2024 Technology Fee Full Proposal

Title: Enabling Scientific Discovery through Virtual Reality in the Classroom

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Sponsoring Organization: College of Liberal Arts and Sciences

Purpose and Specific Objectives:

Virtual reality (VR) is not just a buzzword; It is the future for pedagogical engagement and science education and is particularly effective in the realms of chemistry. VR transports us to immersive worlds, making abstract scientific concepts tangible. When immersed in the VR experience, students get to *touch*, *build*, *modify* and *understand* molecular properties while learning critical chemistry and biochemistry concepts.

Students have a transformative experience as they delve into the 3D nature of molecular chemistry, hydrogen bonding, steric clashes, conformational structures, and a myriad of chemical concepts that depend directly on the spatial properties of molecules. Students can embody an ideal gas atom; build protein and see them fold in their own hands; superimpose 3D molecules to differentiate isomers; see how the interaction between two molecules that leads to disease can be interrupted by *crafting* the active site in an inhibitor molecule, all within the Virtual Reality world. Students going into health-related sciences have the added value that they are introduced to a technology that is common in the training of health professionals.

Our proposal is to bring VR technology to the undergraduate education realm. Specifically, we aim to reach over 2,000 students/yr by procuring the VR infrastructure for technology innovation in large-enrollment, lower-division courses taken by majors and non-majors and taught in the Chemistry Department. We request funds to support the purchase of Oculus Quest-2 and 1 yr Nanome package. Through this technology, the Department of Chemistry will be able to offer an exceptional academic environment serving an extensive fraction of the thousands of students that regularly take courses in Chemistry. We expect that successful implementation within such a large department will pave the way for its implementation in other science departments at UF.

Impact/Benefit:
VR in an academic environment is not new, but until now it has only been implemented in small groups, within very controlled environments, and consequently, reaching a limited number of students with a considerable commitment from the instructors. **The funding from the Technology Fee will be used to expand the implementation of the VR transformational pedagogical tool into more courses and large-enrollment courses; our previous experience shows that the proposal is technically feasible and will impact over 2,000 students every year.**

In 2019, our first pilot used resources offered by the Marston Science Library (Made@UF). We reserved their room for several hours and students were assigned in staggered schedules. There were only three headsets, so this activity was limited to 6 student participants at a time – not a sustainable model for large-enrollment courses. Nevertheless, it provided enough information to prepare us for a second, independent pilot implementation of VR in chemistry courses in 2022/23. Taking advantage of funding from NSF (for a separate outreach program), one of us purchased 12 Oculus Quest-2 headsets. In this new pilot, each pair of students took 15 min turns to build a small protein -one aminoacid at the time- and then, watched it fold. While one performed the protocol embedded within the immersion exercise, the other followed it as it was cast in a laptop screen and could guide the first student through additional steps. The new infrastructure combined with a chemistry-oriented software package (Nanome.ai) allowed us to easily create new immersive exercises and optimize the protocols. We have used them in

- regular classrooms and laboratories,
- during the regularly scheduled class periods,
- working simultaneously with 25 students in the classroom/lab.

Classroom demos are often used to help students learn new concepts. Actively participating within the VR environment put the students at the center of the visualization exercise. For example, in one pilot immersion, students in one Gen Chem course experienced the direct benefit when learning about molecular stereoisomers. Instead of struggling with drawing a 3-D molecule on a flat piece of paper (trying to evaluate bond orientations), inside the VR immersion students walked among stereoisomer pairs, picked them up with their hands, turned them around, tried to superimpose them, and manipulate them in the 3D space until they could see and understand each specific stereoisomer bond orientation. The experience increased students' engagement, which led them to ask more questions and become more curious about the subject. Feedback from those who participated in the pilot program was very positive. It became easier to understand a challenging concept. The success of this pilot is the basis for the proposed scaling up!

Since that first small pilot, we developed, tested, optimized, and implemented experiences in different classroom environments, reaching as many students as the 12 lent headsets allowed us. We are at the point where the impact can be multiplied to reach over 2,000 students if we procure the appropriate infrastructure.

Through the pilot program we learned the requirements to develop good, SLO course-related immersive exercises, and how to standardize the use of the technology in a large classroom. We are already developing planned protocols to **simultaneously** serve up to ~70 students in a regular classroom during a 2-period time frame. We also gained experience with the software and have the expertise required to expand the use to multiple courses, affecting a much larger number of students. The table below shows the potential **benefit to over 2160 students who will engage in chemistry using VR immersions each year**.

Course		# Students
2019 initial pilot with up to 10 students present at the time in the Marston Science Library		
CHM2047 (4cr) 'F19	One-semester General Chemistry course for freshman students	30
CHM3217 (4cr) S'19	Organic Chemistry/Biochemistry 1	65
Current pilot with up to 25 students present at one time in one classroom		
CHM4413L (2cr) S'22	Biophysical Laboratory, students in the Biochemistry track	104
CHM2047 (4cr) S'23	One-semester General Chemistry course for freshman students	34
IDS2334 (3cr) S'24	Chemistry in the Cocina Latina, Quest 2, Gen. Ed.	24
CHM3610L (2 cr) S'24	Inorganic Chemistry Laboratory	10
CHM4413L (2cr) S'24	Biophysical Laboratory, students in the Biochemistry track	100
CHM2050 (3cr) 'F24	General Chemistry 1 Major (Honors) (already planned for Fall)	85
Courses where instructors already committed to use VR with up to 50-60 students present at once		
CHM2047L (1cr)	One-semester Gen Chem Lab for freshman students	30
CHM2051 (3cr)	General Chemistry 2 (Honors)	90
CHM2211L (2cr)	Organic Chemistry Laboratory	1591
CHM3610 (3cr)	Inorganic Chemistry	105
CHM4272 (2cr)	Organic Chemistry of Polymers	40
CHM5275 (2cr)	Organic Chemistry of Polymers	24
IMPACT: Number of undergraduate students that will be reached EACH year		**2161**

Implementation:

We propose to implement the scale-up of VR by starting each immersion with one instructor/TA in a shared VR room with 4 groups. Following the demonstration of some common instructions, each group goes to their individual VR room, where they follow the protocol, accessible within the VR environment. At any time during the class, the Nanome software allows the instructor/TA to enter the room to provide help. Inside the VR room, students will also have access to an interactive tutorial video that can be played at any moment.

Depending on course settings, we consider two models:

- Discussion/laboratory sections (less than 25 students): Requires 10-12 sets at the time with 3 instructor/TA present. Students work in groups of 2, with one student at the time inside the VR room, while simultaneously casting on the laptop screen for their partner. Implementation tested successfully in the pilots.

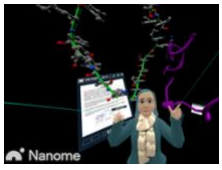
- Lecture/laboratory (~75 students or less): Scaling up the use of VR headsets from 12 to 25-30 is manageable, with groups of 3 students per headset. For every 4 groups there will be one Teaching Assistant (common in some of these course settings) who can assist the students inside the VR rooms. Although these courses might require more preparation, we already have the experience to achieve it. We expect to reach up to 75 students in each section that have 2-period lectures/labs, leading to full access of VR for thousands of students.

Accessibility:

Given that the immersion experience is cast on an external 2D laptop screen, accessibility resources regularly used when a class uses visual presentations (ppt presentations) will be implemented here. Two examples are described here, although student-specific accommodations can only be fully developed by considering the needs of the actual student. A student with vision impairments or low vision can have access to MAGic, magnifying the laptop screen where the exercise is being cast; the student could be paired with a sighted student who can relate the image content as it is cast on the laptop screen. The instructor can also cast the VR immersion in the room screen, facilitating the participation of students who don't use the headset. The exercises don't require to listen to instructions, still a student with a hearing impairment has the option to use a "passthrough" visibility setting (available within Nanome), which permits to maintain visual contact with the classroom (and instructor) while performing the exercise.

One potential challenge associated with VR headsets is the discomfort that some students might feel after long periods of use (dizziness has been reported). Having received feedback from students, we developed the protocols where each student uses the headset for no longer than 15 min, after which they switch, allowing for periods of rest before continuing. Since the exercise is continuously cast on their laptops screen, both partners participate.

Sustainability:



The full implementation of the immersive experiences requires acquisition of the headsets, extended batteries and Nanome package licenses. The Chemistry-oriented package Nanome is ideal for developing the chemistry immersions. Nanome allows for real-time collaborations where the instructor and students share space in a single VR room for an introductory period and then move into their own spaces to work on their assignments. It is also user friendly to develop new exercises, making it well suited to integrate other instructors into the program.

Nanome has different options for their licenses. The free version that we have used for piloting simple immersions has limitations, thus restricting the number of students that could be reached. To implement the expansion to reach 2,161 students, we must use of their ACADEMIC license. A site license option is being explored, but it would depend on the number of headsets purchased.

Once the new equipment is purchased (Oculus Quest-2 with strap and additional battery) the budget requirements of the program will be sustained through their incorporation in the student's Equipment Use Fee (EUF) associated with each course. The cost of maintaining the yearly license will be proportionally distributed to the number of students in each course. Given the proposed list of participating courses shown in the table, **we expect to fully sustain the VR use with an addition of $1.86 per course credit to the EUF of each course in the list**. The Equipment Use Fee Request Form must be submitted to the Office of the Provost for final approval and adoption of fees at least six months prior to the beginning of a term. This means that for the first year (F24/S25) we cannot assess the cost of Nanome to EUF, therefore we include that request in this application as start-up cost. After that first year, the program is self-sustainable.

For the piloting phase of the program, the Dept. of Chemistry provided funding for 12 licenses to support the immersions we are currently developing and piloting. This funding allows us to start developing more immersive experiences and when Fall semester arrives, we will already have a library of exercises for different courses.

Support:

The pilots were based on the work of two faculty (Dr. Perez CHM4313L and CHM2050; Dr Kleiman in CHM2047 and IDS2334). We have secured the commitment from 5 additional faculty to participate in its future implementation. These faculty include Dr. Davidson who already participated in the pilot with its use in CHM3217 (S'19) and is on board to implement it in the Organic laboratory course (CHM2211L); Dr. C. Zheng will use it in CHM3610L and is on board to use it also in CHM3610; Dr. Angerhofer has already agreed to use it in CHM2050, CHM2051; Ms M. Veige will use it in CHM2047L, and Dr. Austin will do the implementation in CHM5275/CHM4272.

The Chemistry IT shop (manager: D. Bailey) together with Dr Kleiman already submitted the info for Risk Assessment for the Nanome package. Management of the headset instruments and software will follow same procedures and rules as other educational instruments already in use. The IT shop will work with the UFIT Infrastructure and communication technology services (CIT) to provide the required wi-fi access, configured through the INSTRUMENT WI-FI NETWORK, and following standard UF policies for teaching instrumentation. The accounts associated with each headset and software licenses will be all under the responsibility of the Chemistry IT shop and never associated with any specific person. **Students will never provide or use their own personal or GatorLink ID information**. The storage of the headsets will be in a locked room, under the same secure conditions as all other teaching equipment used for chemistry courses and laboratories.

Following a consultation with Chris Sharp (CITT) we plan to enlist the support of UF instructional designers to craft additional video tutorials and help-guides that will be posted in each CANVAS course. Additionally, CITT will also help us with the implementation in the classroom during the first day, after which, the instructor, the two of us and departmental teaching assistants will sustain the project throughout the semester (as it has been done up to now).

Timeline:

- Summer 24: Purchase of headsets, registration, installation of software.
- Development of immersive exercises for CHM2050 and CHM2211L for F'24
- Development of a tutorial video to incorporate in each CANVAS course (with CITT support)
- Fall 2024: Implementation of immersive exercises in CHM2050, CHM3217, CHM4413L, and CHM2211L.
- Spring 2025: Developing and implementing immersive experiences in CHM3610, CHM2051, CHM4275.
- Initiate the process to include the Nanome license cost into EUF for the different courses.
- Summer 2025: Evaluation of success, pitfalls, and necessary changes to immersive experiences.
- Fall 2025/Spring 2026: To spread the knowledge gained and expand faculty participation: talk highlighting the state of the program and develop a tutorial to share with other departments where chemistry and biochemistry curriculum is covered. This will require input and support from CITT.

Budget Request and Justification:

	Price per unit	Units	Request
Meta Quest-2 Oculus	$249.99	35	$8,749.65
Meta Quest-2 Elite Strap with Battery	$89.99	35	$3,149.65
Nanome 1 yr start-up Academic license	$82.33	35	$3,869.67
Nanome 1 yr start-up Full stacks	$5,000	Flat fee	$5,000.00
TOTAL REQUEST			**$20,768.97**

The number of headsets requested is based on 2-3 students per group with the instructors that will need to be present in the VR rooms. Since the headsets will be used in several courses, we need to procure additional batteries which come with the elite straps. This additional battery will guarantee that multiple laboratory sections **(~150 students) can use the equipment within one day**. The organic laboratory course (CHM2211L) has three consecutive sections in one day, each one with c.a. 50 students. It is required that all the sections of one course have access to the immersion VR during the same week, hence the request of enough headsets and additional battery to support this implementation. As an additional benefit, it's been reported that the use of elite straps that come with the battery reduces the discomfort that some students might feel after long use.

The Nanome budget request is based on negotiations with the company providing a large bulk-discount.