commons, public website and toolkit created.  
• Held online summit. |

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<td>Collected data via instructor participant surveys, longitudinal interview data, student surveys (1,424 respondents total), and student focus groups on: impact of intervention on faculty perceptions and online teaching behaviors; instructor application of Academy concepts in their courses; experiences of students in humanized online STEM courses; engagement with shared materials (view counts, download counts, toolkit requests, summit attendees).</td>
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Demonstration Grants

**E-Games for Active Training in Engineering Design**

Shortened Project Name: E-Games  
Host Institution: UC Davis  
Partner Institution(s): American River College & CSU Sacramento  
Award Amount: $500,000

### PROJECT GOAL(S)

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; hypothesized that games offer an avenue for exploration that sparks student creativity, increases engagement with the material, promotes self-confidence, and allows the implementation of “hands-on” design training at relatively low cost to students.

### INTERVENTIONS

- Developed two multi-level interactive e-games, Space Zoologist and Corporate Cavalry, to capture student engagement through experiential learning of engineering design (with embedded assessments); providing practice in engineering design and team work.
- Developed toolkit for instructors with sample activities, quizzes, survey instruments, mid and end program assessments, performance charts and rubrics.
- Developed survey to determine assessment methods most beneficial and least biased according to students.

### IMPACT/OUTCOMES

- Increased student engagement.
- Increase in student confidence/ability to solve problems and understanding of engineering design process.
- Some indications that game positively affected student self-confidence and identity as an engineer and increase in degree of commitment to major pre- and post-intervention, but no difference between demographic groups.
- Positive student feedback: students felt game was inclusive and enjoyable to play.
- Expanded community: games now being used by non-engineering faculty.
- See methods section below for additional data.

### DATA COLLECTION / EVALUATION METHODS

- Conducted pre- and post-game surveys and analysis on learning outcomes, user experience, confidence, enjoyability, and satisfaction (755 pre-game survey responses, 252 post-game responses for Space Zoologist; 81 post-game survey responses for Corporate Cavalry).
- Pre-game, understanding of steps of engineering design were random guess distributions; post-game, >78% of student correctly identified most steps; no significant difference for any group for confidence in ability to communicate with teammates or for confidence in giving instructions to team mates.
- Tracked time students spent playing game and utilization of various functions in Space Zoologist: students played Space Zoologist for an average of 2 hours, played sublevels not originally assigned, opened game’s research function an average 24 times for 44 minutes overall, indicating that game was engaging enough that students chose not to skip research and guess, but engaged with and read the material. Corporate Cavalry backend system to collect time tracking data was not fully complete at the time of reporting.
Building College-Level Number Sense with Adaptive Technology

Shortened Project Name: Building Number Sense
Host Institution: CSU San Bernardino
Partner Institution(s): Riverside City College
Award Amount: $499,721

## PROJECT GOAL(S)
To 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; develop course materials including video-based work examples and virtual tutor simulations with culturally relevant situations and examples; implement interventions to help students develop a growth mindset, improve persistence, and overcome stereotype threat.

## INTERVENTIONS
- Developed 10 modules of innovative, culturally responsive curriculum built on mastery learning framework, focusing on metacognitive skills with explanatory text, examples and solutions, and nonstandard problems that lead students to learn concepts.
- Covered the following topics: Estimating and Counting; Quantities and Units; Lengths and Measurement; Multiplicative Reasoning; Additive Reasoning; Spreadsheets and Other Computer Applications; Multiplying Rational Expressions; Dimensional Analysis; Rates; Advanced Percent.
- Integrated modules into LMSs for Early Start Math, algebra, math methods; defined use cases, piloted, received feedback.
- Held information sessions for interested instructors; optional one-on-one PD was available for one (out of two) groups of piloters.

## IMPACT/OUTCOMES
- Findings were limited due to issues with initial integration into Canvas, which put all assignments under a single category, hindering analysis of student growth and ability to track full module completion.
- Students were not using the materials for mastery learning as designed, but student feedback indicated modules were worthwhile.
- Majority of students agreed or strongly agreed with statement “Right now, I feel like this module was worth the time that I spent on it”.
- Feedback from participating faculty indicated usefulness of materials.

## DATA COLLECTION / EVALUATION METHODS
- Collected survey data for Math Methods (55 students total) and College algebra (44 students total) courses: gauging student engagement with modules, growth on content understanding, metacognition; 95% of Math Methods students and 61% of College Algebra students who completed modules agreed or strongly agreed with statement “Right now, I feel like this module was worth the time that I spent on it”, qualitative comments indicated content usefulness.
- Collected qualitative feedback from participating faculty and focus groups with piloters on student growth: feedback used to revise content; faculty feedback indicated belief that students engaging with the material as homework was a meaningful experience.
- Collected quantitative data on student use of piloted materials: not enough data points were available to complete quantitative analysis on student growth in content understanding.
## California Challenges in STEM Energy Education

**Shortened Project Name:** Energy Education  
**Host Institution:** CSU Bakersfield  
**Partner Institution(s):** Bakersfield College & Merced College  
**Award Amount:** $500,000

### PROJECT GOAL(S)

To introduce the concepts behind practical technical problems at the intersection of energy, water, and agriculture—problems relevant to the Central Valley where the host and partner institutions are located—into gateway STEM courses; implement a novel combination of two pedagogies, flipped classroom and Process Oriented Guided Inquiry Learning (POGIL), including pre-class student reading assignments, a highly structured in-class format, assigned student roles, and after class homework assignments.

### INTERVENTIONS

- Developed curricula: Flipped Classroom Enhanced Process Oriented Guided Inquiry Learning (FC-E-POGIL) and accompanying augmented reality (AR) app.
- Developed new engineering service-learning course, Human Centered Research and Design (UC Merced).
- Workshops for faculty PD; PD workshops for students as part of UC Merced course.

### IMPACT/OUTCOMES

- Higher mean scores for topics covered in AR app activity; showed potential for increasing knowledge gains from flipped classrooms.
- Significant differences in learning outcomes for first-generation and Latinx students, but no differences overall across all students following implementation of FC-E-POGIL; significant differences in learning outcomes across all students but no differences for first-generation and Latinx students following implementation of POGIL + AR.
- Human Centered Research and Design course now offered every semester.
- Significant differences in attitudinal constructs, intellectual accessibility, and emotional satisfaction; increased confidence in STEM related skills, learning communication skills; positive student response.
- See methods section below for additional data.

### DATA COLLECTION / EVALUATION METHODS

- Pre- and post-intervention ASCI V2 Chemistry Attitudinal Survey, Satisfaction with Chemistry Scale with paired samples t-test (96 respondents): no differences overall across all students, but higher outcomes in attitudinal constructs and satisfaction for first-gen and Latinx students compared to non-first-gen and non-Latinx.
- Implementing Student Excellence – A Unique Opportunity survey with paired samples t-test conducted for Human Centered Research and Design course (144 respondents): significant increases in student self-efficacy, confidence, content understanding, subject matter interest.
- DFW rates: decreased when compared to non-intervention section for gateway chemistry courses; however, there was no control group, so data was not used.
- Open-ended student survey: themes emerged from coding included “Really useful”; “Made it easier to learn”; “Helps to reinforce ideas/concepts”, indicating positive student response.
Seed Grants

*Equity and Access in Discrete Mathematics*

**Shortened Project Name:** Equity and Access in Discrete Math  
**Host Institution:** San Jose State University  
**Partner Institution(s):** San Francisco State University, College of Alameda, Evergreen Valley College, Foothill College, Hartnell College, Mission College, West Valley College  
**Award Amount:** $100,000

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**PROJECT GOAL(S)**

To address equity and access gaps in discrete mathematics by centering discrete math courses on activities such as group-worthy tasks and team-based adaptive learning in order to increase student sense of belonging and increase students’ course success.

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**INTERVENTIONS**

- Created lesson materials using team-based adaptive learning with multiple rounds of classroom testing and feedback.  
- Created assessments aligned with new lesson materials.  
- Designed and delivered instructor learning opportunities about how to use the activities and assessments.  
- Drafted reformed C-ID for discrete mathematics to facilitate organizational and institutional change.

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**IMPACT/OUTCOMES**

- High degree of student satisfaction with new materials and sense of belonging.  
- Implemented policy scaffolds to support the change via reformed C-ID for discrete mathematics, which will be proposed in upcoming state-level C-ID revision discussions.  
- Conducted feasibility study on the tested interventions to gauge four feasibility factors: technical, organizational, support, and usability. Determined organizational factors were above feasibility threshold, and as organizational and system change was a priority for the project, this was an encouraging result.

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**DATA COLLECTION / EVALUATION METHODS**

- Conducted student surveys to gauge belonging (student perceptions of the overall experience of working on math with others in small groups), access (student perception of pace of lessons), and satisfaction with course (216 respondents total).  
- Data on feasibility was gathered via surveys (of team members, instructors, students, classroom visitors), observations (of team dynamics and online classes), and document analysis and review (of team reflections, student-facing materials, instructor roadmaps, and student artifacts generated during lessons). Data was converted to a numeric score, with a threshold of 2.4 out of 3 indicating feasibility; technical, support, and usability factors were below threshold, organizational above threshold.
Coding Community: Inclusive Space for Programming Tutorials and Adaptive Learning

Shortened Project Name: Coding Community  
Host Institution: CSU Chico  
Partner Institution(s): UC Santa Barbara  
Award Amount: $100,000

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<td>Improve computer science education through the development of Coding Community, an online, inclusive, and hands-on tool for coding classes that connects a diverse population of students across different campuses; improve student retention in coding courses that historically have high attrition rates and empower students who otherwise may not feel confident that they are capable and welcome in coding courses.</td>
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<th>INTERVENTIONS</th>
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| • Created an online platform for minoritized students to share their perspectives on how coding relates to their lives.  
• Recorded videos with URM students demonstrating coding concepts that relate to their lives and interests.  
• Created integrated coding problems for interactive practice of concepts demonstrated in the videos.  
• Developed website that integrates the videos and coding problems. | • Significantly greater gains in affective outcomes among students in experimental group.  
• Data showed students were more likely to engage in both practice and videos when integrated than when offered separately.  
• Positive feedback from students on content usability.  
• See methods section below for additional data. |

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| • Conducted needs assessment: identification of topics/applications that provide equitable motivation, students’ interests.  
• Conducted pre- and post-surveys on student affective outcomes comparing students in classes with intervention (55 students total in experimental group) and students in classes without (161 students total in control group). Students in the experimental group had significantly ($p<.05$) greater gains in affective outcomes ($\Delta M=0.38$, $sd=0.47$) than those in the control group ($\Delta M=0.18$, $sd=0.47$).  
• Conducted study of student usage of videos and coding problems when presented separately, with follow-up study of videos and coding problems integrated (156 student participants total). 58.33% of students practiced less frequently than they watched videos in first study, 62.5% of students practiced at least as frequently as they watched videos in follow-up study.  
• Conducted usability study on students’ interaction to gather formative feedback to improve the website’s interface. |
# Social Online Tools to Support Collaborative and Inclusive Learning in Biology

**Shortened Project Name:** Social Online Tools  
**Host Institution:** CSU Stanislaus  
**Partner Institution(s):** UC Berkeley, Los Medanos College, Los Positas College, Diablo Valley College  
**Award Amount:** $100,000

## PROJECT GOAL(S)
Determine how adaptive technology and other online tools can be leveraged to provide a collaborative learning experience for students in Introductory Biology courses across the segments. The project hypothesized that providing a collaborative learning environment outside of the classroom will provide a space for students to externalize new information, build knowledge, develop their sense of belonging, and build critical study skills, thus reducing achievement gaps for minoritized students.

## INTERVENTIONS
- Developed activity flow pathway and design elements, including assessment (pre- and post-knowledge check questions), multimedia, graphic organizers, template, Google slides, scaffolded social interactions (roles), and online classroom activities to provide collaborative learning experience.  
- Iterated 2-3 times to improve, using feedback from instructors and review of student responses.

## IMPACT/OUTCOMES
- Increases in correct answers on pre- and post-activity knowledge checks, indicating activity effectiveness for student learning; positive evaluation of activities in terms of engagement and usefulness by students.  
- Faculty estimated students had better content understanding than in previous years and continued to use project materials in subsequent semesters.  
- See methods section below for additional data.

## DATA COLLECTION / EVALUATION METHODS
- Student surveys (59 respondents total): correct answers on content-based survey questions increased from 55% pre-activity to 88% post-activity. Self-reported understanding of content (Likert scale; “well” or “very-well”) increased from 43% pre-activity to 84% post-activity; 74% of students in Fall 2021 deployment reported activity was “very useful” or “extremely useful” in helping better understand the concepts, a large increase from Spring 2021 (38%).  
- Faculty feedback: reported better content understanding from students than in previous years; continued use of materials in subsequent semesters.
**STEM Success with Interactive Adaptable Learning Science Videos**

**Shortened Project Name:** STEM Success  
**Host Institution:** Butte College  
**Partner Institution(s):** UC Davis & CSU Chico  
**Award Amount:** $100,000

### PROJECT GOAL(S)

Address the problem of equity gaps and low success rates in introductory biology courses by developing, producing, and assessing two virtual lesson series with short, interactive and adaptable videos on the biology of learning and applying the science of learning to inform successful studying strategies.

### INTERVENTIONS

- Developed adaptive interactive video lessons for lower division anatomy course: content curated to foster student sense of belonging in the chosen STEM pathway, belief in self-success, and growth mindset.
- Each video lesson coupled with adaptable pre-built assignments, activities, and assessments that can be utilized by instructors in any LMS.

### IMPACT/OUTCOMES

- Majority of students in the treatment group reported changing their study habits as a result of the videos, using significantly less cramming than those in the control group.
- Students in the treatment group shifted mindset towards a growth framework and more readily associated learning with physical changes in the brain, a concept also discussed in the videos.
- Grades: differences between students participating in intervention and non-participant were not statistically significant.
- See methods section below for additional data.

### DATA COLLECTION / EVALUATION METHODS

- Collected data on DFW rates and grades (small study numbers limited ability to disaggregate data and conduct analysis).
- Grades: differences between student participants and non-participants were not statistically significant (p=0.171, T-test), but trend towards students in the experimental group doing better; however, this was likely attributable to higher incoming GPA of the group at the start.
- Conducted mixed-methods research study to assess the impact of the videos on student success and equity gaps: data from 7 experimental sections (102 students total) and 5 controls sections (70 student total), and conducted qualitative interviews with 32 students.
- Collected student survey data on science identity, self-efficacy, study practices, assessments on metacognition and motivation, fixed and growth mindset, using MSLQ: data suggest videos had significant impact on student study habits and fixed/growth mindset.
- 12 focus interviews conducted with 37 students, 23 from experimental sections, 14 from control sections: reported that their level of academic preparedness improved during the anatomy course; noted that they now felt a sense of belonging in science.
**Creating New Pathways to Computing**

**Shortened Project Name:** Creating New Pathways to Computing  
**Host Institution:** UC Riverside  
**Partner Institution(s):** Cal Poly Pomona & Riverside City College  
**Award Amount:** $100,000

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<td>To create a sequence of courses in data science that include online modules that aim to build bridges between data science and the physical sciences, the social sciences, the humanities, and the arts, modeled on established pedagogical approaches such as Project Based Learning (PBL); to address achievement gaps between majors, as well as achievement gaps across ethnic and gender identities in introductory computing courses.</td>
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| • Created a sequence of courses in data science (DS) that include online modules; focused on introductory computing course using Python, a gateway to DS and computing pathways for non-experienced students.  
• Implemented Project Based Learning (PBL) and inclusive curricula (using ADDIE framework to develop curricula): series of labs and assignments that introduced students to computing / data science using a data-oriented approach, utilizing instructor-defined real-data projects in the beginning and PBL assignments towards end of term. | • More diverse students either switched their major to DS, decided to take more DS courses, or are planning to pursue the DS minor since implementation.  
• Improvements in student perception of value, inclusivity, engagement, competence, and mastery goals.  
• Creation of DS minor at Cal Poly Pomona.  
• Creation of new second course in sequence at UC Riverside.  
• Riverside City College’s new course adopted by 2 other CCs. |

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| • Student pre- and post-intervention surveys (210 responses across all participating institutions): gauged student perception of value, inclusivity, engagement, competence, and mastery goals; data indicated increases for nearly all measures at statistically significant rate for all institutions except: Riverside City College, where enrollment was too low to show statistical significance; a marginal decline in competence was observed for one term at Cal Poly Pomona.  
• Conducted student panel for feedback.  
• Tracked DFW rates and enrollment by demographic. |
## PROJECT GOAL(S)

To design and determine effective online formative assessments and the associated feedback for online simulations presenting content about two fundamental introductory chemistry concepts: molecular structures and their properties; to run two experiments, one focusing on each concept, that would compare student learning gains between three distinct learning conditions: 1) simulation-based instruction using online formative assessments and online feedback; 2) simulation-based instruction using online formative assessments and in-person feedback; and 3) in-person classroom-type instruction.

## INTERVENTIONS

- Designed and evaluated innovative online formative assessments and associated feedback for online simulations on molecular structures and gas properties; designed and developed corresponding simulation-based and lecture-based instructional content with teaching notes.
- Conducted two experiments: Experiment 1, with students assigned to one of three learning conditions: Condition 1 - simulation-based instruction using online formative assessments and response-level feedback, Condition 2 - simulation-based instruction using online formative assessments and problem-level feedback, and Condition 3 - online lecture-based instruction using formative assessments and providing no feedback; Experiment 2, with students assigned to one of two learning conditions: Condition 1 - simulation-based instruction using online formative assessments and response-level feedback, or Condition 2 - simulation-based instruction using online formative assessments and problem-level feedback.

## IMPACT/OUTCOMES

- Developed instructional materials and assessments that can be used by general chemistry instructors; materials are now being used by high school teachers.
- Pre- and post-experiment measures showed no statistical significance in learning gains between the tested learning conditions; however, statistical analysis was underpowered due to small sample size.
- Subsequently implemented materials in classes at CSU Northridge; reception from students overwhelmingly positive, with significant learning gains demonstrated pre- and post-intervention.
- See methods section below for additional data.

## DATA COLLECTION / EVALUATION METHODS

- Measured pre- and post-intervention learning gains using Mental Rotations Test to gauge student spatial skills. Results showed little to no difference.
- In Experiments 1 and 2, regression analyses did not reveal any differences in learning gains between learning conditions or difference in learning gains between URM and non-URM students. After controlling for pretest score and spatial skills score, regression analyses revealed that there was a marginal effect of URM status on post-test performance (beta = -0.38, p = 0.06). Students from URM backgrounds performed worse on the post-test (M = 14.64) than non-URM students (M = 16.86), regardless of their assigned learning condition. However, statistical analysis for both experiments was significantly hindered due to small sample sizes (51 students in Experiment 1, 30 students in Experiment 2) and unanticipated experiment re-designs (in response to COVID).
The Teaching Experiment Academy

Shortened Project Name: The Teaching Experiment Academy
Host Institution: UC Irvine
Partner Institution(s): San Jose State University (SJSU) & Cal Poly Pomona (CPP)
Award Amount: $200,000

PROJECT GOAL(S)

Create a cohort-based faculty development program that supports STEM faculty in redesigning their courses using guidance from the mastery learning (ML) model and employing specifications grading (SG) to encourage a growth mindset for student success.

INTERVENTIONS

- Created workshops on ML and SG.
- Hosted three-day web conference to educate participants about ML and SG.
- Created a Faculty Learning Community (FLC) on each campus to sustain progress.
- Created STEM Course Redesign Program, a summer boot camp to help participating faculty implement specifications grading into their courses.
- Created Faculty Peer Coach Development Program to train faculty peer coaches in ML and SG.
- Organized campus-based showcases for faculty to present their work to their campus communities.
- Held TEA Summit that was attended by 224 people from 13 states and 2 foreign countries.

IMPACT/OUTCOMES

- 251 faculty participated in trainings; 40 faculty joined TEA program (originally projected to recruit 35 faculty).
- Implementation of ML/SG: survey results showed high percentage of faculty used ML/SG in at least one course and continued application beyond grant program.
- Positive feedback from students, increase in growth mindset.
- Development of FLCs that continue to meet after grant duration; development of new FLCs.
- See methods section below for additional data.

DATA COLLECTION / EVALUATION METHODS

- Post-implementation survey of TEA faculty participants: 36 respondents total. Selected findings as follows:
  - 35 participants reported using ML/SG in at least one course following training.
  - 29 participants responded to question on growth mindset: all 29 indicated agreement that their own intelligence and talents, as well as those of students can change over time with dedication and hard work.
  - 21 participants responded to questions on utility of ML/SG: all 21 agreed these strategies increased students’ understanding of subject matter.
- Student post-intervention surveys: 61 respondents in Fall 2021, 520 in Winter/Spring 2022. Selected findings as follows:
  - 66% or more of the students agreed that academic performance, understanding, and intelligence about course content increased.
  - 58% agreed curiosity for the subject had increased; 82% agreed that the grading system increased their ability to learn from mistakes.
- Dweck Mindset Instrument (DMI) used to test whether students hold a fixed or a growth mindset before and after taking class based on specifications grading.
- URM students’ mean level of agreement on growth mindset items was much higher than non-URM students, indicating that the students after taking the course showed an increased growth mindset.
# Building Community and Facilitating Active Learning in Online STEM Courses

**Shortened Project Name:** Building Community and Facilitating Active Learning  
**Host Institution:** UC Irvine  
**Partner Institution(s):** Santa Ana College  
**Award Amount:** $200,000

## PROJECT GOAL(S)

To provide opportunities for STEM faculty to increase student engagement in online introductory courses through the development of face to face learning periods that leverage evidence-based teaching practices, these practices are aimed at building students’ student sense of belonging in the online course environment and closing achievement gaps traditionally seen for underrepresented students.

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</table>
| • Developed online professional development course for multidisciplinary and multi-institutional faculty.  
• Incorporated learning assistants into online STEM courses. | • Positive feedback from faculty on PD course.  
• Increased awareness of active learning strategies.  
• Increased use of learning- and student-centered strategies in classes taught by participants.  
• High degree of student sense of community and belonging.  
• Did not get 100% of faculty who participated to re-teach their courses after attending the program (due to scheduling conflicts that were out of the faculty members’ control).  
• See methods section below for additional data. |

## DATA COLLECTION / EVALUATION METHODS

- Qualitative feedback from faculty on PD course.  
- Qualitative thematic analysis of post-program survey: community, active learning, peer instruction emerged as themes.  
- Utilized University of Virginia’s syllabus rubric: measured shifts in syllabus language on a scoring scale from 0-58, with 0-18 indicating a syllabus that is content-focused, 18-40 being transitional, and 41-58 being learning-focused. Pre-intervention, most faculty syllabi were in content-focused category; post-intervention, all of the syllabi scored at least a 40, indicating increase on learning- and student-centeredness.  
- Utilized Wieman Teaching Practices Inventory (TPI): gives a percentage that estimates the amount of evidence-based teaching practices used in a course; mean TPI score increased from to 57.14% to 62.3% after participating in PD program.  
- Utilized Freeman’s Sense of Belonging Survey: gauges student sense of belonging with questions on 1-5 Likert scale; was not able to collect pre-program data to compare, but marks consistently high, averaging between 4-5, indicating students felt community with classmates and instructor.
# Closing Equity Gaps in Introductory Biology Through Faculty Professional Development in Active Learning Practices

**Shortened Project Name:** Closing Equity Gaps in Intro Bio  
**Host Institution:** UC Berkeley  
**Partner Institution(s):** CSU East Bay (CSUEB), Berkeley City College (BCC)  
**Award Amount:** $200,000

## PROJECT GOAL(S)
To develop a Community of Practice (CoP) to boost student achievement and narrow observed equity gaps via faculty professional development in active, student-centered teaching practices.

## INTERVENTIONS
- Created Faculty Learning Optimizes Student Success (FLOSS) CoP.  
- Created PD program consisting of 8 interconnected workshops on student-centered practices, barriers to student learning, inclusivity and diversity, metacognition, active learning, critical pedagogical theory, and use of Courselets.  
- Facilitated 2 cohorts of program participants, including both full-time and part-time faculty.

## IMPACT/OUTCOMES
- Recruited and supported 19 FLOSS participants across two cohorts (originally aimed to recruit at least 15).  
- All survey respondents (18 out of 19 participants) agreed that FLOSS workshops achieved the four primary goals of building community, introducing skills/techniques to use in the classroom, foster understanding of barriers to student learning, and engaging with critical pedagogical theory.  
- Faculty survey data indicated increases in faculty skill and knowledge of student needs, pedagogy, importance of equity in the classroom and recognition of role of instructor in DEI leadership, but not at statistically significant level.  
- UCB continuing to support FLOSS; BCC continuing to support workshops.  
- PI at UC Berkeley promoted to position where 15% of her role is to oversee FLOSS.  
- See methods section below for additional data.

## DATA COLLECTION / EVALUATION METHODS
- Faculty survey on whether workshops achieved four primary goals of building community, introducing skills/techniques to use in the classroom, foster understanding of barriers to student learning, and engaging with critical pedagogical theory.  
- Faculty pre- and post- survey data on faculty skill and knowledge on student needs, pedagogy, and DEI (19 participants).  
- Qualitative feedback: gathered via faculty statements.  
- Faculty-student alignment survey: asked students across 5 courses a series of questions on classroom experience identical to those asked of faculty to test if they were well aligned; inconclusive due to small sample size/low student participation.
Bay Area Math Collaborative

Shortened Project Name: BAM-C  
Host Institution: CSU East Bay  
Partner Institution(s): Ohlone College, Peralta CC District, San Francisco State University  
Award Amount: $200,000

### PROJECT GOAL(S)

Restructure traditional (C-ID aligned) Precalculus Course (Math 155), clustering the standard concepts into a “Big Ideas” structure (“Big Ideas” being central learning concepts that link to numerous others).

### INTERVENTIONS

- Grouped precalculus content into a collection of “Big Ideas,” forming a more connected, coherent story for students and help them build the essential conceptual knowledge to be successful in calculus and subsequent STEM courses.
- Developed nested CoP: central steering committee consisting of one representative from each partner institution; local workgroups (45 faculty total) at each partner institution.
- Created 6 online workshops on Big Ideas Framework.

### IMPACT/OUTCOMES

- Developed Precalculus Course Guide to provide faculty with a framework to organize their content around the Big Ideas, including narrative rationale for each Big Idea, suggested activities, and alternative assessment ideas.
- Local workgroups (consisting of 45 faculty total) piloted innovations, provided feedback to steering committee, provided data for evaluation, and engaged with broader math faculty community.
- Workshops had over 200 faculty participants.
- Higher average GPA and more positive distribution of grades were observed in courses with Big Ideas Framework implementation than without implementation.
- See methods section below for additional data.

### DATA COLLECTION / EVALUATION METHODS

- Measured implementation level of Big Ideas Framework across 2 semesters and 6 institutions (score from 0-2; 0 = no implementation; 1 = some implementation; 2 = full implementation): 46% had some or full implementation in first semester (of 692 courses total); 74% had some or full implementation in second semester (of 406 courses total).
- Measured student grades across same 2 semesters and 6 institutions: 1,098 students total with 486 URM and 612 non-URM. Courses that partially or fully implemented Big Ideas Framework showed a higher average GPA (2.41 vs. 2.149 in courses that had no implementation) and a more positive distribution of student grades (greater number of A and B letter grades in courses with some or full implementation). Bayesian analysis of covariance indicated Big Ideas implementation positively impacted outcomes for all students, but provided more positive outcomes for URM students specifically.
Deeper Math Learning Through Metacognitive Conversation

Shortened Project Name: Deeper Math Learning
Host Institution: CSU Chancellor’s Office
Partner Institution(s): Los Angeles CC District/3CSN
Award Amount: $100,000

**PROJECT GOAL(S)**

Engage CSU and CCC mathematics faculty to participate in an intensive, networked, Reading Apprenticeship professional learning program focused on apprenticing students into advanced mathematics literacies.

**INTERVENTIONS**

- Created Reading Apprenticeship professional learning program to support faculty in designing and facilitating active, culturally responsive learning environments via text-based lessons, disciplinary tasks around texts, and facilitating more robust and equitable classroom talk, particularly metacognitive conversations about critical math concepts conveyed via texts.
- Created feedback process: piloted strategies with students, collected feedback, workshopped revisions, conducted second round of piloting with students.

**IMPACT/OUTCOMES**

- Impact was measured along three types: instructor impact; student impact; and systemic impact.
- Instructor impact: Recruited 39 faculty participants, 29 of whom completed Reading Apprenticeship program (74% completion rate); 10 continued to participate in additional “level 2” program to train in math literacy leadership; data indicated an increase in participating faculty’s depth and breadth of professional noticing about student thinking and improved ability to elicit, notice, and respond to the variety of ways students engage with mathematics; upward shift in distribution of intercultural orientation.
- Student impact: students of participating instructors had better performance on average in future courses; however, causality was unclear.
- Systemic impact: measured along four feasibility factors: technical, organizational, support, and usability. Technical and usability factors were above the threshold for feasibility.
  - See methods section below for additional data.

**DATA COLLECTION / EVALUATION METHODS**

- Conducted surveys and interviews with designers/producers of the PD program and instructor participants to measure three factors: instructor impact; student impact; and systemic impact.
- Instructor impact: faculty surveys gauged professional knowledge of Reading Apprenticeship core constructs, strategies for teaching and analyzing student work, methods of student engagement, intercultural orientation with respect to teaching (using Intercultural Development Inventory), and assessed mathematical knowledge for teaching (MKT).
- Student impact: analyzed institutional data on student performance, comparing outcomes historically within participants (pre- and post-participation) and contemporaneously within and across courses (student outcomes for participant and non-participant faculty): 2,513 students who had completed a course with a Deeper Math PD participant as instructor subsequently enrolled in 855 additional mathematics courses, with an average GPA of 2.3 compared to GPA of 2.0 for all attempts of the same courses.
- In the preceeding two years before the Deeper Math PD, average pass rate in target classes was 72% in colleagues’ classes, 78% in participant classes. In target terms, participants’ grade distributions were positively skewed, but pass rates were lower than the historical rate (74% compared to 71% in the same classes taught by colleagues).
- Systemic impact: conducted feasibility analysis along four feasibility factors: technical, organizational, support, and usability. Data was collected via surveys, interviews, and observations of sessions and converted to numeric score from 0-3, with threshold of 2.4 indicating feasibility. Technical factors was rated 2.5; organizational factors was rated 2.3; support factors was rated 2.3; usability factors was rated 2.5.
### Equity in STEM Through Deeper Learning and Metacognitive Conversation

**Shortened Project Name:** Equity in STEM  
**Host Institution:** CSU Chancellor’s Office  
**Partner Institution(s):** American River College, College of San Mateo, Los Angeles CC District/3CSN  
**Award Amount:** $600,000

#### PROJECT GOAL(S)

To engage STEM instructors in a multi-faceted community of practice grounded in a powerful framework for teaching and learning, the Reading Apprenticeship framework; provide time and space for redesigning lessons as well as experience using digital tools to support active learning. The learning community was anticipated to accelerate the pace at which STEM faculty adopt culturally relevant and high-intensity active learning techniques in online and remote environments.

#### INTERVENTIONS

- Developed CoPs: STEM Instructors Learning Community, Facilitator Learning Community, Leadership Community of Practice in Reading Apprenticeship; conducted outreach (through existing networks) to sustain and expand COPs; “spin off” workshops and communities created.  
- Created 10 month professional learning course, Apprenticing Students into STEM Thinking, to build knowledge about how people learn and culturally relevant and responsive pedagogies.  
- Developed website/repository of text-based activities.

#### IMPACT/OUTCOMES

- Engaged 144 faculty members from 21 California State Universities and 40 California Community Colleges and from 23 STEM disciplines in dynamic CoPs; reached at least 17,375 students across 255 courses.  
- Participants reported robust sense of community; changes in approach to teaching practices, understanding of the role of texts in learning, implementing substantial and meaningful changes to their use of text, and more active learning in their courses; high degree of satisfaction with CoP facilitation.  
- Most participants reported CoP transformed their practice to a large or very large extent; faculty were more likely to be confident in ability to implement culturally responsive teaching practices the longer they participated in CoP.  
- Increased student engagement, sense of community in the classroom, and confidence.  
- See methods section below for additional data.

#### DATA COLLECTION / EVALUATION METHODS

- Conducted external evaluation: utilized Value Creation framework (VCF) survey (measuring immediate value, potential value, applied value, realized value, transformative value; 99 respondents total), qualitative analysis on written reflections of 20 community members, interviews with facilitators and embedded coaches, and analysis of learning artifacts.  
- Found meaningful value creation at each level of the VCF framework: robust sense of community; change in approach to teaching practices (working to integrate collaboration and group work into their courses, being more strategic in selection of text and actively supporting their students’ engagement with disciplinary text); substantial and meaningful changes to use of text in their courses, more active learning; increased use of text and shifts in teaching beliefs and philosophy.  
- Survey data on value and impact of CoPs: most participants (63%) reported it had transformed their practice to a large or very large extent, and faculty were more likely to be confident in ability to implement culturally responsive teaching practices the longer they participated; reported improved student engagement, sense of community in the classroom, and confidence.
# Increasing Student Flow and Success Along Intersegmental STEM Program Pathways

**Shortened Project Name:** Increasing Student Flow  
**Host Institution:** Bakersfield College  
**Partner Institution(s):** Merced College, UC Merced  
**Award Amount:** $500,000

## PROJECT GOAL(S)
To expand Program Pathways Mapper system in order to facilitate transfer between community colleges and UC campuses.

## INTERVENTIONS
- Provided free, easily accessible, mobile-adaptive and interactive visual maps for participating campuses of the path to a degree to eliminate disparities in the knowledge of students and makes visible the “hidden curriculum” of how to navigate college.
- Developed statewide templates, transfer maps, guidebook for hosting effective convenings, intersegmental collaboration guide.
- Hosted 3 convenings of faculty to develop buy-in, get input and feedback, and trained faculty on requirements of developing pathways.
- Developed UC Transfer Experience Course.

## IMPACT/OUTCOMES
- Large and sustained increase in community college transfer students to UC Merced.
- Continued growth of numbers in access of PPM sites, with over 16 million total page views across all PPM sites in the year after the launch of UC Merced’s PPM site.
- 239 people participated in convenings.
- Participating faculty trained on the requirements of developing pathways that fulfill GE pattern, upper division graduation, and Associate Degree for Transfer (where relevant) requirements.
- Extensive external engagement, including connection with Central Valley Higher Education Consortium (CVHEC); this resulted in CVHEC becoming a regional champion for scaling the program in the Central Valley, and subsequently the inclusion of $25 million in the 2022-23 State budget to support scaling of intersegmental program pathway mapping.

## DATA COLLECTION / EVALUATION METHODS
- Collected data on numbers of transfer students.
- Collected Google Analytics on usage of PPM site over time.
**Reorienting Formative and Summative Assessment Towards Mastery Learning for Learner Success, Student Equity, and Institutional Resilience**

**Shortened Project Name:** Reorienting Formative and Summative Assessment  
**Host Institution:** UC Berkeley  
**Partner Institution(s):** CSU Long Beach & El Camino College  
**Award Amount:** $650,000

## PROJECT GOAL(S)
To implement mastery learning by developing and deploying paradigm-based question generators (PQGs; a piece of computer code that captures the “essence” or paradigm underlying a specific problem type in a course and can generate randomized question instances); to use PQGs to provide more homework practice problems and generate different exam variants for each student or for giving students “second chance” make-up exams.

## INTERVENTIONS
- Developed and implemented PQGs with feedback from student teachers.  
- Implemented “F’s for None” policy; eventually implemented “A’s for All” policy.  
- Developed faculty PD: raised awareness and facilitated onboarding workshops for faculty and student assistants.  
- Advocated for computer-based testing facility: collaborating with Disabled Students Program, the head of Research Teaching & Learning, the Dean of Engineering, and the Vice Provost for Undergraduate Education at UC Berkeley.

## IMPACT/OUTCOMES
- Over 2,000 PQGs for 13 courses developed (initial goal was 100).  
- 4 courses outside of pilot recruited to program: expanded to data science, statistics, other engineering fields, and other STEM courses (astronomy).  
- Percentage of students who would have otherwise failed had they not been allowed to re-take assessments was higher for URM students than for women, and higher for women than non-URM students; all students who desired to pass the pilot course did so.  
- Increases in Latinx and women student enrollment observed.  
- See methods section below for additional data.

## DATA COLLECTION / EVALUATION METHODS
- Tracked data on student outcomes under “A’s for All” policy by demographic, in comparison with historic rates.  
- Tracked data on student enrollment by demographic.  
- Under the “A’s for All” policy, URM students and women benefitted at a higher rate than majority-group students (234 students total, with 29 women, 32 URM students): 45% of URM students (vs. 31% of non-URM) and 55% of women (vs. 52% of non-female identifying students) benefited.  
- Significant gains in student learning outcomes for underrepresented students, with every URM student group achieving a 3.0/B-average for the first time in the history of the class.  
- An observed increase in enrolled Latinx students upon offering PQGs, averaging around 24% of the overall student body of the courses (compared to an average of around 9% before).  
- An observed increase in the percentage of women enrolled in the course, going from 52% to 72%, its highest number in history.
# A Hybrid Approach for Authentic Scientific Inquiry for Biology Undergraduates

**Shortened Project Name:** Hybrid Approach  
**Host Institution:** CSU Dominguez Hills  
**Partner Institution(s):** El Camino College & UC Irvine  
**Award Amount:** $550,000

## PROJECT GOAL(S)

To develop and assess hybrid, lab-based biology courses that could better serve non-traditional students and more nimbly respond to future challenges like the COVID-19 pandemic; develop modules designed to strengthen quantitative skills, reflect student interests, and incorporate local context and campus resources; help develop students’ quantitative and written abilities, better preparing them for upper-division coursework and future careers.

## INTERVENTIONS

- Designed and implemented hybrid course-based undergraduate research experiences (CUREs) across three colleges; completed 14 (out of planned 15) course redesigns with collaborative, scaffolded, and data-driven curricula.  
- Held faculty symposium to brainstorm solutions and student symposium for students to share research experience.

## IMPACT/OUTCOMES

- Increases in achievement for specific learning objectives: engaging students in the scientific method and in teamwork.  
- Significant increases in: student efficacy in scientific ability and sense of belonging, experience in doing communicating science, experience with research and writing, instructor familiarity, familiarity with peers, ability to discuss the material with their peers.  
- No evidence that outcomes varied significantly across demographic groups; too early to know if re-design addressed equity gaps in graduation outcomes (as most student participants had not yet graduated) or retention in the major.  
- See methods section below for additional data.

## DATA COLLECTION / EVALUATION METHODS

Collected student pre- and post-intervention survey data from CSU Dominguez Hills and El Camino College on student efficacy in scientific ability, sense of belonging, and achievement in specific learning objectives (372 responses on pre-intervention survey, 305 responses on post-intervention survey): majority of indicators showed positive increases in a statistically significant fashion; for learning objective outcomes, saw the most success in engaging students in the scientific method and in teamwork; least successful in developing quantitative skills.
Calc-Boost

Shortened Project Name: Calc-Boost  
Host Institution: CSU San Marcos  
Partner Institution(s): MiraCosta College  
Award Amount: $100,000

### PROJECT GOAL(S)
To leverage the support of trained peer educators, personalized study modules, and active learning sessions in inter-semester programming to boost success for students transitioning from Calculus I to Calculus II.

### INTERVENTIONS
- Developed inter-semester programming targeting students with grade lower than B- in Calculus 1 and enrolled in Calculus 2; programming included an initial content assessment, affective domain components (e.g., growth mindset, how we learn, study skills), specific content questions, and post-learning assessment requiring a score of at least 90% to be certified complete.
- Provided drop-in tutoring.

### IMPACT/OUTCOMES
- 26 students total did Calc-Boost, 18 at CSU San Marcos (including 10 students within target grade range), 8 at MCCC (including 4 students within target grade range).
- All CSUSM students who passed Calc I with a B- or less and completed Calc-Boost earned a C or better in Calc 2 (100% pass rate), compared to 73% who did not complete Calc-Boost.
- At MSCC, 1 of the 4 students who had participated in Calc-Boost and passed Calculus II was a student who has passed Calc I with a B- or less.
- Pre-survey confirmed a relationship between sense of belonging and expectation of higher grades, and between expectations of higher grades and math orientation, but no data on change.

### DATA COLLECTION / EVALUATION METHODS
- Collected data on pass rates in Calculus II.
- Conducted pre- and post- intervention surveys (did not have sufficient return rate to analyze).
- Sample sizes too small to disaggregate by demographics.
## Project Name
Grading for Growth in Calculus

### Shortened Project Name
Grading for Growth

### Host Institution
CSU Monterey Bay (CSUMB)

### Partner Institution(s)
Hartnell College

### Award Amount
$100,000

## Project Goal(s)
To implement standards-based grading (SBG) in multiple sections of Calculus I.

### Interventions
- Developed and implemented SBG materials for Calculus I.
- Created Canvas shells for students with: explanation of SBG concept and benefits; interactive learning outcomes; assignment allowing for assessment of an example assignment using a rubric to understand grading process; modules for concepts/chapters; growth mindset activities.
- Had check-ins with students discussing assessment results in the context of growth.
- Created Professional Learning (PL) workshop and PL Communities (PLCs) to foster faculty buy-in.

### Impact/Outcomes
- At Hartnell: female students performed better than male students in both SBG and non-SBG sections; no statistically significant difference between first-generation (first-gen) and non-first-gen students in SBG sections, but first-gen students performed better in non-SBG sections.
- At CSUMB: spring term data showed fluctuation in student equity gaps.
- Across institutions: student grades in SBG sections were higher than past grades during in-person semesters; held true when disaggregating by all groups of interest; equity gaps by gender, URM, first-gen status, or mathematics preparedness not narrowed in the first semester of implementation.
- Across institutions: larger interest in SBG and equity based assessment both within and outside of math departments; 15 faculty members have now implemented SBG in their Calculus I courses using project materials.
- Comparing underprepared and prepared students (self-reported) across institutions: prepared students more likely to feel course expectations were clear and realistic, instructor feedback was helpful and improved knowledge, and were less likely to feel like giving up on the course.

## Data Collection / Evaluation Methods
- Collected institutional data on student outcomes by demographic (first-gen status, URM status, and gender; 373 students at CSUMB, 56 students at Hartnell total).
- Collected student survey data gauging degree of preparedness and perceptions of the course (79 students total across all institutions).
### Expanding Students’ Affect, Understandings, and Perceptions of Relevance through Realistic Tasks in Calculus

**Shortened Project Name:** Realistic Tasks in Calc  
**Host Institution:** CSU Long Beach  
**Partner Institution(s):** CSU East Bay & Long Beach City College  
**Award Amount:** $100,000

#### PROJECT GOAL(S)

To develop realistic (context-driven) curricular innovations to transform students’ experience of Calculus I.

#### INTERVENTIONS

- Developed, piloted, and revised open access online homework for Math 122 (Calculus 1) at CSULB using WeBWorK.  
- Developed, piloted, and revised associated real-world tasks.  
- Provided professional development (PD) for pilot instructors and Math 122 student assistants.  
- Piloted new opensource text (OpenStax) aligned to the tasks embedded in WeBWorK.

#### IMPACT/OUTCOMES

- Positive student response, with indications that tasks made positive impact on student understanding, applicability of subject to the real world/everyday life, and enjoyment of course.  
- Students indicated realistic tasks were more challenging, but more useful and memorable.  
- Faculty response indicated belief that tasks supported the students’ understanding of the relevance of calculus and overall enjoyment of course.

#### DATA COLLECTION / EVALUATION METHODS

- Conducted student surveys (160 respondents total) and focus group interviews (23 total): to assess level of agreement of real-world and future relevance of calculus, as well as overall enjoyment of the course.  
- Collected data on completed student work.  
- Conducted instructor surveys and interviews.
Access for Equity: Reimagining Calculus Education Through Mobile-Friendly Course Design

**Shortened Project Name:** Mobile Friendly Calc  
**Host Institution:** Bakersfield College  
**Partner Institution(s):** CSU Sacramento & UC Riverside  
**Award Amount:** $100,000

### PROJECT GOAL(S)
To develop a mobile-first online calculus course shell that would be made freely available on Canvas Commons.

### INTERVENTIONS
Created an online calculus course designed to close equity gaps through three dimensions: access, relationships, and learning.
- **Access:** students would be able to complete the course entirely on their phones, earn skills-based badges, and use Open Educational Resources.
- **Building relationships:** course included a faculty resource module that would support faculty in building meaningful relationships with students to support student success and retention.
- **Learning:** course incorporated active learning strategies; included a PDA corner module with professional development for faculty, an orientation module, and 10 modules on Calculus 1.

### IMPACT/OUTCOMES
- Two faculty at Bakersfield College and one faculty at San Diego City College piloted the course; team was unable to identify faculty to pilot at UC Riverside and CSU Sacramento. Success of student participants varied across institutions, with 100% pass rate at San Diego City College and slightly lower pass rate of participants than overall course pass rate at Bakersfield College.
- Faculty indicated usefulness of calculus connection videos, success tips, learning content pages, and reflections.
- Positive student feedback on conveniences of being able to watch lectures on mobile devices, how course design helped them stay organized, and the ability to communicate and connect, but students reported that small screen and lack of keyboard made it challenging for doing work. Students indicated a frequent preference for physical copies of textbooks/worksheets, with mobile device as last resort or second choice.
- See methods section below for additional data.

### DATA COLLECTION / EVALUATION METHODS
- Collected data on pass rates of students in pilot courses: Bakersfield College Course 1 - 34 students enrolled, 38% passed (13); Bakersfield College course 2 - 37 students enrolled, 48% passed (18); San Diego City College course - 18 students enrolled, 100% passed (18). Bakersfield College’s combined success rate for the pilot was 44%, in comparison to overall success rate for all students in Calculus 1 at 43%; San Diego City College’s success rate for the pilot was 100%, compared to overall success rate for all students in Calculus 1 at typically ~35%.
- Conducted student focus groups to establish understanding of how students use their mobile devices for learning and how they want to use their phones for learning.
- Conducted faculty focus groups to gain insight into faculty perceptions of mobile learning.