Transforming Teaching and Learning at the University of California: Clearing Institutional Barriers

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Abstract Book

Abstracts 2017

A High Active-Learning Teaching Approach in Introductory Biology Courses Reduces Retention and Performance Disparities amongst Students from Underrepresented Minorities

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Abstract

Every year, a disproportionate number of UCSB students from underrepresented minorities decide to abandon their pursuit of a degree in biology and often switch to non-STEM majors. The largest disparity in student retention between URM and non-URM groups are observed in the first two years of the biology major. Current educational literature provides evidence that active-learning teaching approaches reduce performance disparities among vulnerable student groups, including URMs. Therefore, at UCSB we have designed an alternative, parallel lecture section of the introductory biology series to assess the efficacy of active learning in URM student retention and performance when compared to traditional lecturing methodologies. The alternative section is capped at a significantly smaller number of students than the traditional section; yet, the student demographics of both sections remain comparable. The learning objectives as well as the material covered by both sections remain the same, however, the alternative section incorporates a robust number of active-learning and student-centered teaching techniques including in-class activities and team problem-solving workshops. A number of parameters were evaluated to determine the efficacy of the High Active-learning approach (HAL), including common exam questions among the two sections, and the comparison of students to a predictive performance linear model based on academic and demographic characteristics. Our data indicate that the HAL section performed significantly better in most of the common questions. Importantly, URM students that participated in the HAL section performed significantly better than the corresponding prediction by the linear regression model as well as their comparable peers in the traditional lecture section. Further, the short-term retention, as measured by the proportion of students who enroll in the subsequent introductory courses, was significantly higher in the HAL section. Collectively, these results suggest that the High Active-learning approach are a viable, scalable strategy to significantly reduce the performance and retention gaps observed among URM and other vulnerable populations of students at early stages of their biological sciences education.

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A model for sustainable curricular undergraduate research experience in MCD Biology

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Abstract

One of the major challenges facing the Department of Molecular, Cellular and Developmental Biology is providing undergraduate research experience for our students. Only 10-15% of our ~2000 students are able to join faculty labs before they graduate. This is a problem, because nearly half of our majors are first generation college students and over one third are from under-represented groups. Our department recognizes that significant performance disparities exist, across our curriculum, for students from different genders and ethnicities, and that these gaps are reduced in laboratory classes.

To ameliorate this problem, I am working to leverage the past success of project-based labs, to launch curricular undergraduate research experiences (CUREs). These faculty-led labs will engage 35-50 undergraduate students in discovery-based research projects. My goal is to scale this program so that it serves all of our majors. To achieve this level of faculty-led undergraduate research, we are partnering with donors and industry.

In the last year, I engaged donors, companies, the UC Santa Cruz Technology Transfer Office and Industry Alliance Office to develop a consortium plan capable of supporting this initiative. One of the major driving forces for industry interest in this program is the development of human resources. If successful, our program will be able to provide a diverse, talented pool of well-trained scientists to our consortium members. I also piloted a CURE, called Splicing Lab, which engaged five undergraduates and forms the basis for the Toxic RNA Lab which launches in Fall 2017 and supports 36 students. This project is hypothesis-driven, discovery based lab that enables students to visualize themselves as scientists. The abstract for their project is described below:

Precursor messenger RNA (pre-mRNA) splicing is a critical post-transcriptional process in eukaryotic cells. For each splicing event, the complex cellular machinery known as the Splicesome must assemble onto the mRNA and excise precisely the desired number of bases. This concerted process is regulated by cis-elements within the RNA, such as splicing enhancers and silencers, and trans-elements such as RNA binding proteins. Approximately 10% of all disease-causing mutations affect consensus splice sites sequences, resulting in aberrant pre-mRNA splicing. It is less well understood how mutations affect other splicing regulatory-elements. Recent studies conducted by the Sanford lab and others, suggest that around ~26% of disease causing missense and nonsense mutations also interfere with splicing regulatory cis-elements (Sterne-Weiler et al. 2011). In this project, we focus on characterizing the molecular impact of mutations within the galactosidase A gene (GLA), which encodes the lysosomal enzyme alpha-galactosidase A. Deficiencies in this enzyme result in Fabry disease, a debilitating disorder which causes kidney disease, heart attack and stroke among other symptoms. Our previous studies identified 26 putative splicing sensitive mutations within the GLA gene. We hypothesize that these sites disrupt important functional elements involved in exon recognition by the splicing machinery.

Assessing the impact of Biology 20: The Dynamic Genome using quantitative and qualitative measures

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Abstract

Biology 20: The Dynamic Genome (DG) is a CURE for first-year undergraduates at UCR. The first half of the course focuses on key concepts in genetic information transfer and genome organization. Students complete three experiments where they learn techniques of PCR, gel electrophoresis, and pipetting to generate data that demonstrate the results of splicing, genome polymorphism, and regulation of transcription and bioinformatics such as BLAST, multiple sequence alignment, and genome browsers. During the second half of the course students complete a guided project from a professor's research. All students who take DG are part of the learning community program at UCR as are the students who take the traditional Biology 5LA lab course. Thus, we have a randomized controlled experimental design to assess the impact of the two lab courses on first-year undergraduates in the life sciences.

The strictly qualitative approach uses data collected by the institution such as grades, math readiness, ethnicity, and other socioeconomic factors. Mining these data strikingly shows that 93% of DG students earn a B (n = 648) or better in the introductory lecture course Biology 5A while only 43% of the control group earn an A or B (n= 809) regardless of math readiness or socioeconomic factors. Secondly, we are using a mixed-methods approach of interviews and surveys to identify which specific components of DG are causing the effect. Results from the pilot survey will be presented

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Attending to diverse student identities in the STEM classroom

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Abstract

Identity is a broad topic within STEM education research. At its core, identity seems to be an amorphous construct: There is something more than opportunity, experience, or aptitude at play that influences how students might engage or fail to engage in learning. In this study, we examine identify frameworks (discourse and positioning, figured words, and narratives) to operationalize and understand the diversity of student identities and their intersectionality: how students' developing sense of self as scientists, engineers, and mathematicians may interact with their ethnicity, gender, race, and socioeconomic class to create complex opportunities and challenges for learning and persistence in STEM. Specifically, we apply these identity frameworks to revisit classroom videos of students engaging in a well-studied inquiry-based calculus activity called the catwalk problem. Even though the catwalk problem is grounded in mathematical content, we discuss general insights into how students develop their STEM identity and what we as educators can notice and attend to in our classrooms to create more inclusive learning environments.

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Biomentors: Peer-led Collaborative Learning for Introductory Biology Students

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Abstract

Biology is one of the most popular majors at the University of California Santa Barbara with ~21% (~1000 students) of the incoming freshman class selecting pre-biology as their major. During the first two years, ~50% of the students leave the biology major. At UCSB, students enroll in a yearlong series of introductory biology lecture courses during the sophomore year after successful completion of introductory chemistry during the first year. The majority of students enroll in a large (600+ students) lecture course that has no discussion sections. To improve student success and retention in the major, several years ago we implemented an optional co-curricular peer-mentoring program called Biomentors to provide support to students enrolled in the introductory biology courses. This program involves pairing a successful upper class biology major with a group of 5-6 students to form a small collaborative learning community. The Biomentors act as facilitators to guide discussion among the group and encourage students to answer each other's questions. In addition, they discuss strategies to improve student study skills. Analysis of course performance indicates that students that who participate in Biomentors do significantly better than those that do not participate in the program.

Cal Teach Instruction at UC Santa Cruz

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Abstract

The Cal Teach program at UC Santa Cruz engages science, math, and engineering majors in exploring secondary teaching careers through coursework and field experiences in local and regional public schools and at UCSC. The program provides prospective secondary math or science teachers with undergraduate coursework, internships, advising, professional development, and scholarships to support participants from the exploration of secondary teaching careers through the teacher credentialing process and into their early teaching careers.

The ethnic diversity of Cal Teach students is similar to that of the campus as a whole, with greater participation from Hispanic/Latino and Asian students than that of the science division. Graduation data and anecdotal reports indicate that Cal Teach participation is associated not only with the recruitment and retention of secondary math and science teachers, but with college graduation rates.

Since 2006, Cal Teach has provided coursework linked with middle and high school-based internships. Student interns observe and assist in the classrooms of volunteer mentor teachers, taking on increasingly challenging teaching tasks. In 2016, Cal Teach expanded its opportunities for undergraduates to develop teaching skills. With support from a Howard Hughes Medical Institute grant, selected large lecture classes were transformed to integrate small group activities and conceptual problem solving; undergraduate Learning Assistants support the instructional teams during regular class meetings. Cal Teach provides the pedagogy course for the Learning Assistants, helping to prepare the Learning Assistants for success in the transformed classes and to develop skills for possible future teaching careers.

Claim, evidence, and reasoning: can students improve their ability to articulate scientific explanations in undergraduate biology?

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Abstract

Articulating scientific explanations is one of the most fundamentally important practices in biology, but it is rare that students are explicitly taught this competency within the context of their undergraduate courses. During the winter of 2017, we developed a quarter-long scientific literature project in introductory development and physiology aimed at teaching students how to articulate scientific explanations using the claim, evidence, and reasoning framework by reading and presenting an explanation of a peer-reviewed paper. We assessed student proficiency in this practice using a previously validated instrument and a rubric adapted to allow focus on practice distinct from content learning. A matched pairs t-test of pre- and post–assessment data revealed significant improvements in average student performance over a ten-week period. Given that only the reasoning and evidence dimensions of our adapted rubric show significant gains when isolated from the total score for matched pairs, our results suggest that these two dimensions drove the overall pre/post score improvement. These results indicate that making claims using evidence and reasoning is a skill that may be teachable to undergraduates within the context of an introductory course despite its complete absence in most traditionally taught college biology classes. Given the positive relationship between scientific practices and student motivation, self-efficacy, and retention, these types of practice-based interventions should be executed more often by higher education biology instructors to ensure a more equitable and authentic scientific curriculum.

Design and Evaluation of a Transitional Seminar Course on Transfer Student Experiences in a Research Intensive Institution

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Abstract

Students who transfer from community colleges to the UC System often struggle academically the first quarter and often report feelings of isolation, lack of belonging, even a year after their transition. Although statistically most students continue in the major and finish their degree successfully, the transition into the 4-year university can have negative impact on their self-efficacy and identity. Transfer students are a diverse group of learners, many come from low socio-economic backgrounds and are first-generation students. When surveyed, transfer students at our institution report that, although they feel academically prepared at the time of transfer, they were not prepared for the university culture, and have found the available resources lacking in this respect. Thus, we developed a seminar course to address the unique challenges faced by the students transferring into the College of Biological Sciences in our institution. This seminar course was loosely modeled after the existing first year program for Freshmen at our college, which consists of 1hr-faculty talks that expose the students to the research existing on campus, together with a presentation from the library and Health Sciences Advisor. However, we implemented significant changes tailored to our transfer student population. These changes included: (1) more class time designated to student interactions and discussions; ; (2) and a Q&A second-year transfer panel, (3) a values-affirmation exercise aimed at increasing self-efficacy; (4) a class session designated to address midterm stress, study skills, and increased metacognition. We are currently assessing the impact of this seminar through attitudinal surveys, weekly questionnaires, and first quarter GPA. We also plan to compare the long-term performance and attitudes of this group students compared to prior cohorts.

Favorable Results with Videos Instead of Lectures in Intro Cell/Molecular Biology

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Abstract

At University of California, Riverside, Introductory Cell/Molecular Biology (BIOL 5A) is taken by Life Sciences Majors as well as Engineers and students majoring in the Humanities. The course covers the Macromolecules, Cell Structure, Cellular Respiration, Photosynthesis, Chromosomes, Mendelian Inheritance, Gene Expression, and Mutations. A companion laboratory course (BIOL 05LA) is separate from the lecture. In recent years, much effort has been directed at improving student engagement and performance, such as use of clickers, weekly quizzes, and offering additional resources for outside help. Nonetheless, students continue to exhibit uneven engagement, evidenced by similar exam performance over time, irregular class attendance, and mixed results on course evaluations.

In response to a particularly low-attendance quarter in fall of 2016, and findings by instructors in the physical sciences, I converted the entire 10-week BIOL 5A course into a set of 64 Topic Videos of average length 8.25 minutes. These consisted of narrated, closed-captioned high-definition videos, mostly desktop capture of Powerpoint-style slides with some 15% of time working on a Whiteboard. Students watch the videos on the online platform PlayPosit, which allows embedding of multiple-choice questions. In summer of 2017, the course was offered with these videos in place of lecture; the classroom time was kept for exams and optional office hours. A 1hr/week Discussion, found in the traditional offering, was run by a Graduate Teaching Assistant and dedicated to going over past exam questions with the purpose of explaining the answers.

Despite eliminating the lecture for primary content delivery, student performance appeared to increase by approximately 5% on a set of 46 repeated questions distributed among the exams. Student evaluations showed an increase in self-described enjoyment of the course and its instructor. The evidence suggests that students can engage and perform better in introductory Cell/Molecular Biology with a suitably designed hybrid course.

Focusing on Equity and Inclusion to Improve Persistence in the Active Learning Classroom

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Abstract

There is widespread support for the importance of creating an equitable and inclusive classroom environment to improve persistence by underrepresented groups in STEM fields. Yet, as many instructors move to active learning and flipped course designs, explicitly integrating course elements that support equity and inclusion as part of this process is less common. We converted an introductory physiology and development course for majors to an active learning course design, and through two iterations of the course in Spring 2016 and Winter 2017, developed course elements to support three specific evidence-based areas to improve equity and inclusion. These areas included providing multiple opportunities to engage in STEM practices, providing opportunities for recognition by peers and instructors, and a variety of course community elements aimed at ensuring a sense of belonging by all students. Students were asked to complete a course evaluation in which we asked about their experience of equity and inclusion in the course. Over 80% of respondents in the active learning course reported that they felt more like a scientist after completing the course and that they felt the course was equitable and inclusive. We also had many qualitative examples of students expressing sentiments both in written and oral form that suggest the course has a positive influence on development of STEM identity. These results suggest that equitable and inclusive curriculum design is highly complementary to active learning course transformations. We propose that explicitly designing active learning courses with elements to foster an equitable and inclusive classroom environment should be as important as any other aspect of course design.

Identifying General Chemistry Students' Mind Maps

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Abstract

Constructivist theory states that knowledge is a dynamic entity that changes constantly. Experts' ability to effectively solve problems highlight that meaningful learning does not occur unless knowledge is organized. A learner is required to metacognitively revise the interaction between existing and gained knowledge in their mind. The organization of these structures is an important predictor for one's success in solving scientific problems.

A word association test was developed by selecting major concepts in the first course of Chemistry 2 as stimulus words. This test was further modified with concepts from the second and third courses in the series. For each test, students were asked to provide five response words within forty- five seconds of reading each stimulus word. After determining the frequency of the responses, the top twenty-five responses for each stimulus word were used to calculate relatedness coefficients, which measures the close relationship between words. Pathfinder and Gephi, network generating programs, were utilized to interpret the data and determine mind maps, a.k.a. knowledge or cognitive structures.

Depending on the differences in these knowledge structures, methods will be recommended to strengthen students' ability to monitor their knowledge structures. Connections between existing and new stimulus words from later courses will illuminate how successful a student in general chemistry is at constructing his or her knowledge structure.

Pen-and-paper modeling: recreating collaborative science practices in biochemistry and organic chemistry

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Abstract

The ISEE Professional Development Program trains graduate and postdoctoral researchers in the design and facilitation of active learning experiences that convey authentic STEM content and practices within an equitable and inclusive environment. Two original activities with widely variant content (ribosome function vs. molecular orbital theory) were designed around the same STEM practice: developing models to explain observed outcomes. Rarely formally taught in the undergraduate classroom, modeling integrates STEM content and practice into a meaningful learning experience that mirrors authentic research environments. Multiple avenues to engage this practice were designed into these activities, including content familiarization, group investigation, and assessment. Outcomes will be discussed from facilitating these activities with STEM junior college transfer students from diverse educational backgrounds.

Research Deconstruction: Building Knowledge and Self-Efficacy by Demystifying Sophisticated Science

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Abstract

Less than half of students who arrive at college with an intention to major in STEM fields eventually graduate with a STEM degree. This lack of persistence is particularly pronounced for students from underrepresented groups, women and who are first in their family to attend college. Although inadequate preparation for college level STEM coursework may play a role in this lack of persistence, social and psychological phenomena, such as stereotype threat, are also impediments to student success in STEM fields. I will describe a course, Research Deconstruction, that seeks to address these issues in freshmen and sophomores with an interest in biology. The class begins with a faculty colleague presenting a normal research seminar. In subsequent class meetings, I lead students through the seminar; help them identify and understand hypotheses considered by the speaker; explain the techniques described in the seminar; discuss experimental design, control experiments and data analysis; and have the students evaluate and critique the speaker's conclusions. Other lectures focus on being successful in college, choosing a major, finding research opportunities and career options. Although Research Deconstruction is open to all students, I specifically seek out students who are at risk for leaving STEM. My goals are to demystify science, to show these students that they can be successful in a rigorous scientific curriculum and to help them explore their potential interest in scientific research early in their college careers.

Small group inquiry as a way to foster critical thinking, further understanding of material, and improve test performance

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Abstract

Critical thinking is an important skill, but students are rarely given opportunities to develop it. Discussion sections are an ideal platform for students to practice critical thinking, as they are meant to reinforce the information taught in lecture in a more intimate setting—something that can be achieved many ways. In order to facilitate proper preparation for a critical discussion of topics in an introductory marine science course, I had students submit a question that required mastery of the reading material and critical thinking to fully answer; one such student submitted question being, “What would happen if thermohaline circulation stopped?” The questions were turned in on a public discussion forum—preventing students from submitting similar questions and allowing students who struggled with the task to look at examples. Student voting selected some of the questions we went over in discussion. However, after failing to engage students in vocalizing their critical thinking using a round table discussion format to discuss these questions, I developed a method of community based inquiry. Students were broken up into small groups and assigned a different student developed question to research and answer using any resources they wanted. Small group inquiry had three main benefits: 1) it was correlated with higher participation (100% vs. 76.7%±32.2%, $p<0.001$); 2) it was correlated with higher overall performance on exams (80.0%±10.5% vs. 72.8%±15.2%, $p=0.02$) and higher performance on exam questions that required critical thinking to answer (65.1%±25.1% vs. 47.2%±24.7%, $p=0.003$); 3) the students preferred small group inquiry (91.4 %) and felt that they learned more than they did with either a round table discussion (97.1%) or a more traditional question/answer format (80%). Many students stated that they were "comfortable expressing opinions," and that they "felt more included," which I think contributed to their mastery of the information.

Undergraduate Peer Mentoring Promotes EOP/URM Freshmen Academic Success

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Abstract

Over the past 20 years, the undergraduate student population at UCSB remained relatively static at approximately 19 000 students. However, the composition of the UCSB student body has changed dramatically. Enrolling freshmen classes comprise approximately 29% underrepresented minority groups (URM, African American, American Indian, and Chicano and Latino students), and nearly 40% of freshmen are first generation college students. Further, UCSB has recently been designated a Hispanic Serving Institution. The Biological Sciences is the most popular major selected by freshmen at UCSB. The ~1100 incoming prebiology freshmen reflect the overall campus diversity in that 30% come from URM and almost 40% are eligible for the Education Opportunity Program (EOP, based on parental education and family income).

Freshmen and sophomore students are part of the UCSB Prebiology Major until entering into their junior year. Although students are part of prebiology, freshmen students do not participate in Introductory Biology classes until their sophomore year. The first year of common courses include mandatory Introductory Chemistry with laboratory in each of the three quarters (Chem1A, B and C). In order to progress to full Biological Sciences major standing in their junior year, students must complete the Chemistry 1 series with at least a 2.0. Approximately 50% of prebiology freshmen do not progress to junior standing due, in part, to failing Introductory Chemistry. Therefore, in an effort to increase student retention of the freshmen cohort, we sought to establish small, active learning seminar classes led by near peers that foster the establishment of learning communities, discuss metacognition and promote academic success. Here we demonstrate that this seminar course promotes equity amongst the diverse students in the prebiology major; importantly, this course improves both EOP and URM student academic success and persistence at UCSB.

Using Student Annotated Hashtags and Emojis to Collect Nuanced Affective States

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Purpose

Determining affective states such as confusion from students' participation in online discussion forums can be useful for instructors of a large classroom. However, manual annotation of forum posts by instructors or paid crowd workers is both time-consuming and expensive. In this work, we harness affordances prevalent in social media to allow students to self-annotate their discussion posts with a set of hashtags and emojis, a process that is fast and cheap.

Main Findings

For students, self-annotation with hashtags and emojis provides another channel for self-expression and a way to signal to instructors and other students on the lookout for certain types of messages. This method also provides an easy way to acquire a labeled dataset of affective states, allowing us distinguish between more nuanced emotions such as confusion and curiosity. From a dataset of over 25,000 discussion posts from two courses containing self-annotated posts by students, we demonstrate how we can identify linguistic differences between posts expressing confusion versus curiosity, achieving 83% accuracy at distinguishing between the two affective states.

Description

A hashtag feature was rolled out to NotaBene (NB) and used in summer and fall quarter iterations of a course at University of California, Davis titled Introductory Biology 2A. Each iteration of the course enrolls over a thousand students. Reading assignments from on-line textbooks were posted on NB, and course points were awarded for commenting in NB. From the two courses, 293,316 posts were made by 2,353 unique authors. From the discussions, we extracted all the posts that contain a hashtag in the text of the post. We experiment with four different classification algorithms and compare their performance. The algorithms we choose are Logistic Regression (LR), Support Vector Machines (SVM) with a linear kernel,

Adaptive Boosted Decision Trees (ADT), and Random Forests (RF). We use 10-fold cross validation and average the results.

Relevance and Takeaways

We expect that others may be interested to learn about how NB can be used to learn student affect to inform instruction and how we are using these data to train automated classifiers that may one day help to streamline the automated acquisition of similar information from student commenting.

Young Physicists Tournament - competition for prospective students based on research conducted at high school

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Abstract

The US Invitational Young Physicists Tournament (USIYPT) is a debate-based competition for high school (HS) teams of students who work on a set of research problems with a HS teacher. This limitation make students more creative in the way they approach research vs. research at big universities, where HS students do not participate in building new apparatuses and do not develop their own experimental methods. Physics Olympiad is one more way to involve HS students, but is shortterm, lasting several hours, compared to USIYPT. The Tournament helps students develop research skills, as well as decide if they are interested in a research career. The Young Physics Tournament helps select research oriented prospective students. USIYPT-like problems could comprise part of the lower division lab curriculum. College of Creative Studies is using a similar approach in the last quarter of its sophomore physics lab course.

Going On-line with Chemistry and Biochemistry: Where Are We After 6 Years?

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Abstract

The Department of Chemistry and Biochemistry at UC Santa Barbara has been offering on-line Biochemistry Lecture (CHEM W 142A) during the Summer Session since 2012; this course is currently offered fully on-line also during the Fall quarter. An on-line Organic Chemistry Lecture (CHEM W 109C) has been taught three times since Spring of 2016.

The courses consist of an extensive open-book component, which includes (i) video recordings of classroom lectures as well as topic-based Learning Glass explanations, (ii) structured lessons, (iii) quizzes with a variety of interactive question types, (iv) and synchronous class discussions via video conferencing software. Each course ends with a comprehensive closed-book exam using questions similar to ones that have been used in the traditional face-to-face course taught by the same instructor. The day-to-day observed benefits of the on-line instruction include a high-rate of student participation in all point-earning activities, and the efficient identification and rapid remediation of specific weaknesses in student's understanding of the material. A consistently high correlation is observed between student performance on open-book assignments, and the final exam score. A long-term analysis of student performance before, during, and after on-line courses is still underway, but a few general trends have emerged. First, the enrollment in on-line courses has been notably lower than than in traditional face-to-face courses. Second, the performance of students in the closed book exam has been more-or-less the same regardless of the mode of instruction since 2004.

These two classes are available to all qualified UC students through the UC cross-enrollment system. However, the vast majority of students taking these on-line courses are from UC Santa Barbara. One barrier to including a broader set of UC students to these two classes is the difference in the content taught in the last part of the Organic Chemistry lecture series. For example, the CHEM W 109C at UCSB is heavily focused on the chemistry of bio-organic molecules, and serves as an effective preparation for the subsequent CHEM W 142A course. However, a few non-UCSB students who have taken the CHEM W 142A without prior coverage of bio-organic chemistry in their organic chemistry series have done well in this on-line Biochemistry course.