Pilot Desktop and Immersive Virtual Reality Field Trip Study of Coastal Maine Indicates Equivalent Student Learning Outcomes and High Engagement



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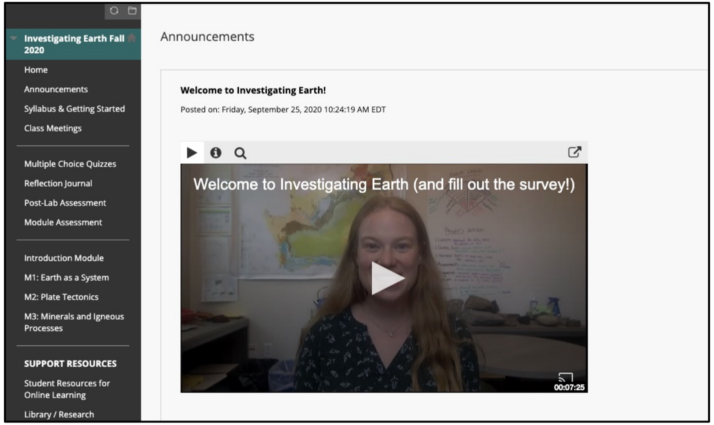
Motivation – 1

1. Create an accessible geoscience field experience for:
   - Students with mobility constraints
   - Large format classes
   - Remote learners

Introductory Physical Geology Class at Giant's Stairs, Maine



Blackboard Course Page for Intro Geology Fall 2020

Alroyfonseca - Public Domain, https://commons.wikimedia.org/w/index.php?curid=5559428

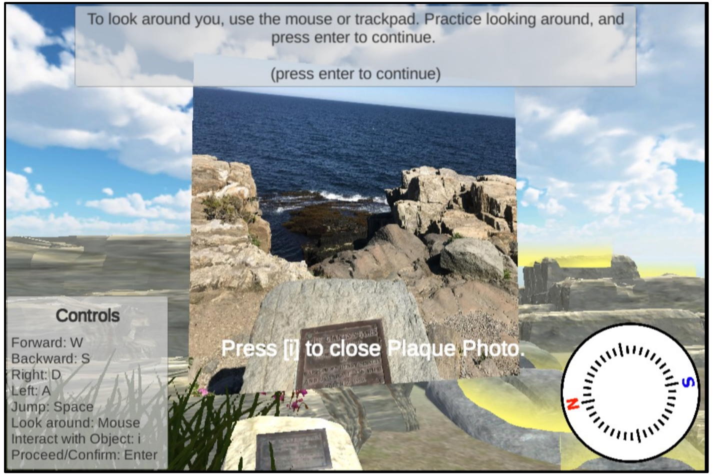
Motivation – 2

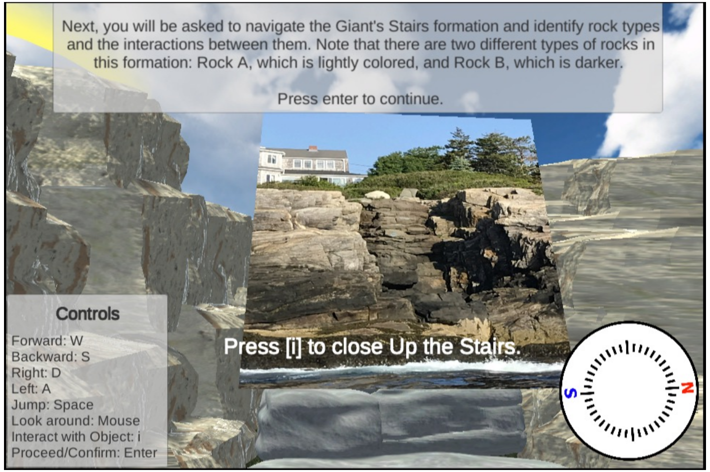
2. Create a tool to enhance spatial reasoning required to solve complex geoscience questions

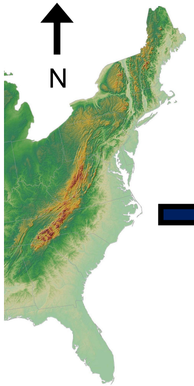
Real-world images of the Giant's Stairs embedded within the virtual environment

Right: View east, down the stairs

Bottom Right: View west, up the stairs.

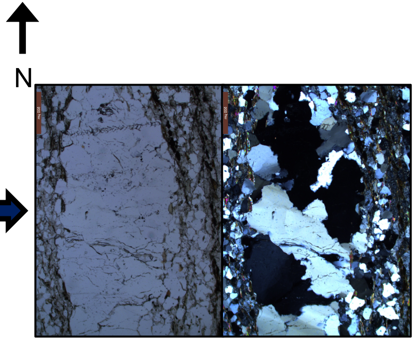






Orogen Scale: Appalachian Mountain Range

Outcrop Scale: Schist at Giant's Stairs, Maine



Microscopic Scale: Plane- and cross-polarized photomicrographs

Research Questions

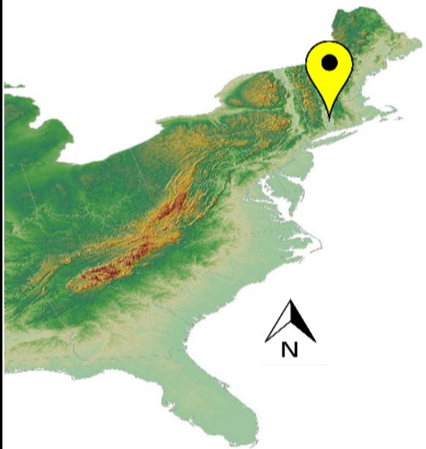
1. Are students able to demonstrate domain specific learning outcomes within an accessible virtual environment as they would in a real-world geology field site lab experience?

2. Will students in the desktop VR (dVR) and immersive VR (iVR) conditions demonstrate equivalent proficiency in lab goals as measured by selected response accuracy?

Virtual Field Trip Design and Protocol - 1

Part I: Map/Geolocation Phase

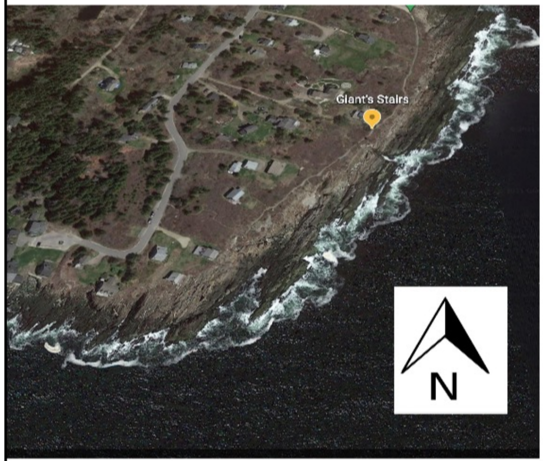
- Overview maps show the field site at several spatial scales to **<u>orient</u>** the student to the location of the field site.



This is a topographic map of Eastern United States. Red marks areas of high topography and light green marks areas of low topography. A yellow pin marks the location of the Giant's Stairs -- Casco Bay, in Harpswell, ME.

Press [ENTER] to proceed to a map of coastal Maine.

Orogen-scale map



Here is an image captured from Google Earth of the Giant's Stairs.

When you are ready to start your virtual laboratory experience, click [ENTER].

You may also return to the map of Casco Bay by clicking [BACKSPACE].

Local-scale map

Virtual Field Trip Design and Protocol - 2

Part 2: Training

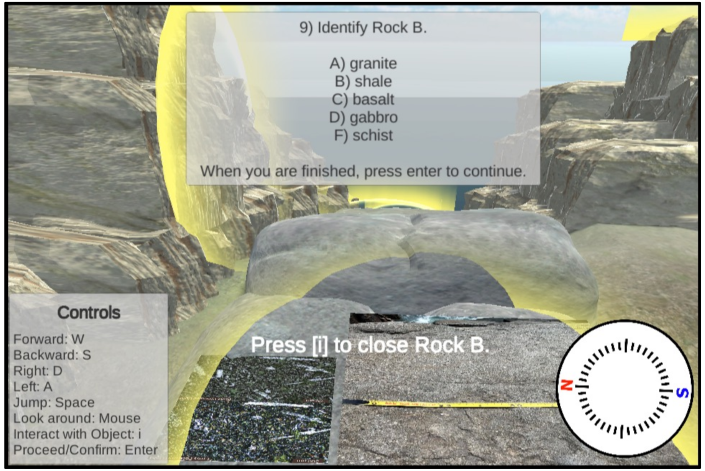
- Students are placed into the model at ground level and asked to perform several tasks to learn how to navigate and use the virtual compass for orientation and spatial reasoning tasks.

Right: Welcome prompt in the virtual environment

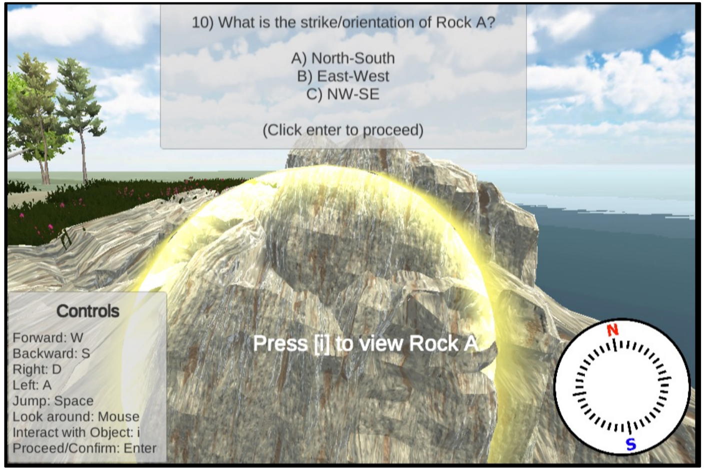
Virtual Field Trip Design and Protocol - 3

Part 3: Geoscience Lab

- Students navigate through prompts to features in the environment. They observe the feature and answer questions with the aid of augmented information embedded in the model.



Rock identification question and embedded real world images within the virtual environment

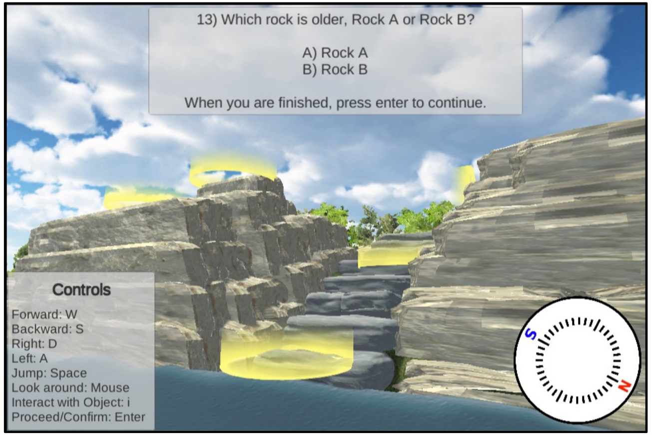


Rock orientation question and embedded real world images within the virtual environment

Virtual Field Trip Design and Protocol - 3

Part 3: Geoscience Lab

- Students navigate through prompts to features in the environment. They observe the feature and answer questions with the aid of augmented information embedded in the model.



Left: Temporal question based on cross-cutting relationships

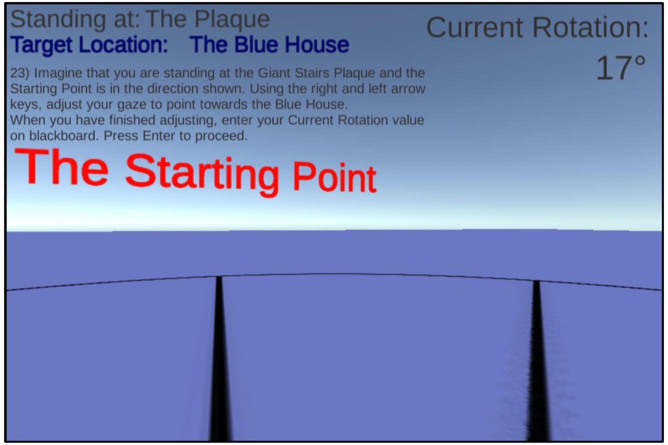
Lab Task	Question
Rock ID	Q7, Q9
Orientation	Q10, Q11, Q12
Spatio-Temporal Processes/Events	Q13, Q25
Collision	Q15, Q17, Q19
Spatial Reasoning	Q22, Q23, Q24

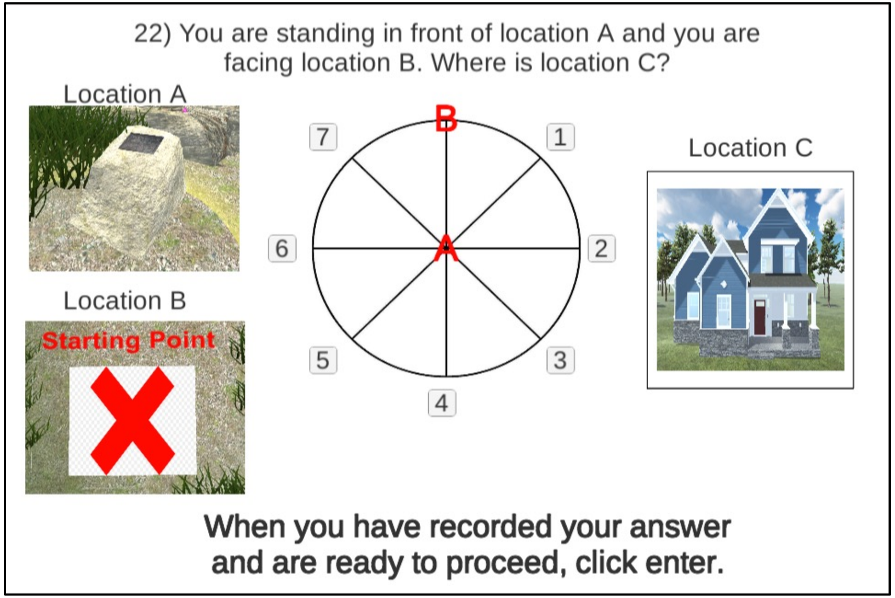
Table 1. Geoscience Lab Assessment Concepts

Virtual Field Trip Design and Protocol - 4

Part 4: Spatial Reasoning

- Students complete spatial reasoning tasks about the orientation and relationship between model features.





Left and above: post lab questions exploring spatial reasoning and retention

Participants

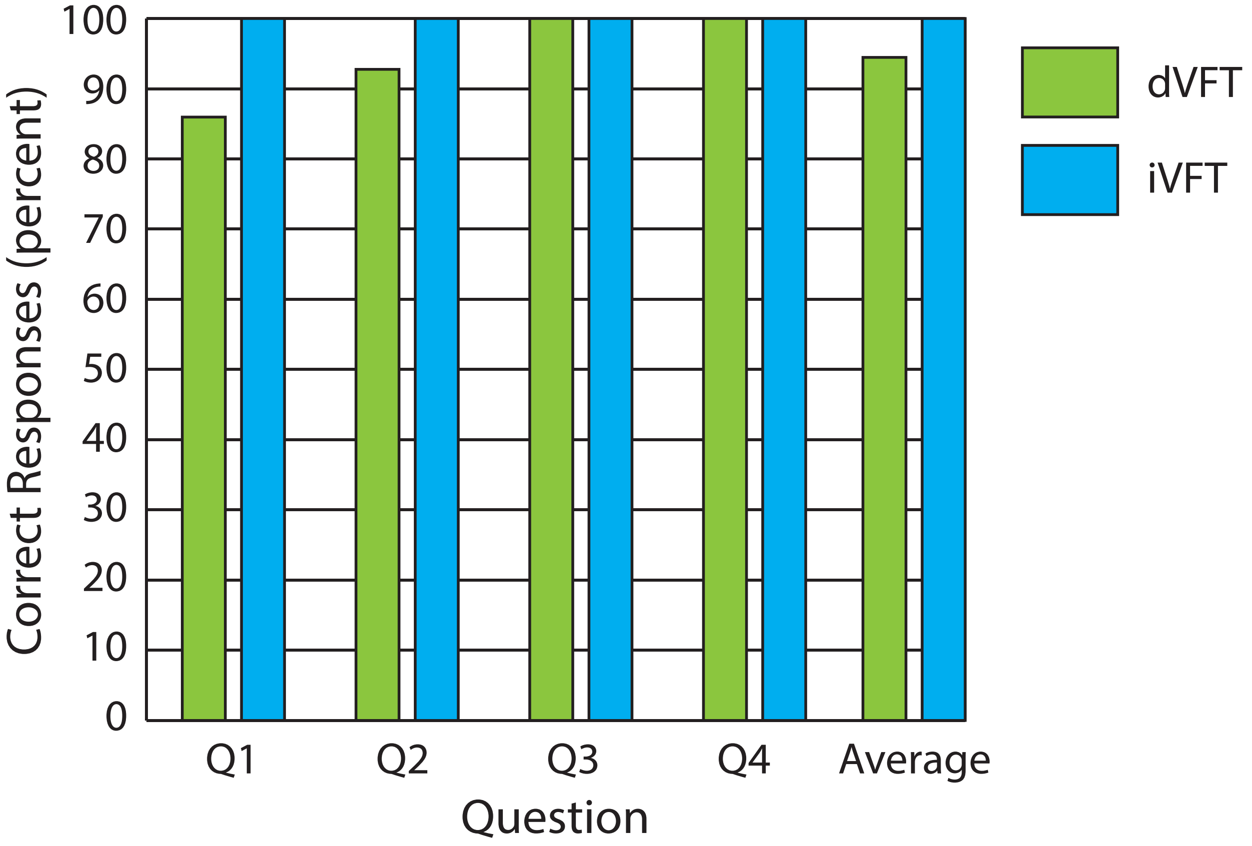
- Intro geology students at a small, liberal arts college (n=25).
- Self-perception of spatial reasoning skills not statistically different between dVR and iVR groups

Condition	Range	Mean	St. Dev.
dVR	48-89	67.86	11.86
iVR	44-68	62.36	9.55

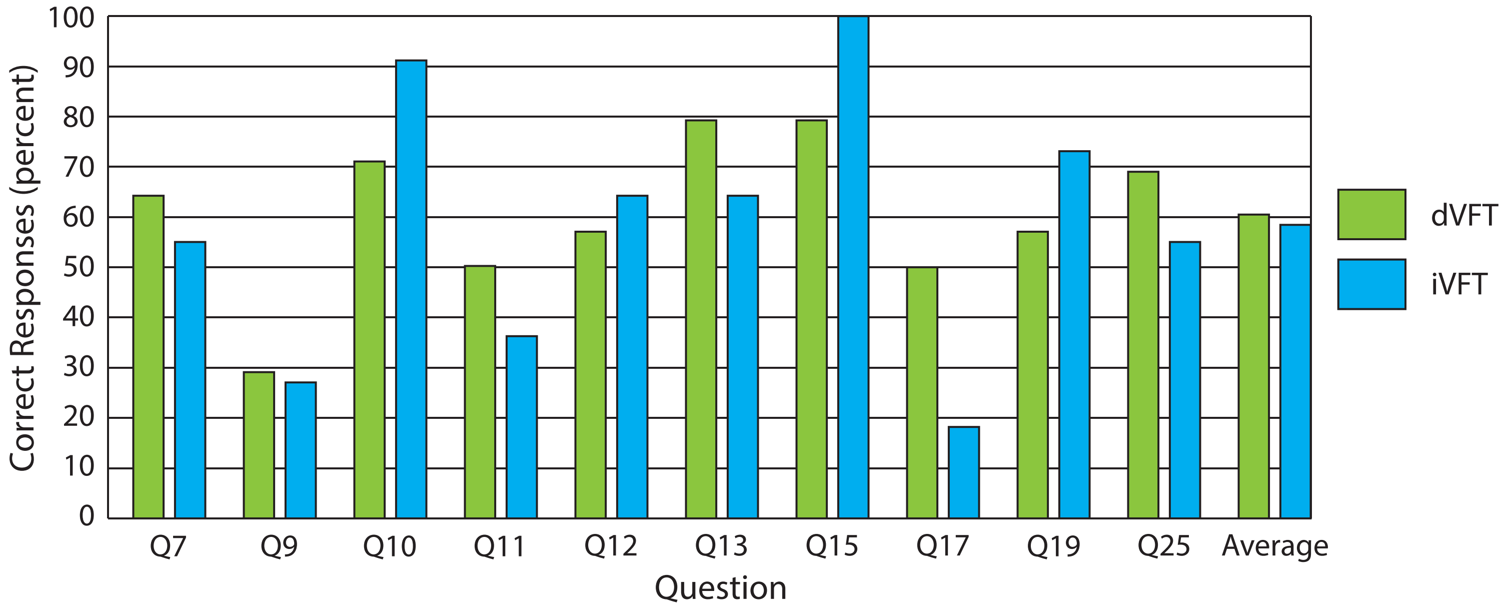
Table 2. Santa Barbara Sense of Direction Survey – standardized self-reporting assessment of student spatial reasoning skills

Training Results

- Highly accurate in both conditions
- Indicates quick and proficient navigation of the environment and initial spatial orientation

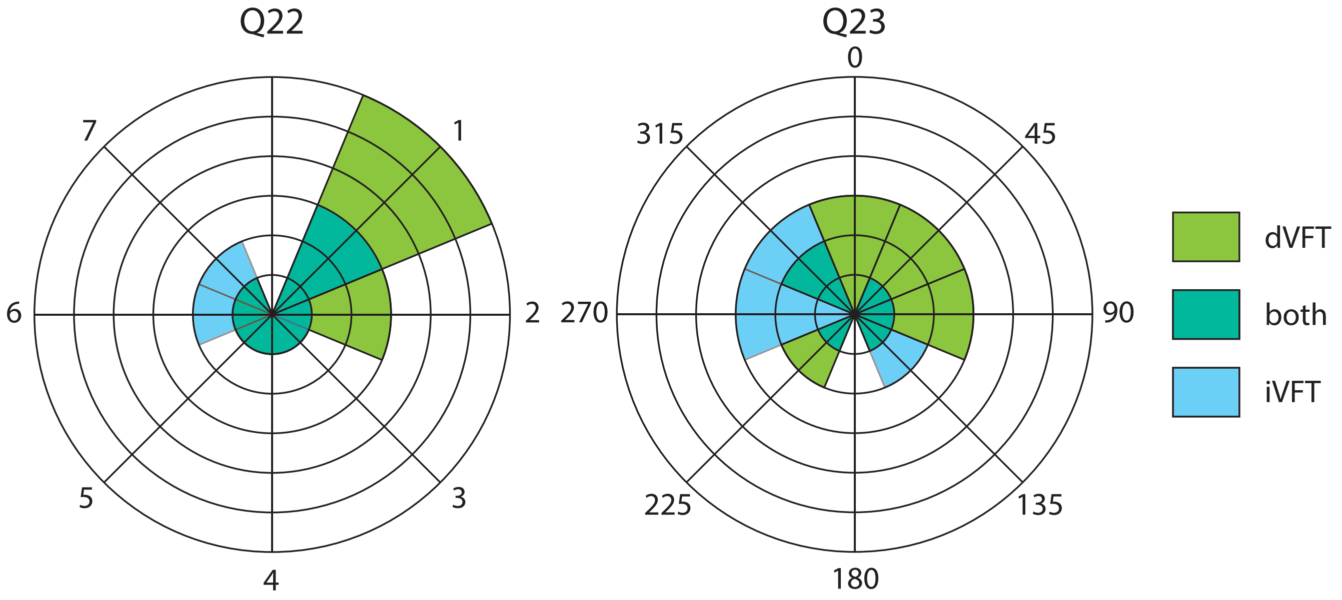


Geoscience Lab Results



- Decrease in accuracy in both conditions compared to in-person experience
- Functional equivalency in accuracy between dVFT and iVFT experiences
- $t(25) = 0.17$ $p = .86$ iVR ($M = 60$, $SD = 19.4$) dVR ($M = 58$, $SD = 29.08$)

Spatial Orientation and Reasoning



- Better results in feature orientation recall accuracy in the dVFT condition
- Both groups found the 360° absolute frame of reference (FoR) to be more difficult

Discussion – Lab Learning Objectives

Mixed Results on Lab Learning Objectives

- Research Question 1: Are students able to demonstrate domain specific learning outcomes within an accessible virtual environment as they would in a real-world geology field site lab experience?
    - Decrease in accuracy on geology lab responses as compared to in-person field site: identifying rocks, assessing rock orientation, and collision processes.
    - Observed increase in spatial reasoning using augmented compass as compared to in-person field skills.
    - Observed increase in independent exploration and reasoning as compared to relying on classmate/instructor assistance.

- Research Question 2: Will students in the desktop VR (dVR) and immersive VR (iVR) conditions demonstrate equivalent proficiency in lab goals as measured by selected response accuracy?
    - Functional equivalency in response accuracy suggests potential for VFT access/scalability without need for iVFT equipment.

Discussion – Student Engagement Survey

Condition	Positive Sentiments	Negative Sentiments
dVFT	• Accessibility • Autonomy of movement • Engagement/Gamification • Augmented information • Immersion in VFT	• Rock images not clear • Computer lab • Answering in L.M.S. • Some trouble with navigation/perspective
iVFT	• Accessibility • Novelty of HMD/VR gear • Engagement/Fun • Augmented information • Immersion in VFT	• Fogging in HMD • Text instructions blurry • Unstable image • Headache

Table 3. Emergent sentiment themes from the desktop (d) and immersive (i) virtual field trip (VFT) experiences.

- Students cited increased accessibility as top benefit
- High engagement results with no statistically significant difference between groups
- 100% of students indicated they wanted access to more VFT experiences
- Students cited VFT experiences as way to pre-train/review spatial reasoning skills and geology concepts

Thank You

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