Exhibit A – Scope of Work

Project Summary & Scope of Work

☐ Contract ☒ Grant

Does this project include Research (as defined in the UTC)? ☒ Yes ☐ No

PI Name: *Matthew Cover, Ph.D.*

Project Title: *Social Online Tools to Support Collaborative and Inclusive Learning in Biology*

If Third-Party Confidential Information is to be provided by the State:

☐ Performance of the Scope of Work is anticipated to involve use of third-party Confidential Information and is subject to the terms of this Agreement; ***OR***

☐ A separate CNDA between the University and third-party is required by the third-party and is incorporated in this Agreement as Exhibit A7, Third Party Confidential Information.

Project Summary/Abstract

The goal of this project is to 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 California public system of higher education. 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.

The project has three objectives: Objective 1 obtains and analyzes baseline data on online learning by surveying availability of online components in 1 UC, 1 CSU, and 3 CC institutions, reviews “best practices” in the literature, and identifies existing curriculum to modify for interventions. Objective 2 develops social, collaborative curriculum interventions to pilot test online alongside traditional classrooms of intersegmental partner institutions. Assessment will include surveys of students and faculty, and semi-structured interviews or focus groups of participating faculty. In addition, Objective 3 further develops and expands institutional partnerships and prepares to scale up the interventions.

Scope of Work

Describe the goals and specific objectives of the proposed project. Describe the plan for implementing the project (including, if applicable, discussion of overall strategy, methodology and analyses to be used) and summarize the expected outcomes. Discuss how the data will be collected, analyzed, and interpreted and identify expected project milestones and deliverables.

Overview

In 2018, Assembly Bill 1809 established the California Education Learning Lab ("Learning Lab"). Housed at the Governor's Office of Planning and Research, the Learning Lab has an annual budget of $10 million to fund intersegmental faculty teams in order to increase learning outcomes and close equity and achievement gaps across California's public higher education segments.

In 2019-2020, Learning Lab grant opportunities focus on curricular and pedagogical innovations that combine educational technologies with the science of learning to reduce equity and achievement gaps in online and hybrid STEM "gateway" courses across California's public higher education segments.

Learning Lab's grant awards are intended to support faculty in discovering, designing and implementing learning environments and pedagogical approaches that work best for today's students and support faculty in their teaching mission. Learning Lab is part of California's vision to grow and sustain a highly educated workforce that can meet the challenges of our changing world, whether it's combating the effects of climate change, feeding the world sustainably, ensuring a healthy population or lifting communities out of poverty. Learning Lab's goal is to promote collaboration among and leverage the assets within all our institutions of public higher education in California.

Problem Statement

Across California public institutions of higher education, Introductory Biology is often taught in large classes (50-500+ students) that emphasize traditional lecture-based pedagogies. To communicate complex concepts in biology, introductory courses often focus on transferring knowledge to build a body of information that students will later draw on in advanced courses. This lecture format has been shown to be ineffective, however, because it carries a high cognitive burden: the delivery of visual material (e.g., PowerPoint slides) spreads information across multiple frames, requiring students to mentally merge elements, and each slide often carries non-essential elements and imagery that must be processed and analyzed (Castro-Alonso & Kitt 2019). Concepts are often unfamiliar to students, and are frequently presented at an expert level (Johnstone 2010). Consequently, students continue to see concepts as disconnected, and fail to develop a clear mental framework on which to anchor new information, resulting in poor academic performance in Introductory Biology and future classes.

Active learning (such as small group discussion, writing, predicting, recalling information, asking questions, etc.) reduces reliance on the ineffectual lecture format, instead providing space for students to contemplate and externalize concepts (Ebert-May et al. 1997; Freeman et al. 2007). Although active learning is highly effective for helping students develop a deeper understanding of difficult concepts, many instructors are resistant to include active learning because of the perception that these activities take up too much time and reduce the amount of information that can be presented. Compounding the content issue, lecture and testing approaches are also inconsistent among instructors.

In addition, biology courses are socially complex, which can discourage students and lead to loss of motivation because of perceived competition for grades, cultural differences in participation, and impersonal interactions with peers and instructors, among other factors. Psychosocial and cultural factors, including stereotype threat (Steele & Aronson 1995) and cultural norm framing, are present in both in-person and online environments, resulting in stress and anxiety that reduces cognitive resources for learning. Even with lectures redesigned to include active learning, students still report a lack of a sense of belonging; this effect is especially pronounced for minoritized students (Haynes & Winters, unpublished report). Students who transfer from community colleges to 4-year institutions may further experience this lack of sense of belonging. Many faculty at four-year institutions believe that there is a lack of rigor in foundational community college courses, and blame this lack of rigor when transfer students are not successful at their new institutions. Transfer students experience stress from this stereotype threat, and they interact with faculty at lower levels and participate in fewer enrichment activities than non-transfer students in the same degree programs (Kuh et al. 2006).

Cultural norm framing plays a role in signaling to a student whether they belong in an environment. For example, interdependent framings focus on a collaborative approach where members contribute together toward common goals, a framing aligned with values of many minoritized students. Conversely, independent framings, which are common in students from continuing-generation backgrounds and emphasized in American universities, focus on the role of the individual as being solely responsible and recognized for their own success (Stephens et al. 2012a). Mismatches between a student's background and norm framings in the environment can cause distress (Stephens et al. 2012b). Instead, culturally relevant models of student success emphasize that barriers to learning can be mitigated in learning environments that validate and engage students' cultural backgrounds. Interactions at the institutional level (Stephens et al. 2012a) and in classrooms, both in-person and online, provide the main cues about whether the educational environment is inclusive and welcoming (Hurtado et al. 2015). Moreover, building science identity and engaging student values are predictive factors for persistence in STEM career pathways up to 4 years after graduation (Estrada et al. 2018). For example, many Latinx students in California report that positive relationships with instructors strongly influence their motivation and success (Kaupp 2012), indicating that the social environment where students regularly receive feedback from mentors and peers is a critical motivator for academic success. Positive feedback on performance contributes to a student's self-efficacy, defined as one's belief in their own ability to succeed in similar situations in the future (Bandura 1977).

Online learning strategies, including blended formats, are widely used across segments of higher education to provide opportunities for students to review lecture content and supplemental material, participate in discussion forums, and complete courses remotely. These strategies rarely account for variation in cultural norm framing, however, and thus do not necessarily address equity gaps as well as they could. To improve online education, researchers have recommended greater social interactions between online students (Bosch et al. 2019: Wang et al. 2013; Xu & Jaggers 2014). Additionally, online learning strategies often fail to incorporate authentic interactions with instructors. Even online, instructors can model and help establish norms for respectful interactions and promote a sense of belonging, reducing the need for minoritized students to navigate an unfamiliar social environment with unwritten rules.

These recommendations for greater social interactions in online learning environments are supported by psychological research. The cognitive apprenticeship model (Collins et al., 1987) posits that humans learn best from others, by observing and learning in a scaffolded environment, especially if supports are scaled within the Zone of Proximal Development (Vygotsky 1980). For example, seeing an instructors' hand motions (Chue et al. 2015, Ormond et al. 2017) and learning to sketch complex 3D landforms (Ormond et al. 2017, Gagnier et al. 2017) are critical activities for students to understand spatial and temporal relationships in chemistry and geology; biology carries similar spatial and conceptual challenges related to change over time (e.g., evolution, Halverson et al. 2011).

In recognition of the problems described above, the approach of this project is to develop social online tools to support collaborative and inclusive learning. In a collaborative model, peers participate under interdependent norms toward a common goal. Working in groups is a 21st century skill (Johnson & Johnson, 2014), and, by extension, practicing collaboration is essential for students in the biological sciences to effectively solve future workplace and real-world problems. This project proposes that new technologies that allow for person-to-person interactions through existing collaborative tools and live group video conferencing can systematically increase access for students to practice active learning alongside traditional lecture with peers from their courses, or even with students from other schools.

Goals and Objectives

The overall goal of this study is to determine how adaptive technology and other online tools can be leveraged to provide a collaborative learning experience for introductory biology courses across the California college system. The project team hypothesizes that providing a collaborative learning environment outside of the classroom will provide a needed space for students to externalize information, build knowledge together, and develop their own sense of belonging, thus reducing achievement gaps for minoritized students. The project includes three objectives in the 18-month seed grant project.

Objective 1: Obtain and Analyze Baseline Data on Online Learning. To begin, the project team will gather baseline information on existing types of online learning tools available to students in introductory biology courses at each of the five partner institutions (1 UC, 1 CSU, and 3 CC). Data will be collected through faculty surveys, evaluation of Learning Management Systems (LMS) for each course, and student experience surveys. Special attention will be paid to the cultural norm framing in the online tools. The team hypothesizes that online resource availability is low for traditional format courses, with few systematic elements that promote student-student interactions, authentic instructor-student interactions, or interdependent cultural norm framing. Second, the team will identify the opportunities and barriers to adoption of online collaborative components through a review of “best practices” and existing curriculum; the team expects that faculty resistance to adoption results from discomfort with technology, time availability, and uncertainty in how to best encourage and assess student participation.

The project team notes that the response to the spread of the COVID-19 disease by institutions of higher learning beginning in March 2020 is resulting in dramatic changes to the teaching and learning environment. Lecture classes are rapidly transitioning to online instruction as a result of this emergency, with little time for planning or development of online learning tools. As of April 2020, there is great uncertainty about the modality of future course offerings in Fall 2020 and beyond. Given the uncertainty and challenges facing faculty, students, and institutions, it is likely that pedagogies and curriculum will be in flux during the 2020-2021 academic year. Nonetheless, with little time to develop novel online tools, the team expects that most instruction in Fall 2020 will continue to replicate the traditional lecture format, whether the modality is online or in-person, and that the results of the analysis of online learning tools that occurs in late summer and fall 2020 will be broadly applicable to recent trends in introductory biology education.

Objective 2: Develop and Pilot Test Interventions. Based on findings of the baseline surveys, the project team will develop three distinct online learning modules that emphasize social, collaborative, and inclusive online learning for Introductory Biology courses. These three modules will be pilot tested at partner institutions in the Spring 2021 term. Assessments of student engagement and learning outcomes in the pilot study classes will be compared with the same assessments of students before these interventions and to students from other courses that lack the modules. Following analysis and evaluation of the pilot modules, the project team will modify the modules as needed, and test a second iteration of the modules in courses in the Fall 2021 term. Again, assessment of student engagement and learning outcomes will be compared to control classes and pre-intervention data. The team hypothesizes that, in contrast with existing online learning activities, the novel activities focused on collaborative learning will result in improved sense of belonging and academic self-efficacy, improving overall learning and reducing gaps.

Objective 3: Develop and Enhance Institutional Partnerships. As a result of the intersegmental collaboration during this project, the project team will develop stronger institutional partnerships among and across the educational segments (i.e., UC, CSU, CC). Through the seed grant proposal development process, it has become clear that there are different opportunities and challenges for individual and institutional participation, and for support in this project among higher education segments and among faculty classifications (i.e., tenured/tenure track, long-term contracts, short-term/adjunct faculty). The team anticipates a major, continuing activity throughout the 18-month seed grant is the augmentation of institutional buy-in to facilitate the full participation of team members across institution types and employment classifications. By the end of the 18-month seed grant the team anticipates the development of a full-scale project proposal with full institutional partnerships for all team members, as well as identification of additional potential institutions as partners.

Implementation Plan

The 18-month seed grant will include two phases (Table 1, with timeline, below), aimed at fulfilling the three project objectives (described above). Phase 1 aims to survey the landscape of online learning activities in Introductory Biology courses as offered at team members' institutions and existing curriculum resources, using a lens of interdependent (collaborative) learning and recognizing the critical role of psychosocial environments in fostering learning. Phase 2 will build upon these findings from Phase 1 to propose, implement, and evaluate the effectiveness of several online interventions that aim to increase students' sense of belonging and self-efficacy. The development of stronger institutional partnerships will occur throughout both Phase 1 and Phase 2.

Phase 1a: Review of current implementation. To understand the frequency of implementation and inclusion of adaptive technology for online components in Introductory Biology courses, the project team will review courses stored in Learning Management Systems (LMS) for participating faculty and their colleagues at their home institutions, as available. The team will develop a rubric to score the availability, consistency, learning goals, and cultural norm framing of online components. Based on direct experience, the team expects that online components are uneven (patchy among and within courses) in implementation and goals, do not address inclusion for first-generation and minoritized students (independent framing), and are limited in integrating the social element of learning. Using interviews of faculty, the team will quantify barriers to use of online curriculum; the team predicts that barriers include frustration with past technology offerings, training, cost, and time. To understand the student experience, the team will use surveys to determine experience and comfort levels, access issues, challenges, and if online activities have included adaptive technology or collaboration modes. The project team will use institutional data to quantify achievement, performance and completion gaps stratified by student demographics (including intersectionality) and segment.

Table 1: Project plan and timeline by team member role type. Biology Team Member = Biology faculty at each Team Member institution; Assessment = Educational Assessment faculty or specialist.

	Biology Team Member Task	Assessment Task
Phase 1a: Review of Existing Online Resources in Courses (Partners at institutions)		
July 2020	Demographics and performance: Course offerings, student demographics and performance. Identify courses offered and instructors who have taught the courses.	Assessment Design: Assist with IRB approvals. Assist with the development of a rubric and train team members to assess online components.
Aug-Sept 2020	Review and assess LMS online component according to rubric.	
Sept - Nov 2020	Faculty Experience: Identify faculty who have taught the course at the institution, conduct semi-structured interviews of experience with active learning and using online course materials in classes.	Survey & Interview Instrument: Assist with the development of faculty and student survey and interview questions. Compile and analyze results of surveys.
Oct-Nov 2020	Student Experience: Distribute survey to students for use of online elements to support courses.	
Phase 1b: Contribute to “Best Practices” & Existing Curriculum Resources Review (Collaborative)		
Oct 2020-Jan 2021	Literature Review: Synthesize selected research and examples of the design and implementation of social online tools for STEM education. Identify existing resources and approaches that can be utilized for pilot interventions.	
Phase 2: Online Collaborative Intervention Cycles (Partners at institutions)		
Jan - July 2021	Intervention design & pilot: Develop and pilot 3 collaborative online interventions.	Intervention Surveys: Design of intervention surveys. Pre- and post-surveys for students and faculty. Perform semi-structured interviews of faculty.
July - Aug 2021	Review outcomes of interventions and design modifications for Fall 2021.	Intervention Assessment: Review of data, data management.
Aug - Dec 2021	Implement the revised interventions, and/or assist with intervention for other faculty at the same institution.	Revised Interventions: Pre- and post-surveys for students and faculty.

<u>Phase 1b: Review of “Best Practices” and Existing Curriculum Resources in the literature.</u> Team members will collaboratively conduct a literature review to compile evidence from DBER, active learning, cognitive science, psychology, and online education research to develop a resource of case studies to serve as models for implementation and assessment. Simultaneously, the team will review and score existing curriculum resources for Introductory Biology and adjacent subjects (microbiology, geology, environmental sciences) for features desired in the design framework described in Phase 2. Digital resources to be reviewed include CourseSource (https://www.coursesource.org), the Science

Education and Research Center at Carlton (SERC, https://serc.carleton.edu), The American Biology Teacher Journal (https://abt.ucpress.edu), and others. The project team expects that these resources will need to be modified for deployment in an online, social and collaborative environment. These reviews will be used to build a list of candidate interventions for Phase 2.

Phase 2: Design and pilot collaborative and inclusive online interventions. Because the project team expects that faculty will report challenges with adding online curriculum components, the team will design the interventions to be used alongside the regular course content outside the classroom to occur in a “study group” environment. This approach reduces the burden on individual faculty to displace lecture material, instead adding support for students to develop connections with others. Moreover, this modular format allows the team to test the interventions alongside different courses. By emphasizing study skill activities such as drawing, mapping, and organizing information, rather than computationally graded activities the team expects to reduce stress of student-student interactions. These collaborative activities will all be developed to work without custom software, instead focusing on campus supported tools such as Zoom and Google Apps.

Data Collection/Analysis/Interpretation

At each institution that pilots the online interventions in the Introductory Biology course, the project team will evaluate the effectiveness of the interventions at increasing students’ sense of belonging and positive learning outcomes, using mixed methods assessments involving triangulation of data sources. The team will perform these evaluations in one class where students take part in the interventions, and one control class without interventions. All survey and interview instruments will undergo IRB review. The assessment will include: (1) measures of course-level student learning outcomes (e.g. exam performance and final course performance; (2) student surveys (pre- and post) designed to assess student self-regulation (e.g., UC Berkeley Bio1B Assessment tool, Haynes & Winters; Motivated Strategies for Learning Questionnaire, and others reviewed by Roth et al. 2016); (3) semi-structured interviews or focus groups of faculty; and (4) faculty self-evaluation of the course experience to identify constraints and opportunities for institutional segments.

Expected Milestones/Deliverables

Deliverable 1 [9/1/20] is an ADA-compliant TED-TALK style video describing the project, as well as a project graphic, tag-line, and team member photos for the Learning Lab web site.

Deliverable 2 [1/31/21] Year 1 Semi-Annual Report (written report and Zoom meeting with CELL): a summary report of Phase 1 data gathering that includes the landscape of the existing situation: (1) current Introductory Biology course offerings for the 5 institutions, including size of course, frequency of course offerings, available student demographics for the courses, and course-level student performance measures; and (2) a descriptive summary and rubric evaluation for each course on the current use of online materials, their quality, challenges for faculty, and student perceptions.

Milestone 1 [Feb 2021] is the design of the three 3 pilot interventions based on the literature review of best practices.

Milestone 2 [April 2021] will be classroom deployment of 3 pilot interventions.

Deliverable 3 [7/31/21] Year 1 Annual Report (written report and Zoom meeting with CELL and the cohort): a summary report of the pilot interventions, including results from faculty and student surveys.

Milestone 3 [September 2021] is an iterative redesign of interventions, ready for redeployment.

Milestone 4 [December 2021] will conclude surveys and interviews from iterations.

Deliverable 4 [12/31/22] Year 2 Final Report (Written Report and Zoom for CELL): a summary report of the results of the interventions, and a plan for scaling up the project to additional institutions. The project team plans to develop a full-scale CELL Innovation Proposal.

References

Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychological review. 1977 Mar;84(2):191.

Bosch N, Huang E, Angrave L, Perry M. Modeling Improvement for Underrepresented Minorities in Online STEM Education. InProceedings of the 27th ACM Conference on User Modeling, Adaptation and Personalization 2019 Jun 7 (pp. 327-335). ACM.

Castro-Alonso JC, Atit K. Different abilities controlled by visuospatial processing. In Visuospatial processing for education in health and natural sciences 2019 (pp. 23-51). Springer, Cham.

Chue S, Lee YJ, Tan KC. Iconic gestures as undervalued representations during science teaching. Cogent Education. 2015 Dec 31;2(1):1021554.

Collins A, Brown JS, Newman SE. Cognitive apprenticeship: Teaching the craft of reading, writing and mathematics. Thinking: The Journal of Philosophy for Children. 1988 Mar 1;8(1):2-10.

Ebert-May D, Brewer C, Allred S. Innovation in large lectures: Teaching for active learning. Bioscience. 1997 Oct 1;47(9):601-7.

Estrada M, Hernandez PR, Schultz PW. A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. CBE—Life Sciences Education. 2018;17(1):ar9.

Freeman S, O'Connor E, Parks JW, Cunningham M, Hurley D, Haak D, Dirks C, Wenderoth MP. Prescribed active learning increases performance in introductory biology. CBE—Life Sciences Education. 2007 Jun;6(2):132-9.

Gagnier KM, Atit K, Ormand CJ, Shipley TF. Comprehending 3D diagrams: Sketching to support spatial reasoning. Topics in cognitive science. 2017 Oct;9(4):883-901.

Haynes A, Winters J. Biology 1B Resource Assessment: 2017 and 2018. Unpublished report, University of California, Berkeley. 2019 Jun.

Kuh GD, Kinzie JL, Buckley JA, Bridges BK, Hayek JC. What matters to student success: A review of the literature. Washington, DC: National Postsecondary Education Cooperative; 2006 Jul.

Hurtado S, Ruiz Alvarado A, Guillermo-Wann C. Creating inclusive environments: The mediating effect of faculty and staff validation on the relationship of discrimination/bias to students' sense of belonging. Journal Committed to Social Change on Race and Ethnicity. 2018 1 (1), 60-80.

Johnson DW, Johnson RT. Cooperative Learning in 21st Century.[Aprendizaje cooperativo en el siglo XXI]. Anales de Psicología/Annals of Psychology. 2014 Aug 4;30(3):841-51.

Johnstone AH. You can't get there from here. Journal of Chemical Education. 2010 Dec 18;87(1):22-9.

Kaupp R. Online penalty: The impact of online instruction on the Latino-White achievement gap. Journal of Applied Research in the Community College. 2012 Apr 1;19(2):3-11.

Ormand CJ, Shipley TF, Tikoff B, Dutrow B, Goodwin LB, Hickson T, Atit K, Gagnier K, Resnick I. The spatial thinking workbook: A research-validated spatial skills curriculum for geology majors. Journal of Geoscience Education. 2017 Nov 1;65(4):423-34.

Roth A, Ogrin S, Schmitz B. Assessing self-regulated learning in higher education: a systematic literature review of self-report instruments. Educational Assessment, Evaluation and Accountability. 2016 Aug 1;28(3):225-50.

Steele CM, Aronson J. Stereotype threat and the intellectual test performance of African Americans. Journal of personality and social psychology. 1995 Nov;69(5):797.

Stephens NM, Fryberg SA, Markus HR, Johnson CS, Covarrubias R. Unseen disadvantage: how American universities' focus on independence undermines the academic performance of first-generation college students. Journal of personality and social psychology. 2012a Jun;102(6):1178.

Stephens NM, Townsend SS, Markus HR, Phillips LT. A cultural mismatch: Independent cultural norms produce greater increases in cortisol and more negative emotions among first-generation college students. Journal of Experimental Social Psychology. 2012b Nov 1;48(6):1389-93.

Vygotsky LS. Mind in society: The development of higher psychological processes. Harvard university press; 1978.

Wang CH, Shannon DM, Ross ME. Students’ characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning. Distance Education. 2013 Nov 1;34(3):302-23.

Xu D, Jaggars SS. Performance gaps between online and face-to-face courses: Differences across types of students and academic subject areas. The Journal of Higher Education. 2014 Sep 1;85(5):633-59.