



# COLUMBIA | SOLER

## Science of Learning Research Initiative

### 2021 Provost's SOLER Seed Grants Proposal Template

Section 1: Project Summary			
<b>Award Year:</b>	2021-2022		
<b>Title of Study:</b>	Evaluating Oculus Quest 2 and Glue as a Virtual Reality (VR) Platform for Learning Biochemistry		
Principal Investigator (PI) Information			
<b>PI #1 Name:</b>	Brent Stockwell		
<b>PI #1 Title:</b>	Professor		
<b>PI #1 Department:</b>	Biological Sciences		
<b>PI #1 Email:</b>	bstockwell@columbia.edu		
Co-Investigator (CI) Information			
Use an asterisk (*) to denote any CI who will serve as a Co-PI.			
<b>CI #1 Name:</b>		<b>CI #2 Name:</b>	
<b>CI #1 Title:</b>		<b>CI #2 Title:</b>	
<b>CI #1 Department:</b>		<b>CI #2 Department:</b>	
<b>CI #1 Email:</b>		<b>CI #2 Email:</b>	
<b>CI #3 Name:</b>		<b>CI #4 Name:</b>	
<b>CI #3 Title:</b>		<b>CI #4 Title:</b>	
<b>CI #3 Department:</b>		<b>CI #4 Department:</b>	
<b>CI #3 Email:</b>		<b>CI #4 Email:</b>	
Abstract: Describe the project in non-technical language; articulate the project objective; specify what makes the project innovative; describe your assessment or evaluation plan to ascertain student impact or other insights. (Limit 250 words.)			
Learning biochemistry is challenging for students using chalkboards, Powerpoint and Zoom, due to 3D aspects of molecular conformations. In all environments, learning can be compromised by a lack of attention. VR offers a solution to both issues—it can be more immersive and enhance attention due to the lack of distractions, and it allows engagement with 3D objects, such as proteins, that cannot be directly experienced in the real world. We previously performed a pilot study using VR to teach biochemistry using Oculus Quest 1 headsets and Spatial.io, meeting with students to discuss 3D aspects of biochemistry. We propose to improve upon that experience by upgrading the tools: Quest 2 headsets will allow up to 40 people to meet together in the online platform Glue, whereas Quest 1 headsets will only allow 15 people to meet. Quest 2 headsets will be needed to accommodate the size of the GU4505 VR Biochemistry course. Glue offers more realistic animated avatars that provide a better sense of presence—being together in a VR space—which may enhance student engagement. Finally, we will explore the feasibility of generating animated FBX files to show molecular motion in VR, which may further aid in understanding biochemical mechanisms. To evaluate the impact of these			

tools, we will perform a survey of students, administer a voluntary quiz, and compare performance on the normal course exams between students in GU4505 (the VR recitation) and GU4501 (the Zoom recitation).

## Section 2: Project Description

Please complete each subsection taking into consideration the accompanying guidelines.

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

- Framing
  - State your overarching objective(s).
  - Identify specific aims and explain how they align with the overarching objective(s).
  - Describe the overall methodology that will be used in this study, covering such factors as retrospective vs. prospective data collection, interventional vs. non-interventional, randomized vs. non-randomized, observational, experimental, etc.
- Participants
  - Identify your target participants (e.g., students).
  - Specify how participants will be identified and contacted.
  - Estimate how many participants will be impacted during the grant period.
  - Briefly describe how the innovation will continue to benefit student cohorts beyond the PSSG duration (e.g., through curricular changes).

The overall objective of this study is to evaluate a new set of tools for teaching biochemistry in VR; these tools include Quest 2 headsets, the online VR platform Glue, and animated FBX files. These tools will be evaluated for up to 25 students in GU4505 (VR Biochemistry) and up to 75 students in UN3511 (Zoom Biochemistry). Students choose to register for one of these courses in the upcoming Summer A session. All students who enroll in these two courses will be invited to participate in this study. The specific aims are:

1. Acquire and distribute Oculus Quest 2 headsets to up to 25 students enrolled in GU4505 (a biochemistry course taught in VR). Headsets will be shipped to students who cannot get to campus, and headsets will be distributed to students on campus through the Library. Headsets will be returned by Fedex, and cleaned after return.
2. Pilot Glue as a VR meeting space for learning biochemistry. We will sign a license agreement with Glue for 2 months to enable the GU4505 students and staff to meet together in this space to learn biochemistry once each week on Friday mornings. We will use the breakout rooms and spatial audio features to allow students to work in teams in VR, along with Polleverywhere accessed via a browser, with results shared using the camera feature in Glue. The students' experiences on this platform will be assessed using a survey, a voluntary quiz, and the normal course exams. The students who enroll in GU4501/UN3511 (the normal Zoom recitations) will serve as a control group.
3. Pilot animated FBX files in Glue to allow students to see molecular motion in VR. We will create animated FBX files showing molecular motion using Blender. The science visualization design firm Digizyme will collaborate with the research team to support this effort. The effectiveness of these animations will be evaluated with the same tools used in aim 2.

The comparison between the students in GU4501/GU4505 and GU4501/UN3511 is not ideal, because the VR and Zoom recitations meet on different days, the registration was not randomized but rather at the students' discretion, and the Zoom recitations are led by teaching assistants whereas the GU4505 VR recitation is led by Professor Stockwell. These differences introduce confounding factors that limit the interpretability of our results, i.e., the extent to which any measured performance or attitude differences between the two recitation sections can be explained by their respective formats. . However, given the logistical constraints, this study will nonetheless be a pilot on the technical feasibility of using these new advanced VR tools and provide a preliminary assessment of their

potential effectiveness. Any positive results could be followed by a subsequent randomized controlled trial to rigorously assess the impact of VR vs Zoom once the ideal platform is established. We envision a long-term impact of incorporating a VR aspect to biochemistry for all students once the ideal platform and impact have been established. This would be the first Biochemistry course in the world taught in VR, and could be a model for other science courses, such as introductory Biology, that also feature major learning objectives related to molecular conformations and interactions

Section 2b: Rationale and Literature Review. (Limit 500 words.)

- Describe how the project aligns with national and/or Columbia strategic initiatives.
- Highlight key findings of relevant educational research. Include citations as appropriate.
- Describe any prior work your team has done in this space.

A major question facing Columbia University, and indeed all high education institutions at this time, is what the value proposition is for learning at an expensive private university. With the continually increasing tuition of the past decades, and the rise of MOOCs, Coursera, EdX, LinkedIn Learning, Udemy, Youtube, and other low-cost online learning options, the financial pressures on Columbia have grown. The urgency of these pressures were greatly accelerated by the pandemic and the need for remote learning. A potential solution to these challenges is to provide a technologically advanced learning platform with two key features: (1) enhancement of both remote and in-person learning by leveraging the group experience of learning with fellow Columbia students and instructors, and (2) accessibility to students around the world. This would validate the expense of a Columbia education whether experienced on campus, in hybrid mode, or fully remotely. Virtual reality offers the possibility of such a technologically advanced solution for accelerating deep learning. We previously evaluated the Oculus Quest 1 headsets with Spatial.io as an online VR platform. We learned a number of things from this pilot study that informed the current proposal:

1. Being able to create reliable 3D molecular models is key to helping students learn—thus, we now will use Blender to render 3D protein structures in FBX format, and explore animating protein motions.
2. Students need training in how to use VR headsets, the online platform, and how to interact with and understand 3D molecular models in VR; we will offer them training in each of these aspects this time.
3. Student performance on exams was generally already high—we will thus offer a dedicated voluntary quiz that specifically relates to the advanced 3D concepts we cover in VR.
4. The greatest advantage in VR lies in both the simulation of presence and in learning 3D-related concepts; thus, we will switch to the Glue platform, which has a better simulation of presence, and focus on 3D aspects of protein biochemistry that are hard to learn with 2D tools.
5. Finally, students need a way to take notes in VR as they can in Zoom; thus, we will have students exit VR towards the end of the session, take notes on as much as they can recall from the session using Padlet, making use of the recall effect for learning, and then rejoin VR, where we will all share the notes from all of the teams, which will also be available to them offline after the session.

Section 2c: Assessment and Evaluation Plan for Specific Aims. (Limit 250 words.)

- Describe novel or to-be-adapted measurement tools (e.g., surveys).
- Outline key comparisons and briefly describe data analysis procedures.

We will enroll students in an IRB-approved human subjects protocol to evaluate the impact of these VR improvements on learning biochemistry. Students will be offered a \$20 Amazon gift card as an incentive for enrolling. Students who enroll will be asked to complete a survey about their experience and a quiz at the end of the course, and their performance on normal course exams will be compared in Zoom vs VR recitations. Students in the Zoom recitation will receive the same materials, but in 2D format (PDF). Students in the VR recitation will also receive training in how to use the Oculus Quest 2

headset, how to use Glue, and how to examine molecular structures in VR. We will compare the performance of the students in the Zoom vs VR groups, knowing that other confounding variables may impact the results, but expecting that this study will be a technical pilot on the feasibility of these alterations.

**Section 2d: Role of Key Personnel. (Limit 150 words.)**

- Specify the expectations and obligations of all project personnel.
- Outline expected needs for in-kind support from SOLER facilitators.

Professor Stockwell will run the VR recitation and work with Glue and CUIT to create and import 3D assets and 3D animations. We will collaborate with Digizyme on creating some animated 3D files. SOLER will assist in IRB protocol approval, generating the survey and quiz, and analyzing data. CUIT will assist in ordering headsets and arranging a license with Glue. The library will assist in distributing headsets.

**Section 3: Graphical Project Timeline**

Use a graphical 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. Indicate how you will monitor the effectiveness of the project as it evolves. All elements of the project should be completed within 12 months of receiving funds.

Activity	Launch of course				During course							Post course
	5-Apr	12-Apr	19-Apr	26-Apr	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	
Obtain funds from SOLER and Provost												
Order headsets												
Arrange license with Glue												
Create 3D FBX files												
Create animated FBX files												
Initiate IRB												
IRB approval												
Design survey												
Design quiz												
Recruit students												
Run study												
Administer quiz and survey												
Analyze data												
Write report												

**Section 4: Budget Overview and Justification.**

Provide a detailed budget and justification for funds. Funding can be used for expenses such as equipment, shipping, media development, compensation for study participants (typically students), compensation for research assistants, and conference registration. Please mention all other sources of funding, if any. The total budget requested should not exceed the maximum award amount of \$5,000.

**Purchase 10 Oculus Quest 2 headsets (\$400 x 10) = \$4,000**  
**Gift cards for students (40 x \$25) = \$1,000**  
**TOTAL: \$5,000**