COLUMBIA | SOLER

Science of Learning Research Initiative

2020 Provost SOLER Seed Grants
Proposal Template

Section 1: Project Summary			
Award Year:	2020-2021		
Title of Study:	Evaluation of virtual reality for learning biochemistry and enhancing student engagement		
Principal Investigator (PI) Information			
PI #1 Name:	Brent Stockwell		
PI #1 Title:	Professor		
PI #1 Department:	Biological Sciences		
PI #1 Email:	bstockwell@columbia.edu		
Co-Investigator (CI) Information Use an asterisk (*) to denote any CI who will serve as a Co-PI.			
CI #1 Name:		**CI #2 Name:**	
CI #1 Title:		**CI #2 Title:**	
CI #1 Department:		**CI #2 Department:**	
CI #1 Email:		**CI #2 Email:**	
CI #3 Name:		**CI #4 Name:**	
CI #3 Title:		**CI #4 Title:**	
CI #3 Department:		**CI #4 Department:**	
CI #3 Email:		**CI #4 Email:**	

Abstract: Describe the project in lay terms; articulate the project objective; specify what makes the project innovative; describe your assessment or evaluation plan to ascertain student impact. (Limit 250 words.)

While some students have the necessary foundational knowledge to effectively learn biochemistry through traditional modalities, a sizeable group of students struggle to understand key concepts and apply them effectively to solving biochemistry problems. For these students, small group discussions with the instructor and with other students is a crucial part of the learning process, likely because this exposes the misconceptions they have but are not aware of. This small group discussion with peers and the instructor is difficult to replicate online, even in a video chat format such as Zoom.

We propose that virtual reality (VR) provides a technology that can improve student engagement in a small group discussion format by creating an immersive experience where attention is focused on challenging concepts in biochemistry. In addition, VR affords the use of realistic 3D structures to illustrate key biochemical concepts more effectively than with 2D tools in Zoom or even with textbooks and a whiteboard in discussions on campus. Thus, holding small group discussions and office hours in VR may substantially enhance student experience relative to being on campus or current online formats. We will evaluate the impact of holding weekly small group discussions on Zoom versus in VR on several outcomes: quiz, exam, and problem set performance, student satisfaction, and research proposal quality. We hypothesize that the immersive nature of small group discussions in VR will enhance student outcomes as assessed by these metrics.

Section 2: Project Description
Please complete each subsection taking into consideration the accompanying guidelines.

Section 2a: Project Scope. (Limit 500 words.)

- *Framing: Specify your overarching objectives; identify and describe sub-goals or specific aims and how these align with the overarching objectives; identify how the proposed innovation will meet those goals.*
- *Participants: Identify your target participants (e.g., students); specify how participants will be identified and contacted; approximate how many participants will be impacted during the grant period; briefly describe how the innovation will continue to benefit later student cohorts beyond the PSSG duration.*

Introductory Biochemistry. In GU4501: Biochemistry I, we explore the basic biochemistry of living systems and how this knowledge can be harnessed to create new medicines. Students learn how living systems convert environmental resources into energy through metabolism, and how they use this energy and these materials to build the molecules required for the diverse functions of life. We discuss the applications of this biochemical knowledge to mechanisms of disease and to drug discovery. We look at examples of drug discovery related to neurodegeneration, cancer, and the SARS-CoV-2 COVID19 pandemic. This course satisfies the requirement of most medical schools for introductory biochemistry, and is suitable for advanced undergraduates, and some beginning graduate students. The fall 2020 course is projected to enroll 90-130 students. Traditionally, this course has been taught on campus, but has been adapted to an online format due to the SARS-CoV-2 COVID19 pandemic.

The challenge of creating immersive online learning experiences. While some students have the necessary foundational knowledge to effectively learn biochemistry through traditional modalities, a sizeable group of students struggle to understand key concepts and apply them effectively to solving biochemistry problems. For these students, small group discussions with the instructor and with other students is a crucial part of the learning process, likely because this exposes the misconceptions they have but are not aware of. This small group discussion with peers and the instructor is difficult to replicate online, even in a video chat format such as Zoom. The difficultly in replicating the effectiveness of small group discussions online is due to lack of an immersive experience in the videoconference format such as Zoom. This low engagement is caused by a number of issues, such as small screens with many participants, and the constant presence of distractions with a high degree of salience, including social media, email, and household distractions, and the difficulty and inequity of enforcing continuous webcam use. The lack of total immersion in a conversation makes it challenging to find and correct the sources of student errors and misunderstandings.

Proposed use of virtual reality to create an immersive small group learning environment. We propose that virtual reality (VR) provides a technology that can improve student engagement in a small group discussion format by creating an immersive experience where attention is focused on the challenges of learning biochemistry. In addition, VR affords the use of realistic 3D structures to

illustrate key biochemical concepts more effectively than with 2D tools in Zoom or even with textbooks and a whiteboard in discussions on campus. Thus, holding small group discussions and office hours in VR may enhance student experience relative to on campus or current online formats.

Impact and Application of Results. The results of this study will be used to determine whether virtual reality is a preferred format for small group discussions of biochemistry. The students have reported enjoying a team-based approach, so I hypothesize they will enjoy the more immersive version of these discussions. If we find that virtual reality is more effective and enjoyable for these student discussions, in a future year, we will be poised to examine whether larger groups or even the entire class would benefit from use of virtual reality.

Section 2b: Rationale and Literature Review. Highlight key findings of relevant educational research. Include citations as appropriate. Describe any prior work your team has done in this space. (Limit 500 words).

Use of prior tools for maximizing student learning. To maximize student learning and engagement, we implemented several changes to the course in the last few years, relative to traditional undergraduate science pedagogy, involving (1) pre-class online videos to create class time for active learning, (2) online quizzes completed before class to motivate students to prepare for each class, (3) an LMS-integrated live polling audience response system (PollEverywhere) to monitor student understanding in class, (4) team-based problem solving in class, (5) reading and discussing frontier primary research papers to expose students to the discovery nature of science, and (6) developing an original research proposal to learn the process of designing research projects in biochemistry. Despite using these methods, we suspect that the online format may fall short of the traditional on-campus experience for some students, where they engage more deeply in office hours on the topics that they struggle to master. Unfortunately, current methods for teaching science online, such as Zoom, are likely to have limited effectiveness for many students due to low engagement in the online medium, leading to high attrition of students from science and medicine, especially for underrepresented groups (Kaupp, 2012; Wladis et al., 2015).

Proposed use of virtual reality to create an immersive small group learning environment. We hypothesize that virtual reality provides a technology that can improve student engagement in a small group discussion format, by creating an immersive experience where attention is focused on the challenges of biochemistry. In addition, virtual reality offers the possibility of using realistic 3D structures with students to illustrate key biochemical concepts in a way that is hard to explain using 2D tools in Zoom or even with textbooks and a whiteboard in discussions on campus (Garcia-Bonete et al., 2019). Thus, holding small group discussions and office hours in virtual reality may provide a substantially enhancing learning experience compared with both on campus and current online formats.

References:

1. Garcia-Bonete, M. J., Jensen, M., & Katona, G. (2019). A practical guide to developing virtual and augmented reality exercises for teaching structural biology. *Biochemistry and Molecular Biology Education, 47*(1), 16-24.
2. Kaupp, R. (2012). Online penalty: The impact of online instruction on the Latino-White achievement gap. *Journal of Applied Research in the Community College*, *19*(2), 3-11.
3. Wladis, C., Conway, K. M., & Hachey, A. C. (2015). The online STEM classroom—Who succeeds? An exploration of the impact of ethnicity, gender, and non-traditional student characteristics in the community college context. *Community College Review, 43*(2), 142-164.

Section 2c: Assessment and Evaluation Plan. Address how sub-goals or specific aims will be measured: Describe novel or to-be-adapted measurement tools (e.g., surveys). Outline key comparisons and briefly describe data analysis procedures. Indicate how you will monitor the effectiveness of the project as it evolves. Identify curricular changes you envision your project leading to at Columbia and describe how such changes will be achieved.
(Limit 250 words).

Project activities. Students will be invited to enroll in this voluntary study, which will be submitted to the Columbia IRB for approval of this human subjects research. Students who enroll will be randomized into the VR or Zoom small group discussion group. We expect to enroll 60 students in the study, and to randomize them into two groups of 30 students. Students in the VR group will be lent VR headsets, such as Oculus Quest or Pico Neo 2, the latter with eye tracking; students will sign up for small group discussions with the instructor and up to 10 other students, which will be held in a VR videoconference platform, such as ENGAGE, where they will discuss their questions with each other and with the instructor. Students in the Zoom arm of the study will similarly sign up for small group discussions with up to 10 students and the instructor in Zoom. The performance of students on regular course assessments will be analyzed at the end of the study, and students will be given a short questionnaire to determine their satisfaction with the small group discussion format. All students who participate in the study will be given a $20 gift card to compensate them for the effort involved in participating.

When students ask questions that can be addressed using media tools, the instructor will bring these tools into the discussion, either in Virtual Reality or in Zoom, depending on the group.

Analysis: We will compare the mean scores on quizzes, exams, and problem sets between the VR and Zoom arms using t tests for continuous variables. Students will complete a survey at the end of the course which will include satisfaction with the small group discussions using a Likert scale from 1 to 5 and mean scores will be compared between the arms using t tests. Research proposals are graded on a 100-point scale using a defined rubric.

Section 2d: Role of Key Personnel. Specify the expectations and obligations of all project personnel. Include a brief description of requested assistance from SOLER facilitators.
(Limit 150 words.)

The need for rigorous assessment using a randomized controlled trial. It is essential to rigorously evaluate this introduction of VR in the precise environment and manner in which it is being used. Therefore, we will run a randomized controlled trial (RCT) assessing this new approach, with the assistance of Melissa S. Stockwell, M.D., M.P.H, an expert in the design of minimal risk pragmatic clinical studies that take place in real-world conditions as well as in digital technologies (disclosure: she is also my wife). We have together collaborated on two published trials of innovative research methods (PMID 28691073 and 26317458). The Columbia IRB will be asked to approve this trial, in which students who voluntarily elect to participate will be randomized to one of the two groups.

Support provided by Emerging Technologies group. We will need assistance from the Emerging Technologies group to implement the VR discussion groups. This will involve suggesting and training on suitable software, such as Engage and the applications compatible with Engage, as well as recommendations and training in the use of hardware. Some development efforts in VR may be needed, as the project develops.

Support requested from SOLER. A number of questions regarding the study design are likely to arise as the technical component of the project develops. We will seek consultation from SOLER as to the

best way to address these questions. For example, it may be the case that the virtual environment in which small group sessions will take place can also be viewed by students without VR headsets (i.e., on a traditional computer screen); as such it may be useful to modify the study design to examine student experience in that intermediate context (i.e., between Zoom and VR in terms of immersiveness). Support from SOLER is also requested regarding obtainment of IRB approval.

Section 3: Project Timeline
Use a timeline to depict the schedule for your project. The timeline should include start and finish dates for your project as well as the dates or periods during which various project tasks will occur. All elements of the project should be completed within 12 months of receiving funds.

- Selection of VR-related hardware and software, selection and/or development (as needed) of 3D models and other learning materials, and refinement of study design will take place in July-August 2020.
- Study will be implemented concurrently with the course during the fall semester of 2020. All study data will be collected during that semester.
- Data analysis and drafting of final report will begin at the conclusion of the course and will be completed during spring semester of 2021.

Section 4: Budget Overview and Justification.
Provide a detailed budget and justification for funds. Funding can be used for course preparation, external course content, technology and media development costs, administrative costs, and teaching assistants/research assistants. Please mention all other sources of funding, if any. The total requested budget should not exceed the maximum award amount of $5,000.

Other funding sources.
This project received $20,000 in funding from the 2020 Office of the Provost Teaching and Learning Grants, Emerging Technology Grant (awarded June 2020). The costs of content development and software, as well as the majority of hardware costs, will be covered by the Emerging Technology Grant. The PSSG is requested to cover additional costs, detailed below.

Budget.
VR headsets (10 students x $400/student): **$4,000**
Cables and adapters for headsets (10 x $30/unit): **$300**
Carrying cases for headsets (10 x $40/case): **$400**
Shipping costs ($30 each way x 10 headsets): **$300**
TOTAL: $5,000

Budget Justification.
The VR headsets will allow the students randomized to the VR group to complete the study.
The cables will be needed to ensure all headsets can be connected to laptops.
The cases will be needed to ensure headsets and cables are not lost or damaged.