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Supporting Active Learning in Introductory STEM Courses with Extended Reality: the ALIS-XR Approach

Moderated by:
Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor &
Dr. Wei Wu, ALIS-XR

STEM-NET

ALIS-XR
STEM WONDERLAND

https://www2.calstate.edu/impact-of-the-csu/research/stem-net

Speakers

Michele Randel, Fresno State,
Spatial Awareness and its Impact on Design

Lisa Bentley, Sonoma State University,
Investigating VR Experiences for Outreach Related to Climate Change

Laura Mugica Sanchez, San Jose State,
Use of VR for Active Learning in General Chemistry

Dermot F. Donnelly-Hermosillo, Fresno State,
Investigating VR in a Physical Science Course for Future K-8 Teachers

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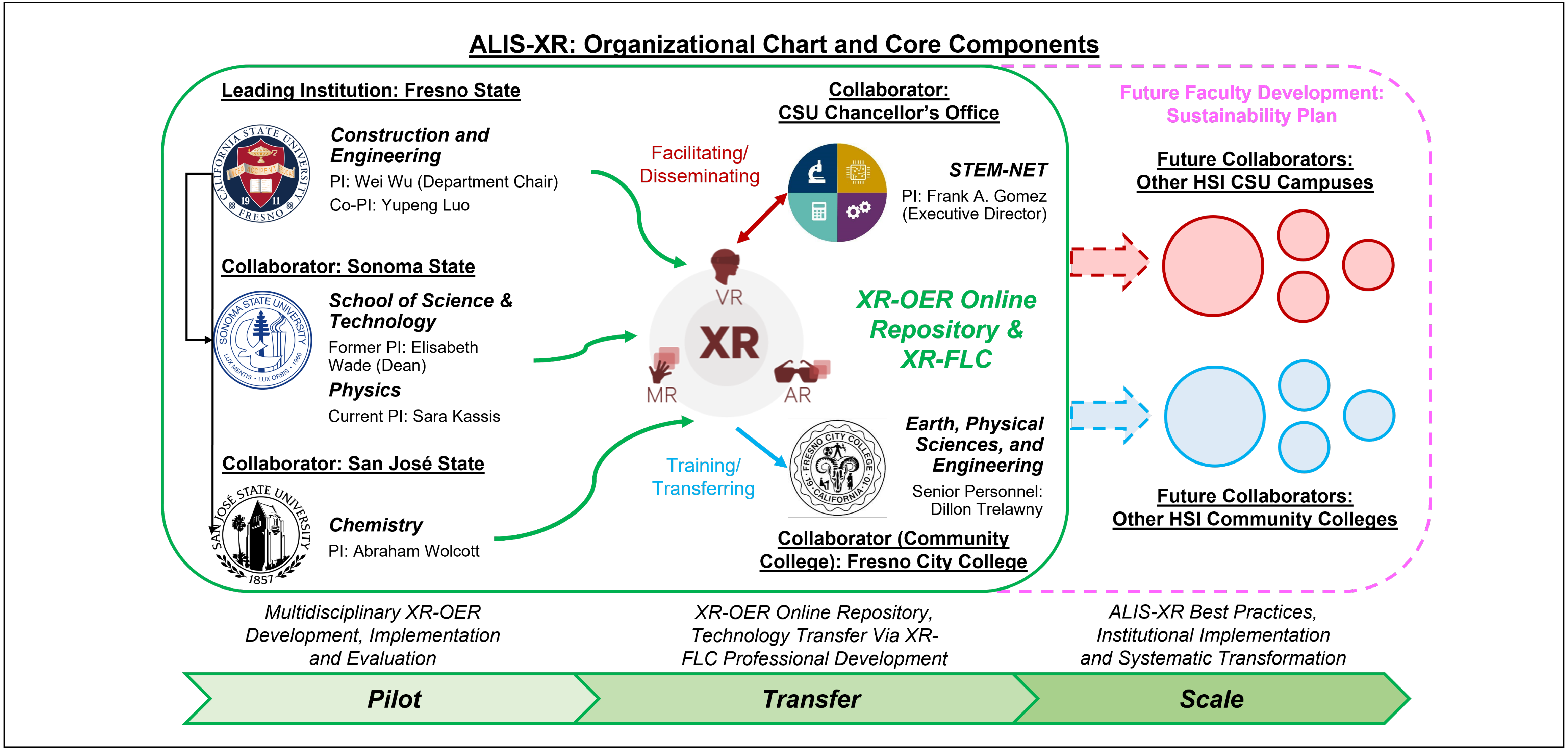
Supporting Active Learning in Introductory STEM Courses with Extended Reality: the ALIS-XR Approach



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Spatial Awareness and its Impact on Design

Michele Randel, M.Arch, AIA, Assoc. DBIA,Architect
California State University, Fresno

"Architecture is the thoughtful making of space"

Louis Kahn

Michele Randel, Architectural Studies Program Coordinator
Fresno State, Department of Construction Management
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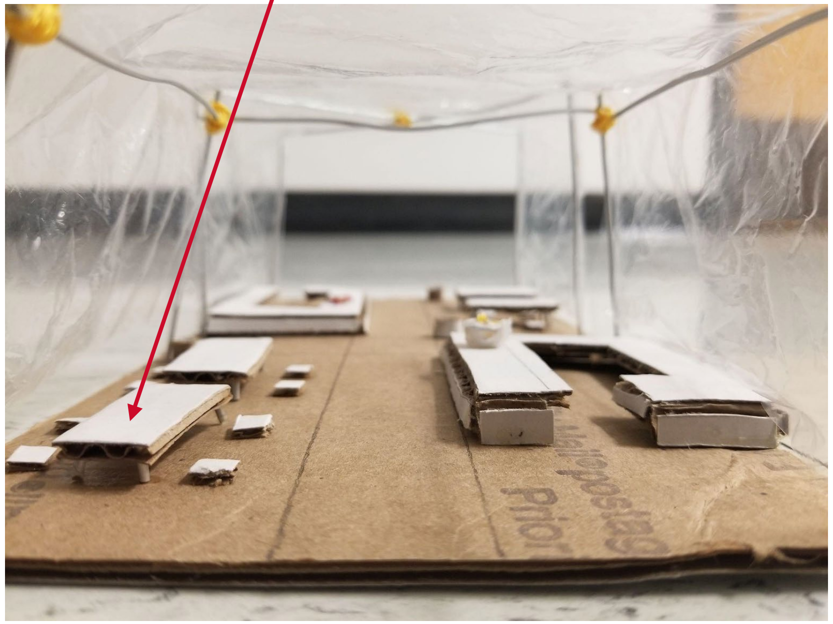
Challenges

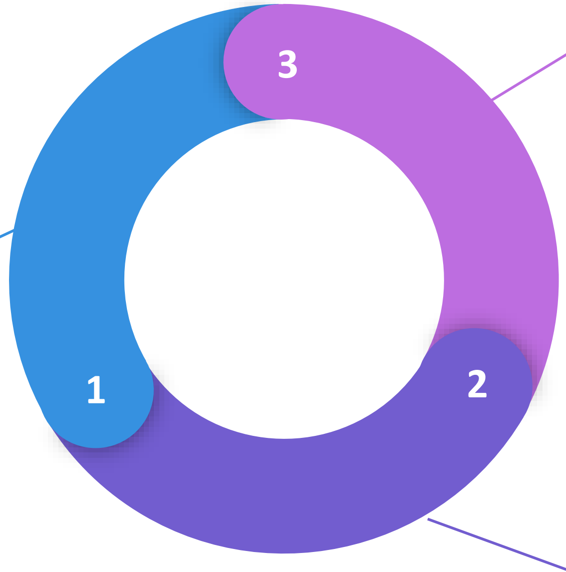
- Students have a hard time with spatial relationships.
- When working in scaled drawings and models, students do not always comprehend:
  - Scale
  - Proportions
  - Space
- 13% - Received failing grades.
- Redesign Architectural Design Course

Table is 2’ off the ground, chairs 6”



Observe with the naked eye -
Can we process scale? Proportions?

Traditional Design Process



Final Model
After critiques, peer reviews, and personal observations, a final model is built. Well crafted and to scale, this model accurately depicts your final design.

Sketch/ Design Ideas
Hand sketch your ideas. Both in 2D and 3D. What do you want your project to look like? What will the user experience?

Study Model
Quick build of model to scale. Needs to portray ideas. Multiple models can be produced.

Spatial Experience Assignments

Phase 1- Individual Project

Hand sketch, design, build study model.

- View study model
- Critiques and Peer reviews
- Build Final Model
- Surveys

Study Model

Final Model

Spatial Experience Assignments

Phase 2 - Group Project - Teams of 4/5

Part 2A - Hand sketch, design, build study model #1. Digitally scan projects in polycam:

- View model in BIM/ SketchUp/ Spatial
- Critiques and Peer reviews
- Surveys
- Reflection on discoveries

Part 2B - Hand sketch, design, build study model #2. Digitally scan projects in polycam:

- Use Oculus 2 to experience study model
- Critiques and peer reviews
- Surveys
- Reflection on discoveries

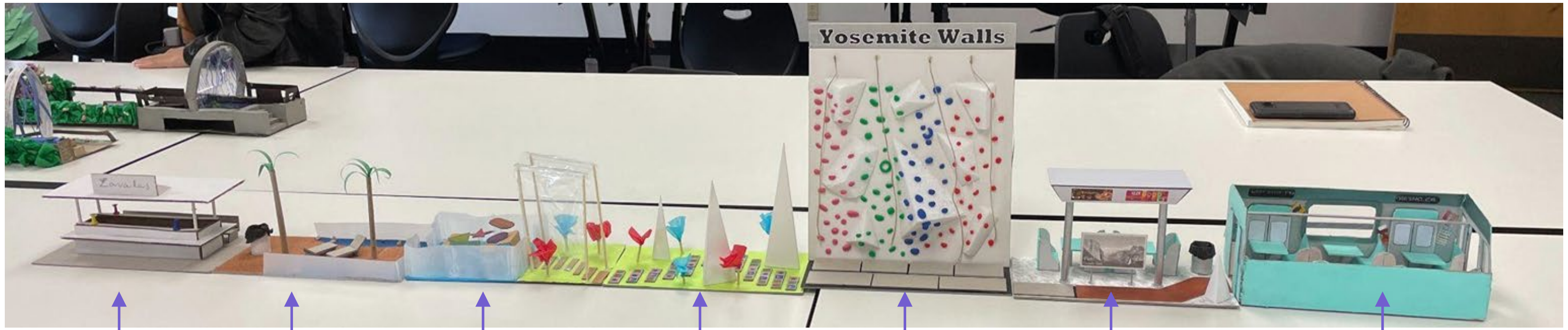
Spatial Experience Assignments

Phase 2 - Group Project - Teams of 4/5

Part 2C - Build final models

- Surveys
- Reflection on total project

Sequence Video



Phase 1 | Part 2A | Phase 1 | Part 2B | Phase 1 | Part 2A | Phase 1

Part 2C

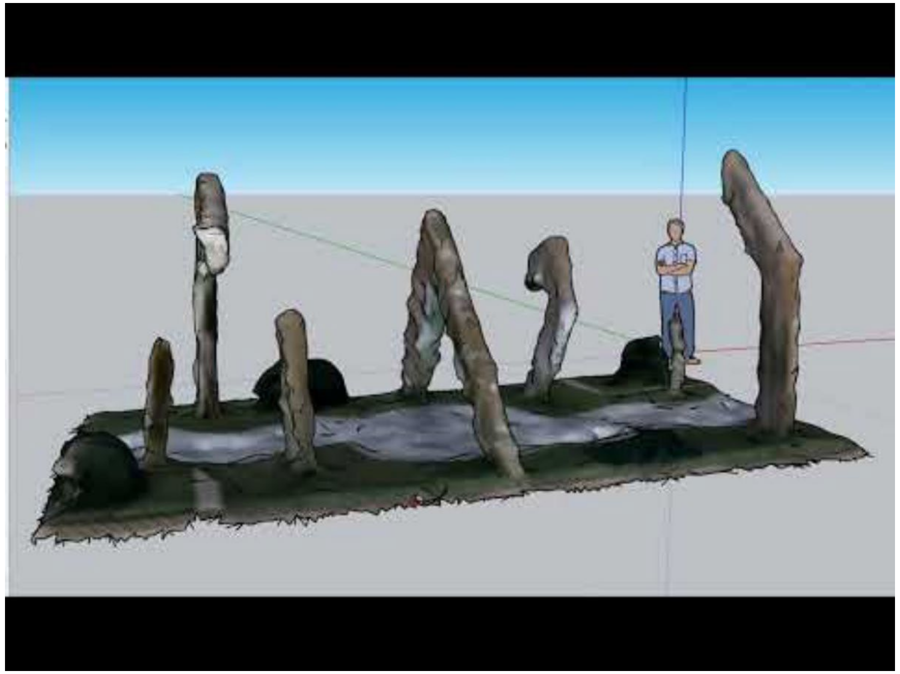
BIM and Virtual Reality

External Viewing Options

Phase 1

Traditional Naked Eye Viewpoint

Phase 2 - Part 2A



SketchUp Viewing

BIM and Virtual Reality

Internal Viewing Options

Phase 2 - Part B

Oculus walkthrough

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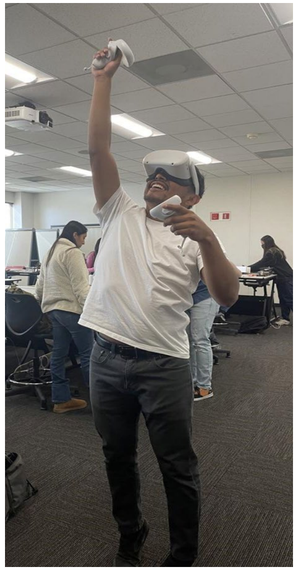
Spatial Awareness and its Impact on Design

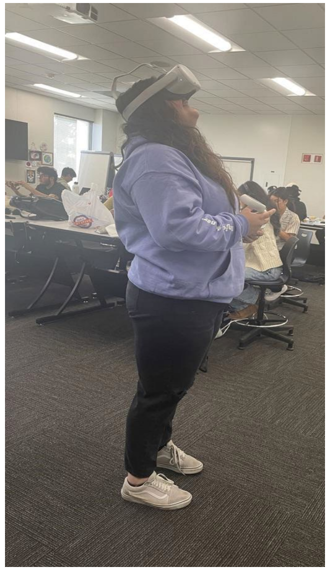
BIM and Virtual Reality

Virtual Reality

We can watch the user move around.

While in VR, users can look around and experience the space from the inside.





Results

Does Virtual Reality promote Spatial Awareness?

General Results

2022

- 22% Previous model making experience.
- 0% Students received failing grades.
- 18% Received C grades.

2023

- 65% First generation college students.
- 55% Previous model making experience.
- 0% Students received failing grades.
- 4% Received C grades.

Results

Students felt they could visualize their designs with both deliverables.

Traditional VS SketchUp

2022

- Traditional - 97% could detect out of scale items.
- SketchUp - 88% could detect out of scale items.
- 72% Stated easier to visualize designs in SketchUp.
  - 10% Found it more difficult.
- 95% Stated SketchUp influenced their design decisions.

2023

- Traditional - 95% could detect out of scale items.
- SketchUp - 90% could detect out of scale items.
- 53% Stated easier to visualize designs in SketchUp.
  - 30% Found it more difficult.
- 97% Stated SketchUp influenced their design decisions.

Results

Students felt they could visualize their designs with both deliverables.

Virtual Reality

2022

- Virtual Reality - 94% could detect out of scale items.
- 91% Stated easier to visualize designs in VR.
  - None found more difficult.
- 96% Stated VR influenced their design decisions.

2023

- Virtual Reality - 94% could detect out of scale items.
- 91% Stated easier to visualize designs in VR.
  - None found more difficult
- 98% Stated VR influenced their design decisions.

Lessons Learned

Student Comments

- “For both, you can see what your models would look like to scale, but VR makes you feel more immersed in your model. You are able to walk through your model and see how a person would experience it.”
- “Personally not a fan of virtual reality because it makes me feel a little sick and dizzy. I will say however it is a great tool for people to use and get a better understanding of their project and what adjustments they can make to improve their design.”
- “It was a better experience in VR as we were able to see how it would be compared to our own height. For Sketchup it is a bit harder to visualize as it is still small and we aren’t able to walk through it.”

Lessons Learned

Student Comments

- "In both SketchUp and VR they show an idea of what it would look like to scale and the problems within the project. With VR you were able to catch the little details that you may have done right or wrong; it was more of a realistic walkthrough compared to that of SketchUp where you will need to use your imagination to visualize it realistically to scale."
- "Personally I prefer the VR because it gave a more immersive feel and understanding on the scaling and proportions."
- "I prefer the VR viewing, walking around gave me some great insight on how the scale of the model was"

Additional Exploration

Architectural Studies Project Showcase

Spatial Room - Advanced Architectural Design

Scan me to experience a Spatial room!

Computer Viewing

Experience the space using a monitor/laptop.

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Additional Exploration

Architectural Studies Project Showcase

Spatial Room - Advanced Architectural Design

Scan me to experience a Spatial room!

Oculus Viewing

Experience the space using a VR headset.

Questions?

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SONOMA STATE UNIVERSITY

Investigating VR Experiences for Outreach Related to Climate Change

Lisa Patrick Bentley – Sonoma State University

Lisa Patrick Bentley, Associate Professor

Sonoma State University, Department of Biology

Lisa.Bentley@sonoma.edu

SONOMA STATE UNIVERSITY

Investigating VR Experiences for Outreach Related to Climate Change

Project Overview

- Is VR an effective way for students to learn about current research in the field of biology related to climate change?

- Teaching case studies using three different VR approaches:
  - 360 videos (ALIS-XR Cohort 2, 2022-23)
  - Virtual environments (Spring 2023)
  - Immersive and interactive VR app (Spring 2024)

Activities: 360 Videos

- **Climate Change Biology class**, 12 graduate (M.S.) students.
  - 64% of students had never used VR for fun, 91% of students had never used VR for education (i.e., in class)

- **Learning objective:**
  - Students will learn about presenting research using VR videos.

- **What were the challenges students were facing?:**
  - Learning about experiments by reading academic papers to discuss current research in their field related to climate change.

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Investigating VR Experiences for Outreach Related to Climate Change

Activities: 360 Videos

- SSU Makerspace
- Each student had an Oculus Quest 1 headset
- YouTube 360 videos
  - National Geographic Expedition Everest (3 min)
  - Tour of free-air carbon dioxide enrichment (FACE) facility (2 min)
  - NASA Exploration of ice in Greenland and coral reefs in Hawaii (8 min)

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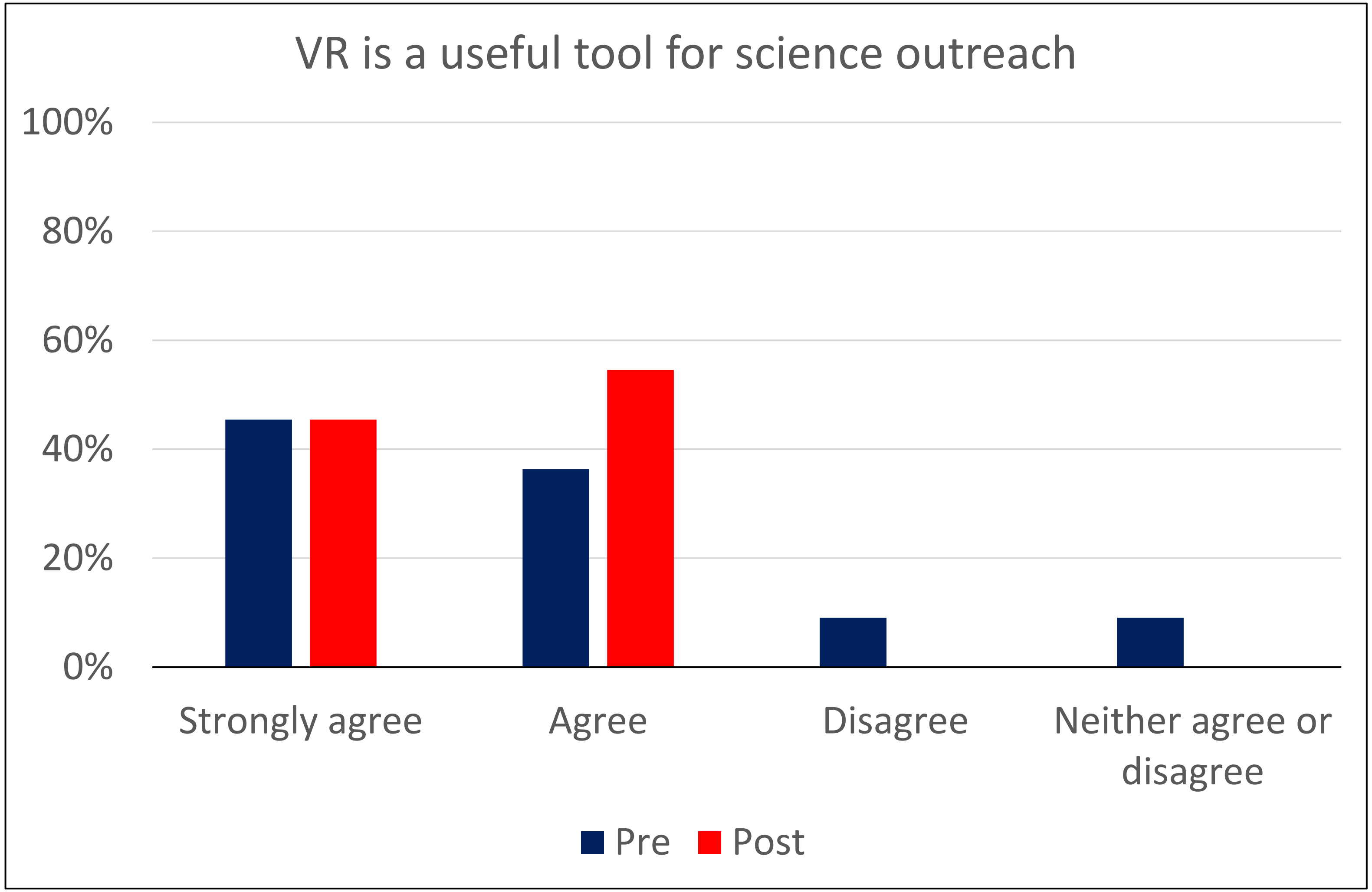
Investigating VR Experiences for Outreach Related to Climate Change

Results: 360 Videos



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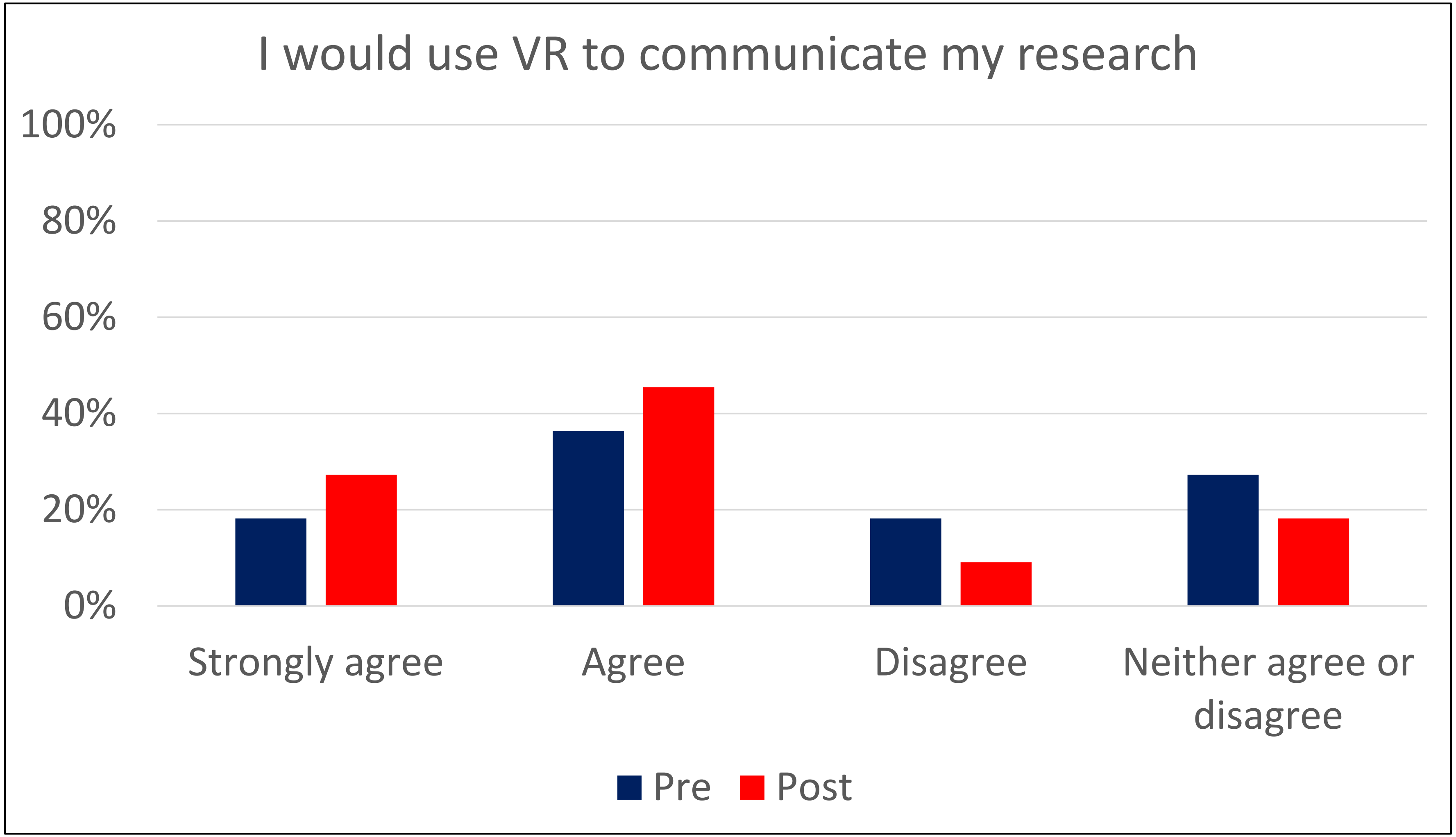
Results: 360 Videos



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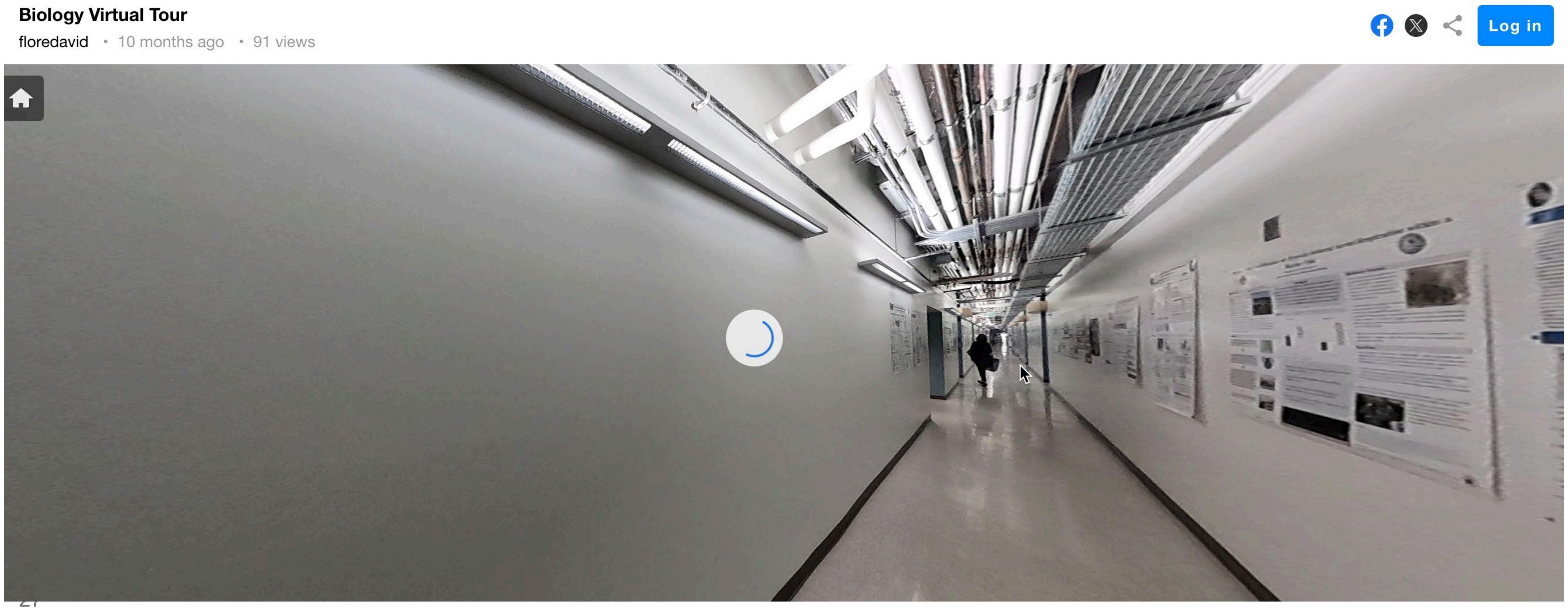
Activities: Virtual Environments

Students enjoyed the exercise and the following week in class they started to prepare multimedia content related to their projects using 360° videos in VR posted to the online platform **ThingLink**.



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Investigating VR Experiences for Outreach Related to Climate Change

Activities: VR App

- Using funding from my NSF CAREER Grant, I've been working with Patrick Stafford (SJSU), Karsten Steinhorst (SSU), Lupe Carrasco (SSU) and Alex Flores (SSU) to develop a standalone Unity VR app to teach students about fire ecology and forest disease using examples from my lab's research.
- VR app includes: Scanning experience (game), tour through research sites showing actual data, 360 videos of field sites and photos
- Prototype was just tested in early March 2024 with 19 students from my undergraduate Climate Change Biology class

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Activities: VR App

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Activities: VR App

Results: VR App

“The immersive aspect was REALLY cool. I had never used VR and it was way cooler than I thought.”

But what about the learning objectives?

Can you explain in your own words how LiDAR works?

“You shoot lasers around that send back data, kinda”

“LiDAR works by pressing the button on the top of the VR controller and seeing the white trigger that releases a bunch of tiny, yellow dots to create a mini-forest”

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Lessons Learned

- Trying to mentor >3 students through a VR lesson needs >1 instructor
  - Scheduling timeslots for 1-3 students to visit makerspace is likely less stressful
- Devices need frequent updating and maintenance
  - Advance planning and support from SSU staff before activity was crucial
- Making your own app is challenging!
- ALIS-XR FLC was essential to the execution of all of these VR experiences
  - Connected me with programmer, learned about pros/cons of current technology
  - Instructional design module assisted with classroom integration and pedagogy

Next Steps/Long-Term Plans

- 360 Videos → Capturing more content this summer
- Virtual environment→ Fall 2024 Climate Change Class will update Thinglink SSU tour
- VR app
  - Currently working to moving out of the prototype phase
  - Demo in elementary schools in May 2024
  - Integrate into undergrad curriculum Fall 2024 (sophomore level Biology class)
- Apply for additional funding to create more VR/XR content using research to support education
  - Build an open-access library of content for climate change classes
- Advocate for using VR as a teaching tool at SSU and beyond

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Investigating VR Experiences for Outreach Related to Climate Change

Summary

Yes! VR can be an effective (and ENJOYABLE) way for students to learn about current research in the field of biology related to climate change.

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Questions?

Contact Information:

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Use of VR for Active Learning in General Chemistry

Laura Mugica Sanchez

Lecturer in Chemistry

Department of Chemistry, SJSU

laura.mugica@sjsu.edu

Project Overview

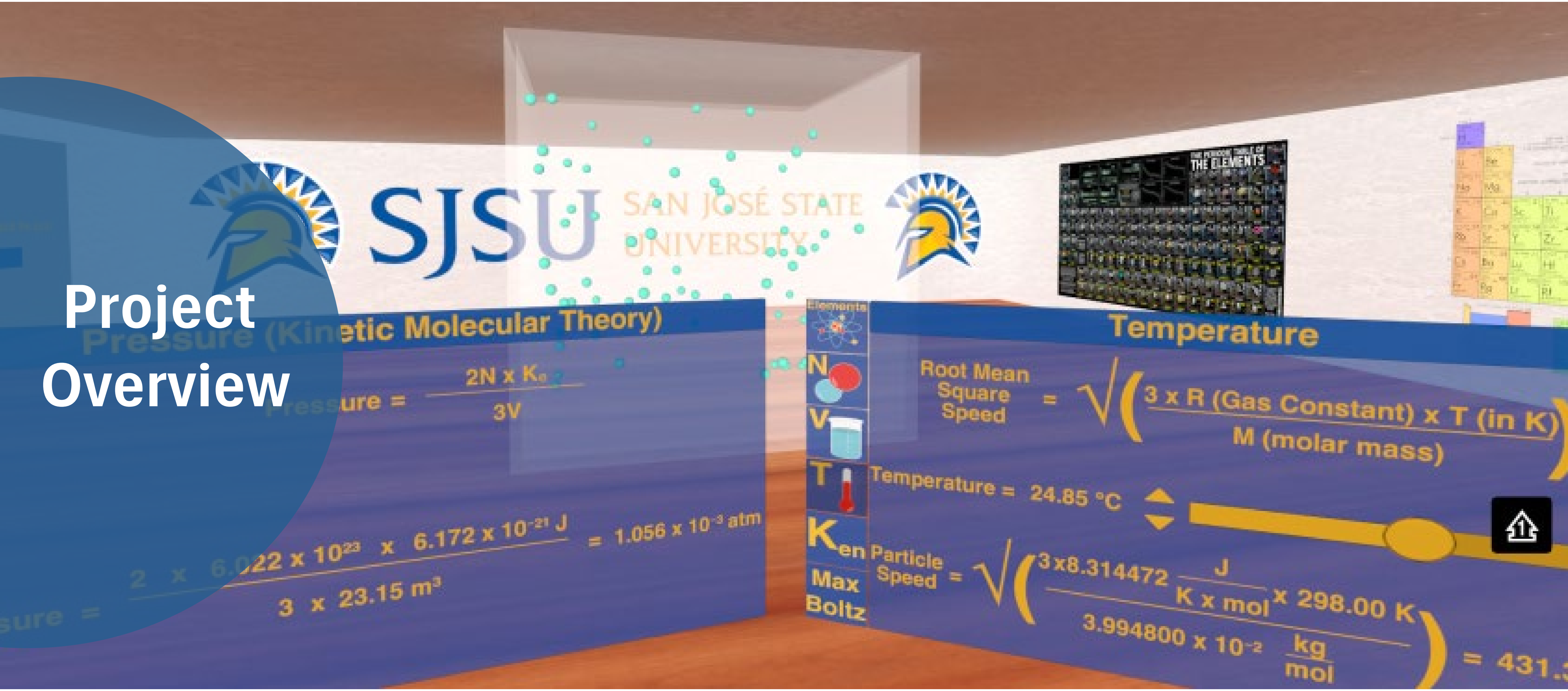
VR: Infer macromolecular properties by *visualizing* molecular movement

VR as an aid to understanding challenging topics

Kinetics

Collision Theory, Arrhenius Equation

Project Overview



Activities

Module Assessment

- Kinetics (all content)

Pre-Survey

ChemVR

- Module Exploration
- Embedded Quiz

Post-Surveys

Results

In-class

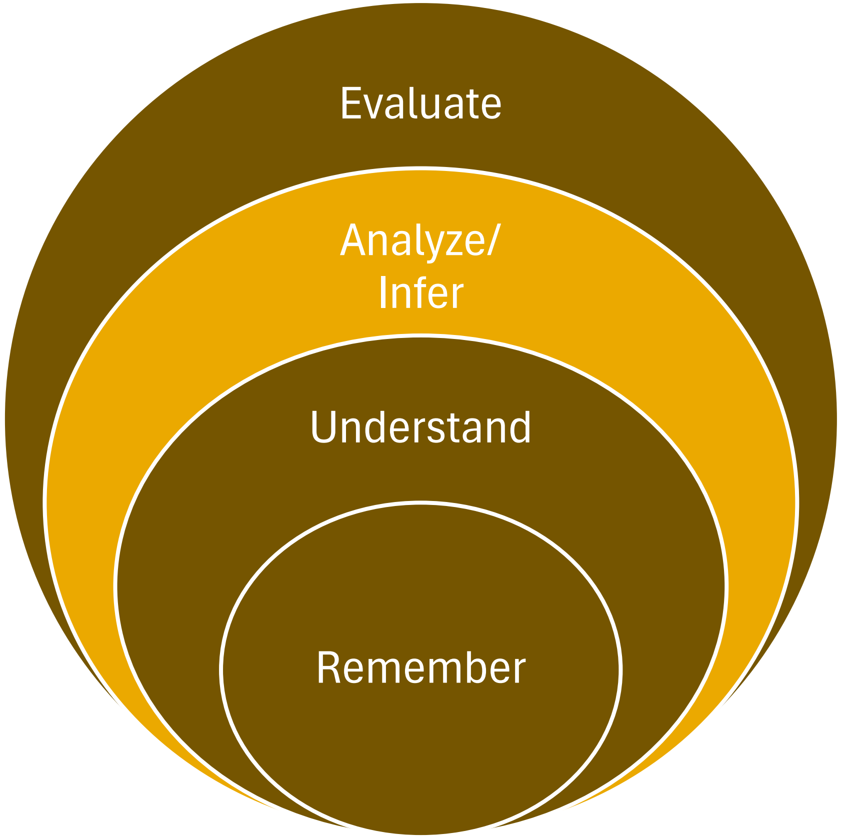
- Lecture Worksheet
- Short-Term Retrieval Practice (Quiz)
- Module Assessment
  - Conceptual (multiple choice)
  - Application (numerical answer)

VR Exploration

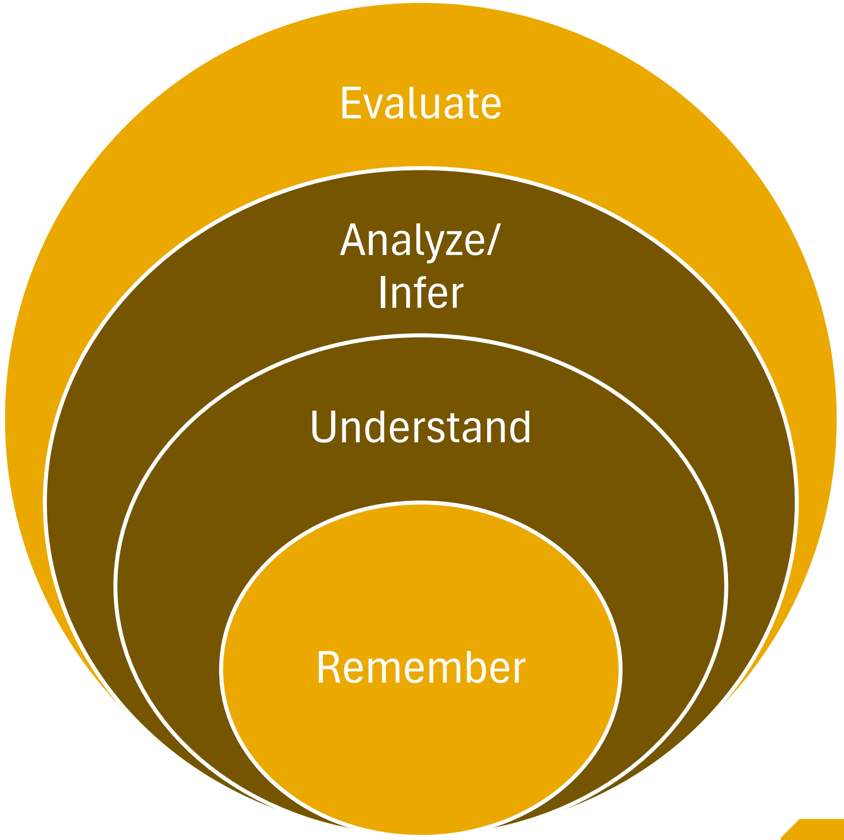
- Exploration of molecular movement based on the Kinetic Molecular Theory
  - Size of the molecule
  - Temperature
  - # collisions
  - Maxwell-Boltzmann distribution
- Quiz embedded within VR space (multiple choice)

Results

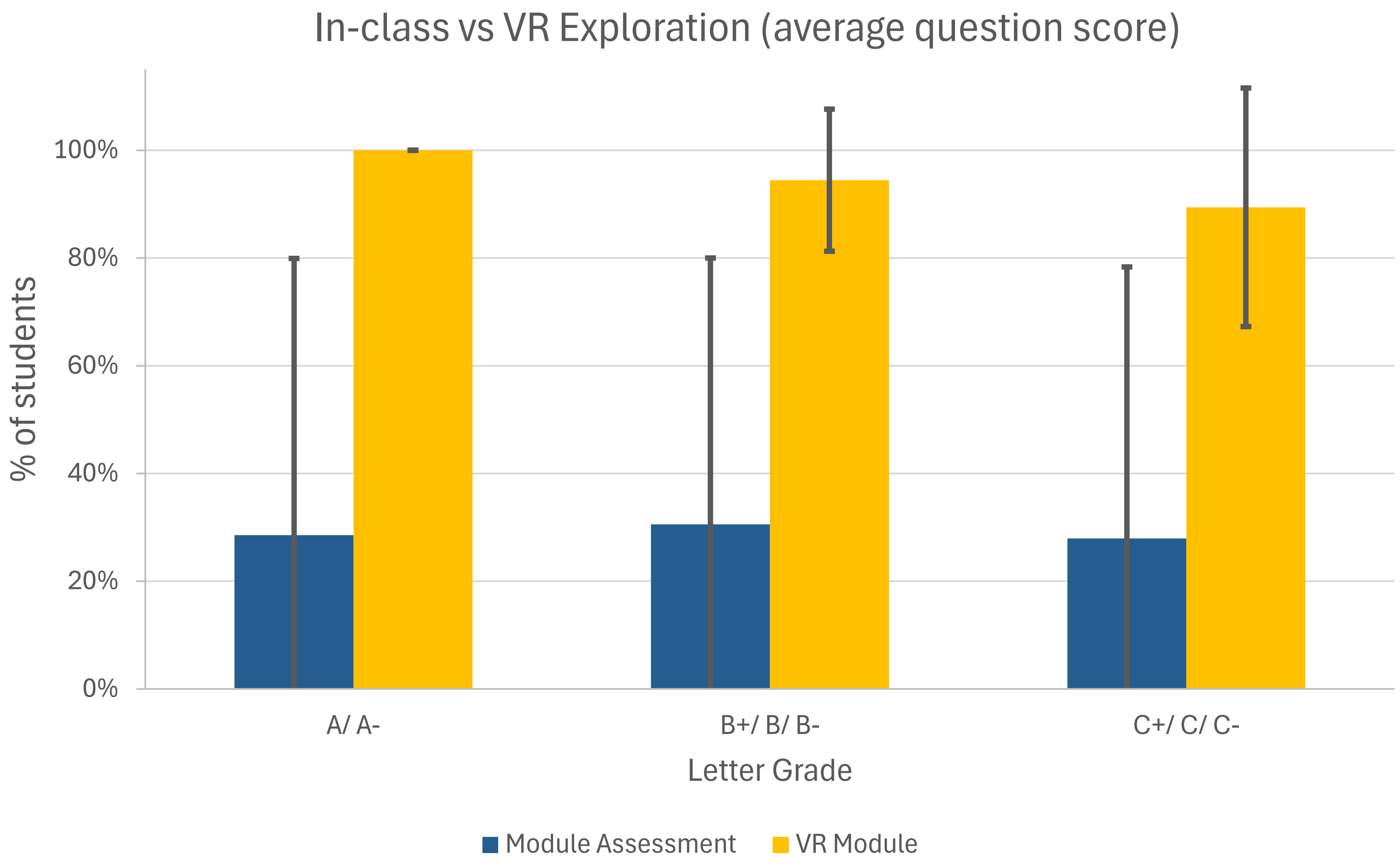
Module Assessment
(In-Class)



Quiz
(VR Module)

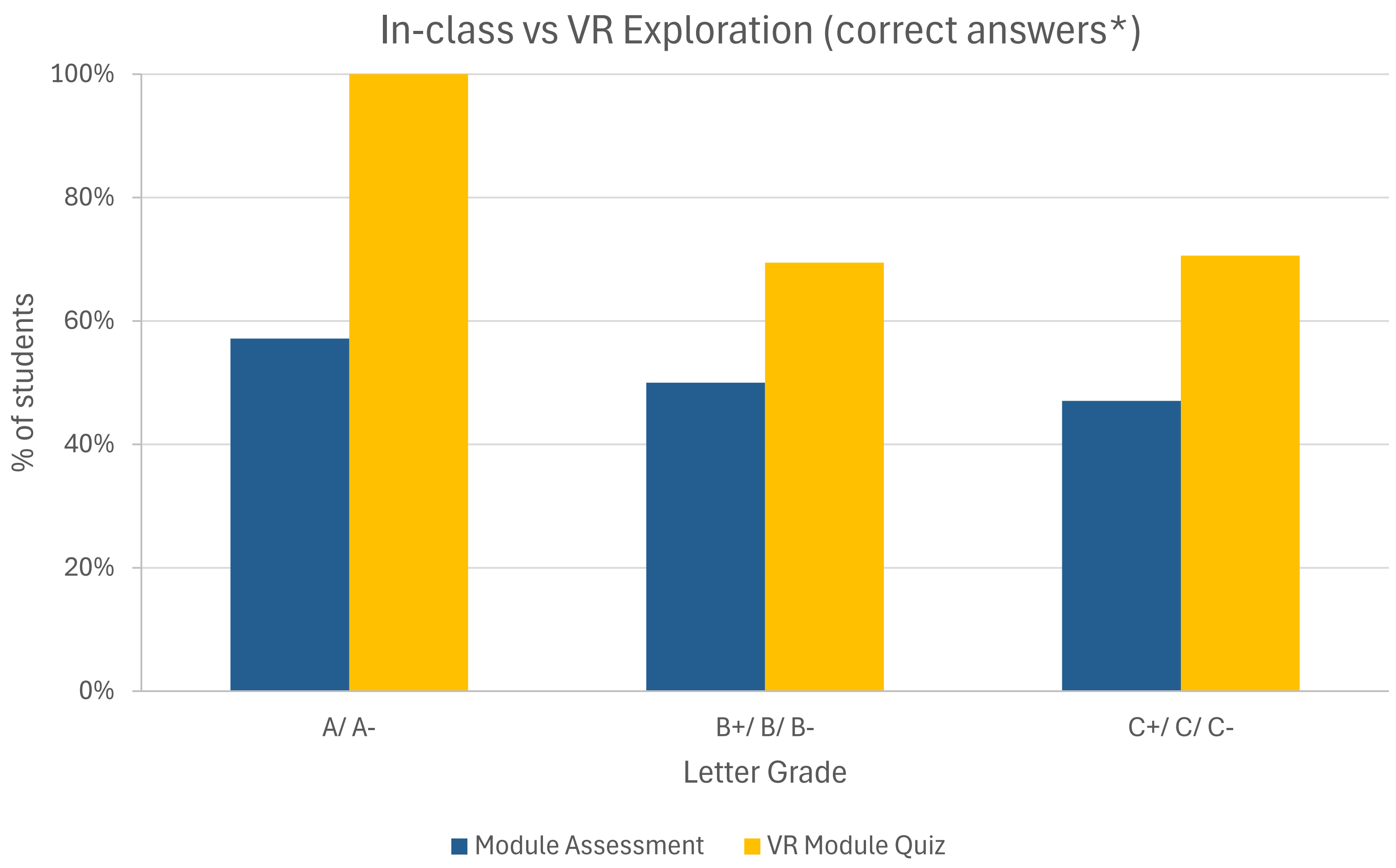


Results



In-class Module Assessment (total of 2 questions)
VR Module Quiz (total of 5 questions)

Results



*only students who answered all questions correctly in each assessment
In-class Module Assessment (total of 2 questions)
VR Module Quiz (total of 5 questions)

Lessons Learned

- VR Exploration provides a deeper insight into molecular movement based on the Kinetic Molecular Theory model.
- 83% of students were able to correctly answer questions involving the collision theory by visualizing the molecular movement within the VR module.
- Overall improvement on understanding the topic. ALL students improved the number of correct answers by ~40%
- 2 students with lower letter grade spent more time in the VR Module to get all answers correct

Lessons Learned

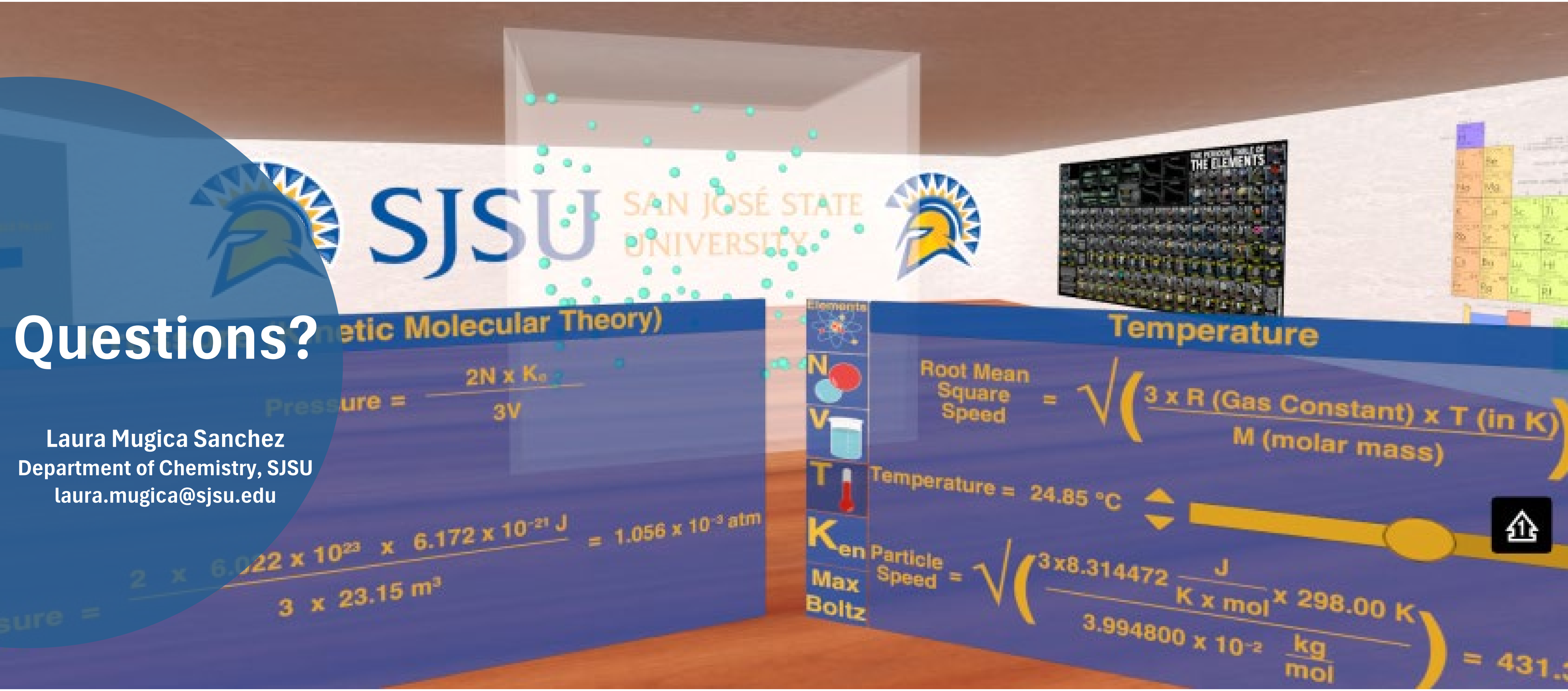
Factors to be considered for a better analysis:

- Review of the topic by students prior to the VR Experience.
- No information on whether students answered the VR quiz at once or if they stepped back into the simulation to verify their answers.
    - Retention of knowledge post-VR experience outside the VR space.
    - Control group (w/o VR experience).
- A unique in-class assessment with the same topics as the VR quiz as opposed to a summative assessment.
- VR space is a more relaxed environment.

Future Steps

- Further customization of the module: Video addition to convert the module to an asynchronous class.
- Assessment of the highest level of understanding for students utilizing VR.
- Exploration of “gamified” chemistry VR Modules (Futuclass) explored during Spring 2024 in CHEM 30A (Introduction to General Chemistry).*

*Many thanks to Sharon Thompson!



Questions?

Laura Mugica Sanchez
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ChemVR developed at SJSU by Nanci Solomon, Patrick Stafford, Jennifer Redd, Jon Oakes

FRESNO STATE

Investigating VR in a Physical Science Course for Future K-8 Teachers

Dermot F. Donnelly-Hermosillo, Associate Professor of Chemical Education

Fresno State, Department of Chemistry and Biochemistry

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Project Overview

1. How does a VR activity impact **student chemistry learning**, specifically naming elements and compounds, identifying atomic properties of elements (protons, neutrons, electrons), and balancing chemical equations?

2. What are **first and second order barriers** to using virtual reality in classrooms for future elementary school teachers?

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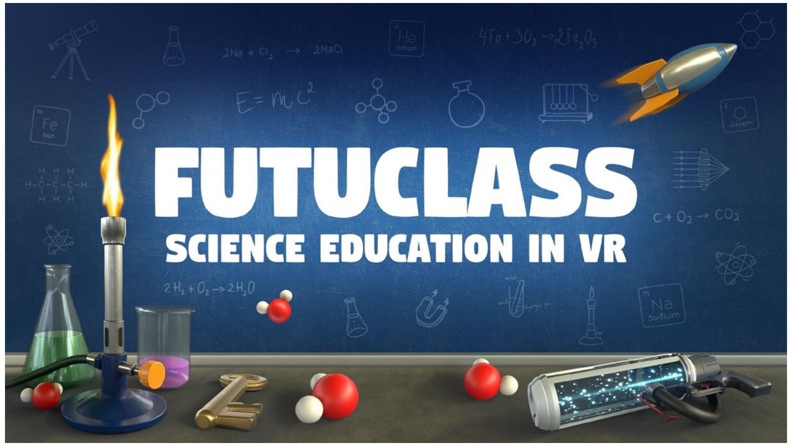
VR in a Physical Science Course for Future K-8 Teachers

Activities

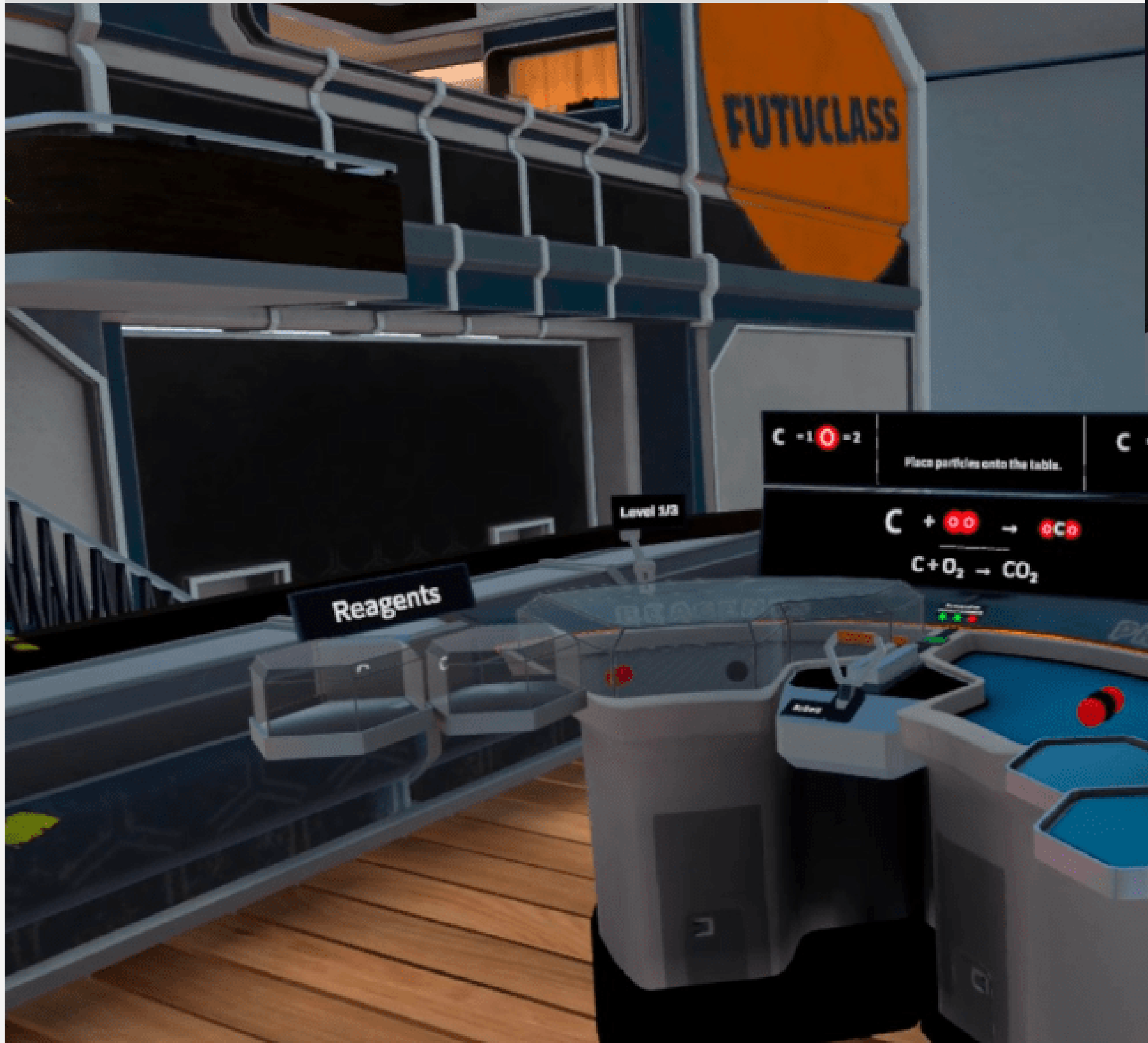
- **Learning theory:** Embodied cognition (Varela et al., 1999; Wilson, 2002)
- **Research design:** Design study. Students completed VR activity in a VR Center outside of class time. First time use of VR with students and smaller sample of students.
- **VR headsets:** Oculus Quest 2
- **VR App:** FutuClass
- **Assessment (RQ1):** 12 open response items directly before and after the VR activity administered via a Google Forms.
- **Assessment (RQs 1 & 2):** 500-word reflection from students with 9 written-prompts plus facilitator interview.

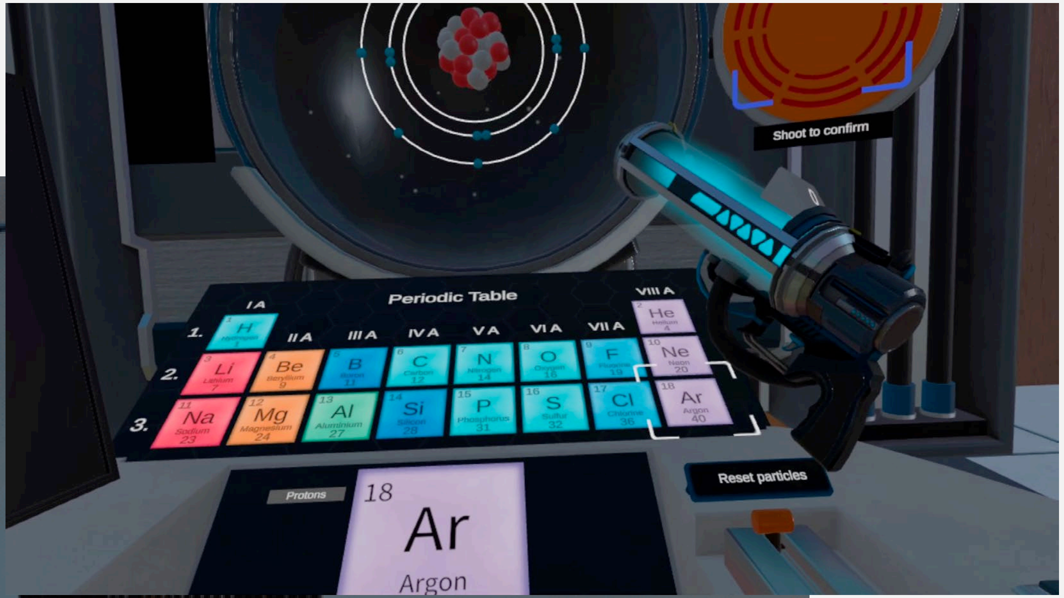


Participants: 35 Preservice Elementary Teachers
Gender: 26 Female (74%)
Race: 29 Hispanic (83%)

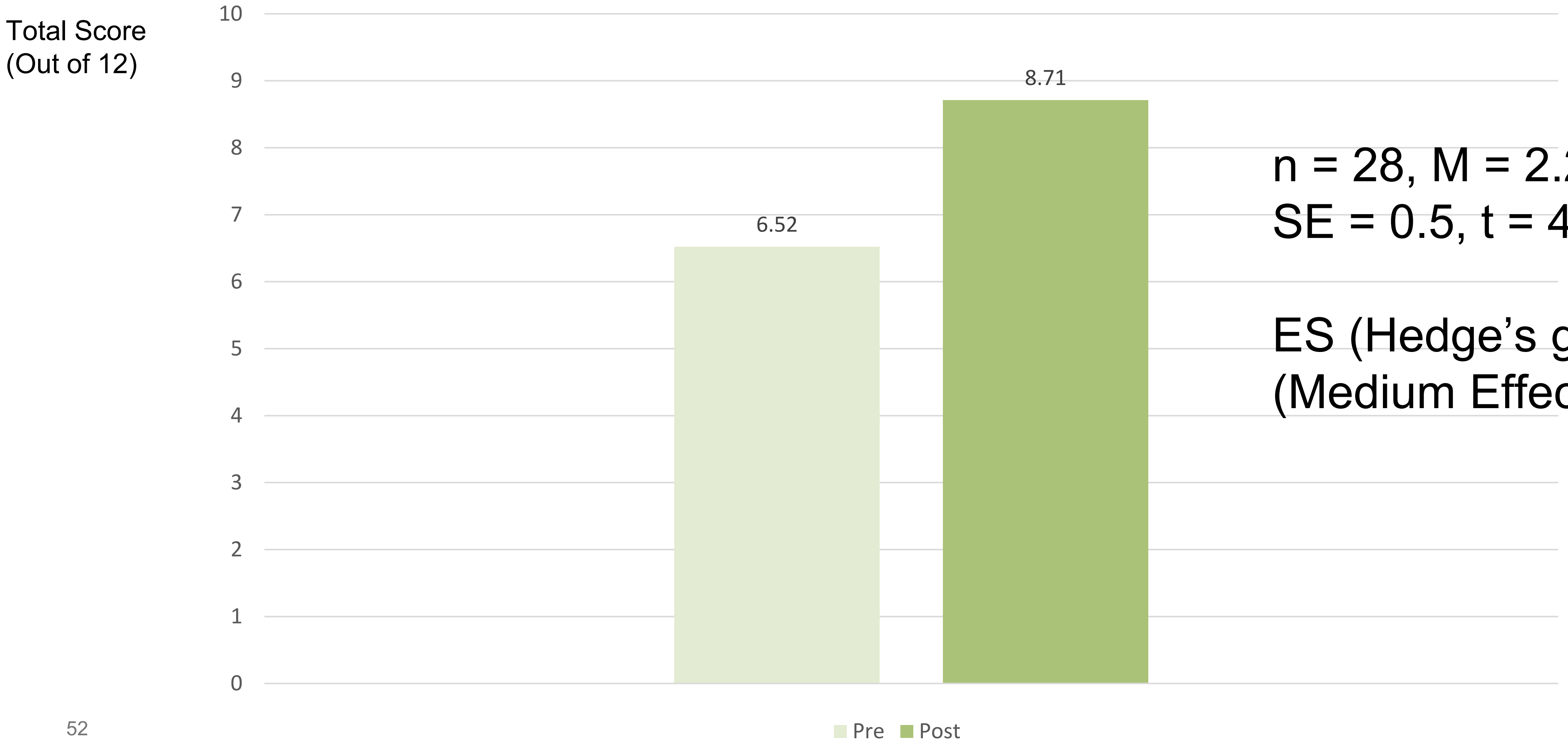
VR in a Physical Science Course for Future K-8 Teachers

Activities





Results – RQ1 – Learning Outcomes



n = 28, M = 2.2, SD = 2.6, SE = 0.5, t = 4.5, p < 0.001

ES (Hedge's g) = 0.78 (Medium Effect Size)

Results – Embodied Cognition

- *"I understood balancing bonds so much better like when* ***I got to grab the bonds and place them*** *where they needed to be."*

Hispanic Female Student (#7)

- *"It showed so many visuals to what I've learned in past chemistry classes. It made so much more sense to me once I got to* ***physically see things like atoms and molecules*** *etc. being made in front of me!"*

Hispanic Female Student (#33)

- *"It is very intuitive to be able to* ***"pick them up" and move them [atoms] in a 3D space****. Balancing the equations is easier when the objects are able to float and aren't restricted to the physics of the real world."*

Male White Student (#6; Didn't complete pre/post test)

Results – RQ2 (Barriers)

*"This was my first time using an oculus device or going into VR. I was a bit nervous that it would take me a long time to learn how to use it, but **it wasn't difficult to get it**."*

Female Hispanic Student (#3)

"maybe it would be cool to have a virtual classroom and try to lesson plan virtually."

Hispanic Female Student (#7)

"kids learn better when they are having fun and are more likely to recall material than if I gave them a dry lecture that would probably bore them to death. I have an optimistic outlook on the usage of virtual reality in education in the future. "

Female Hispanic Student (#29; Did not complete pre/post test)

Lessons Learned

- RQ1: Learning outcomes at larger end of those reported in the VR literature (small to medium).

  (Coban et al., 2022; Cromley et al., 2023; Luo et al., 2021; Matovu et al., 2022; Villena-Taranilla et al., 2022)

- RQ2: Most future elementary teachers see potential value in VR (second-order), but have concerns with cost and breakages (first-order).

- Embodied cognition is a potential insightful learning theory to explain the value-added components of VR for science education.

Next Steps/Long-Term Plans

- Need to obtain more licenses – applying for funding support!
- Transferring VR experiences into classroom practice – not a VR learning center.
- Comparison Study with larger class – Our introductory chemistry course typically has 400-500 students (25 students per lab section).
- FutuClass readily applicable in K-12 classes so another opportunity for research/collaboration with other institutions.

Questions?

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Next Steps/Closing Remarks

Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

https://www2.calstate.edu/impact-of-the-csu/research/stem-net

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STEM-NET Community Events

2024 Spring SoCalGas STEM-NET Student Research Fellowship Virtual Research Café

Date: Friday, April 26, 2024
Time: 12:00 PM – 1:30 PM

Register Here

STEM-NET May Webcast

Topic: AI4SG Symposium
Date: Wednesday, May 8, 2024
Time: 12:00 PM – 1:00 PM

Register Here

Join our CSU STEM-NET Community listserv

csustemnet@lists.calstate.edu

Begin a Conversation with Colleagues and Join our Private CSU STEM-NET Facebook Group

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