

Research on student geoscience learning at Grand Canyon by complementary *in-situ* and virtual modalities

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Overview

Education through exploration, typically in the field, is fundamental in geoscience. But not all students enjoy equal access to field-based learning, while technological advances afford ever more immersive, rich, and student-centered virtual field experiences. Virtual experiences may be the only practical options for most students to explore pedagogically rich but inaccessible places located across and even beyond Earth. We are producers of a growing portfolio of **immersive virtual field trips (iVFTs)** situated around the globe, and engaged in research on their effectiveness. Our methods are more complementary than comparative, given that virtual and in-situ modalities have unique and distinct advantages and disadvantages.

Study Population

We administered the exercise to students enrolled in (1) a spring 2016 *introductory historical-geology course (GLG 102, n = 84)* populated mostly by non-majors, or (2) a fall 2016 *upper-division Southwest regional and environmental geology course (GLG 301, n = 39)* that serves mostly majors in geology or sustainability. Both courses represent the diversity of our large urban Southwestern research university.

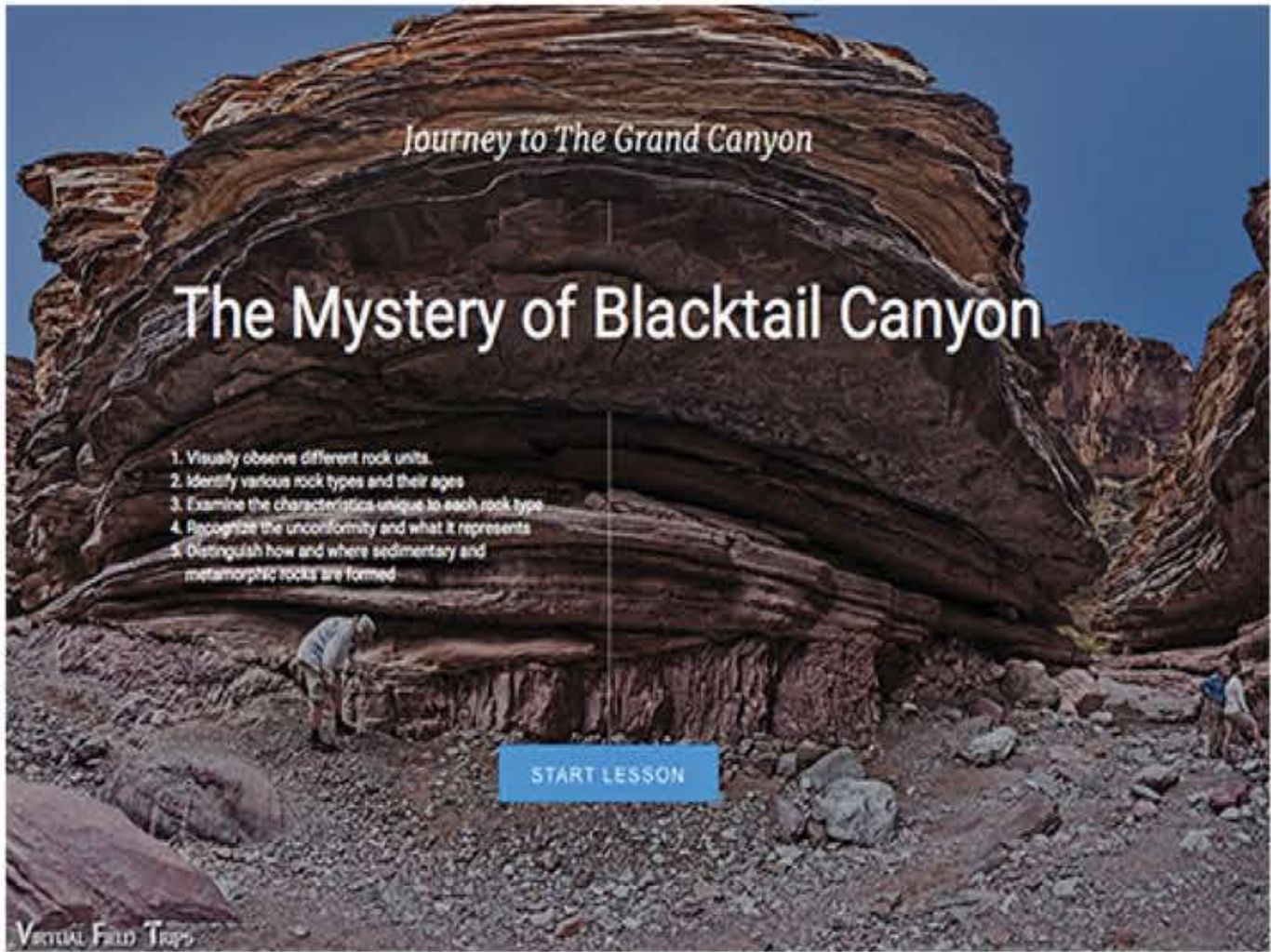
An optional single-day field trip to Grand Canyon National Park is part of each course. For the same extra credit, students in both courses chose either an **in-person field trip (ipFT)** to Grand Canyon National Park (control group) or an **online Grand Canyon iVFT** (experimental group), done in the same time interval.

Field Trip Itineraries

Both groups were enabled to investigate the complete geologic record at Grand Canyon. The ipFT groups collectively took an instructor-guided inquiry hike along the interpretive Trail of Time atop the South Rim **[1]**, while iVFT students individually took a guided-inquiry virtual tour of Grand Canyon geology from river level. Both trip itineraries were designed by the course instructor and each had a duration of approximately two hours. Learning outcomes for both trips were based on the essential concepts of Grand Canyon geology as encapsulated in the design of the Trail of Time exhibition **[1]**.



Trail of Time at Grand Canyon
(National Park Service photo)



Grand Canyon iVFT screenshot

Concept Sketching Exercise

The structure and origin of the *Great Unconformity* in Grand Canyon are content elements common to both modalities. iVFT- and ipFT-group students were instructed to create concept sketches **[2]** of the Great Unconformity from memory, before and after each trip. Sketches were coded with a 17-point rubric:



VISUALIZATION (8 points)

Does it look like the Great Unconformity?

Contact (2 points)

Contact is distinct and clearly drawn (1)

Contact is subhorizontal to horizontal (1)

Rock Units (2 points)

Rock unit(s) drawn above contact (1)

Rock unit(s) drawn below contact (1)

Rocks Above Contact (2 points)

Rocks above contact are layered (1)

Rocks above contact horizontally bedded (1)

Rocks Below Contact (2 points)

Rocks below contact are foliated (1)

Foliation is near vertical (1)

INTERPRETATION (9 points)

Does it correctly and adequately portray the geology?

Contact (1 point)

Labeled as Great Unconformity (1)

Rock Units (2 points)

Above contact labeled sedimentary (1)

Below contact labeled metamorphic (1)

Sed Rocks Above Contact (2 points)

Clastic texture denoted in sketch (1)

Unit labeled as Tapeats Sandstone (1)

Met Rocks Below Contact (2 points)

Unit labeled as basement rock (1)

Additional Features (3 points)

Labeled as a nonconformity (1)

Major age difference noted (1)

Age difference 1840-1700 Ma and 525 Ma quantified (1)

Results

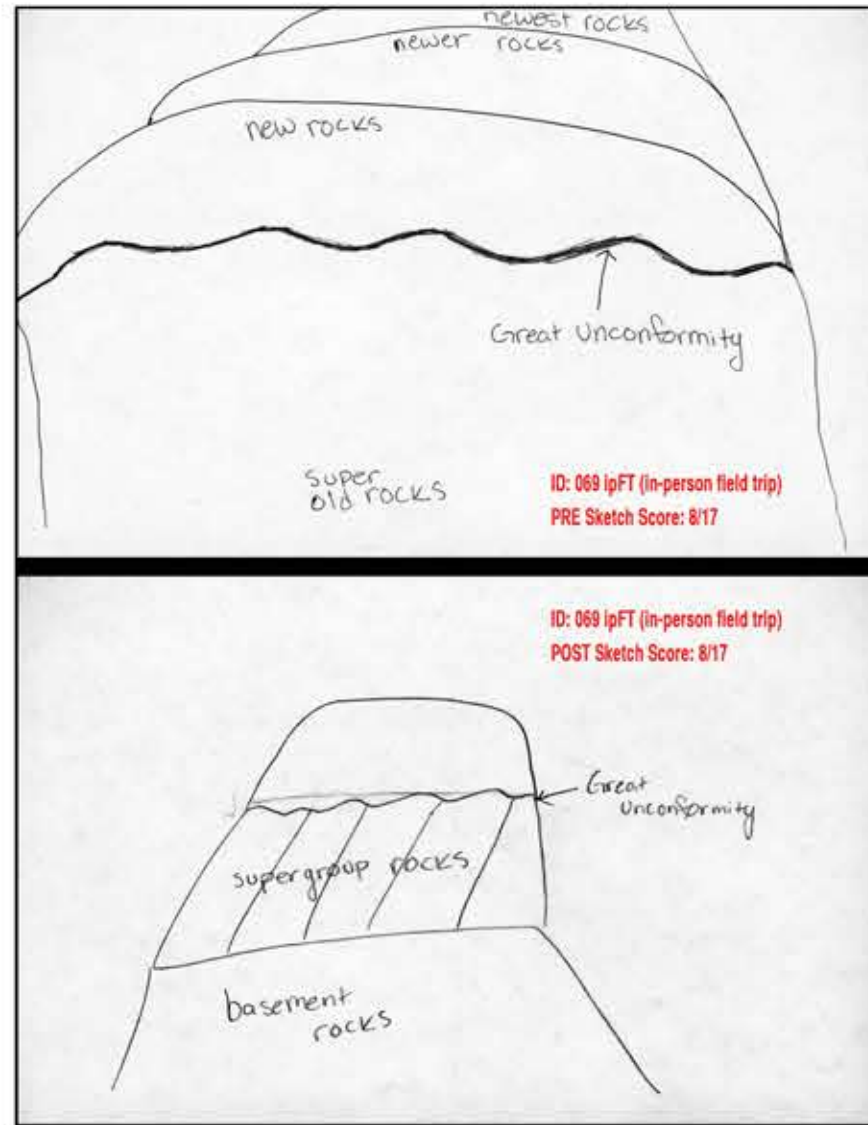
INTRODUCTORY HISTORICAL GEOLOGY (GLG 102) Spring 2016							
Mean Visualization Subscore (8 possible)	Mean Interpretation Subscore (9 possible)	Mean Total Score (17 possible)	Mean Visualization Subscore (8 possible)	Mean Interpretation Subscore (9 possible)	Mean Total Score (17 possible)	Δ Pre-Post Total Score	
ipFT (control) Group (n = 38)							
Pre-ipFT Concept Sketch			Post-ipFT Concept Sketch			+ 0.81* (+ 4.8 %)	
5.50 $\pm$ 1.70	1.53 $\pm$ 1.70	7.03 $\pm$ 2.87	6.00 $\pm$ 1.83	1.84 $\pm$ 1.55	7.84 $\pm$ 2.92		
*Not statistically significant, p (two-tailed) = 0.15							
iVFT (experimental) Group (n = 46)							
Pre-iVFT Concept Sketch			Post-iVFT Concept Sketch			+ 2.52** (+ 14.8 %)	
5.63 $\pm$ 1.81	1.46 $\pm$ 1.21	7.09 $\pm$ 2.36	6.59 $\pm$ 1.71	3.02 $\pm$ 1.90	9.61 $\pm$ 2.71		
**Statistically significant, p (two-tailed) < 0.001							

UPPER-DIVISION SOUTHWEST EARTH SCIENCE (GLG 301) Fall 2016							
Mean Visualization Subscore (8 possible)	Mean Interpretation Subscore (9 possible)	Mean Total Score (17 possible)	Mean Visualization Subscore (8 possible)	Mean Interpretation Subscore (9 possible)	Mean Total Score (17 possible)	Δ Pre-Post Total Score	
ipFT (control) Group (n = 22)							
Pre-ipFT Concept Sketch			Post-ipFT Concept Sketch			+ 0.73*	
6.32 $\pm$ 2.01	2.18 $\pm$ 1.59	8.50 $\pm$ 3.28	7.00 $\pm$ 1.38	2.23 $\pm$ 1.45	9.23 $\pm$ 2.37	(+ 4.3 %)	
*Not statistically significant, p (two-tailed) = 0.13							
iVFT (experimental) Group (n = 17)							
Pre-iVFT Concept Sketch			Post-iVFT Concept Sketch			+2.35**	
5.12 $\pm$ 2.37	1.59 $\pm$ 1.28	6.71 $\pm$ 3.33	6.53 $\pm$ 1.50	2.53 $\pm$ 2.03	9.06 $\pm$ 2.90	(+13.8%)	
**Statistically significant, p (two-tailed) < 0.001							

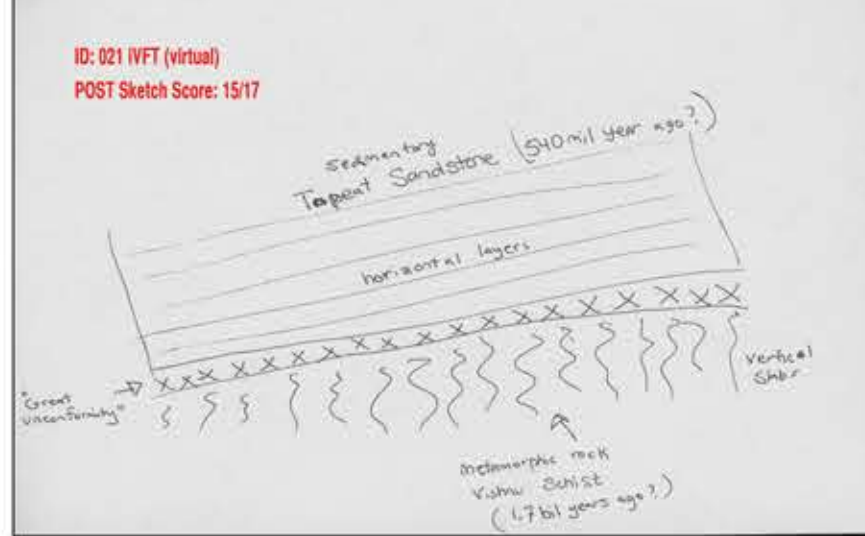
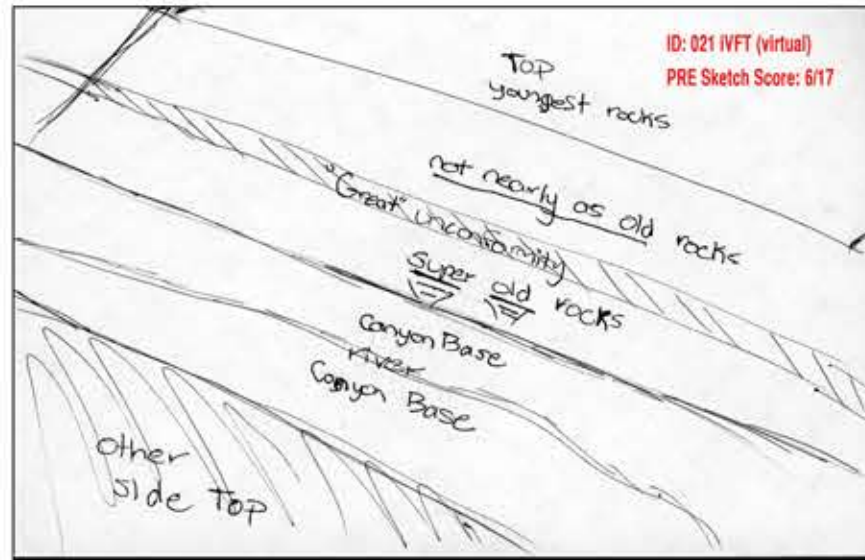
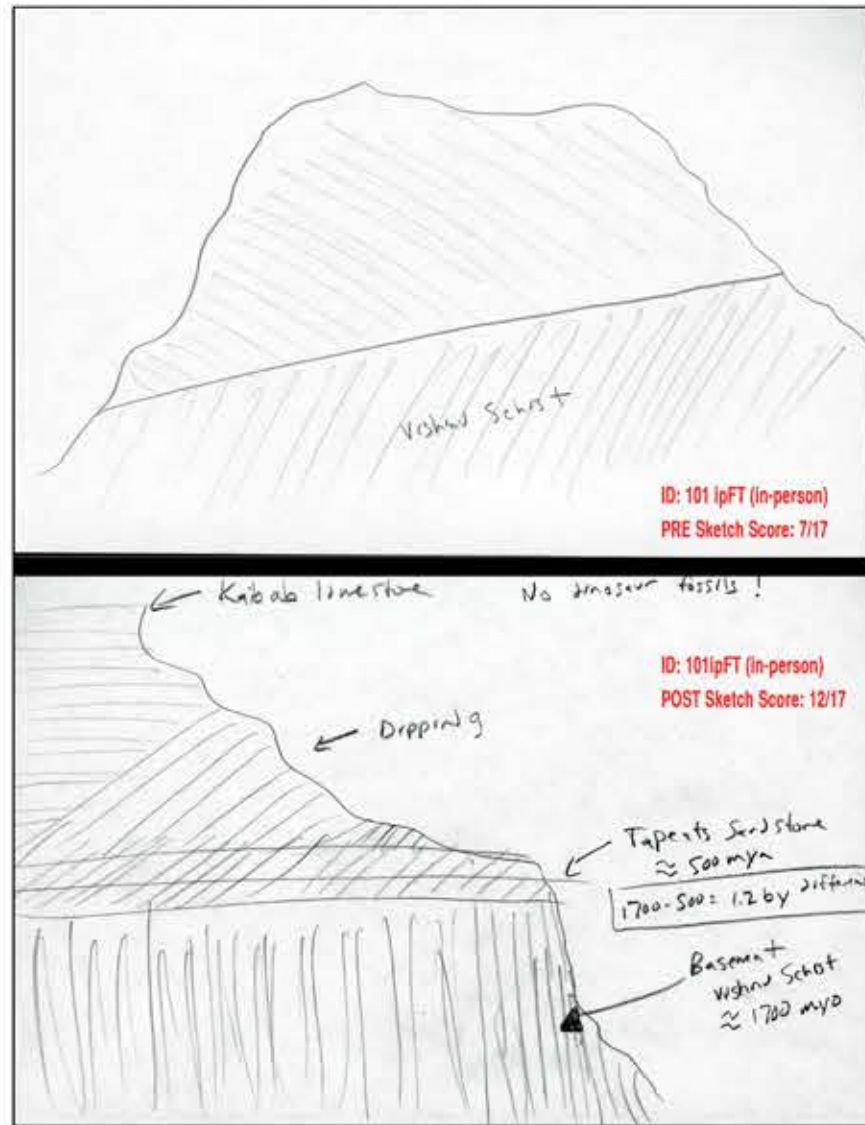
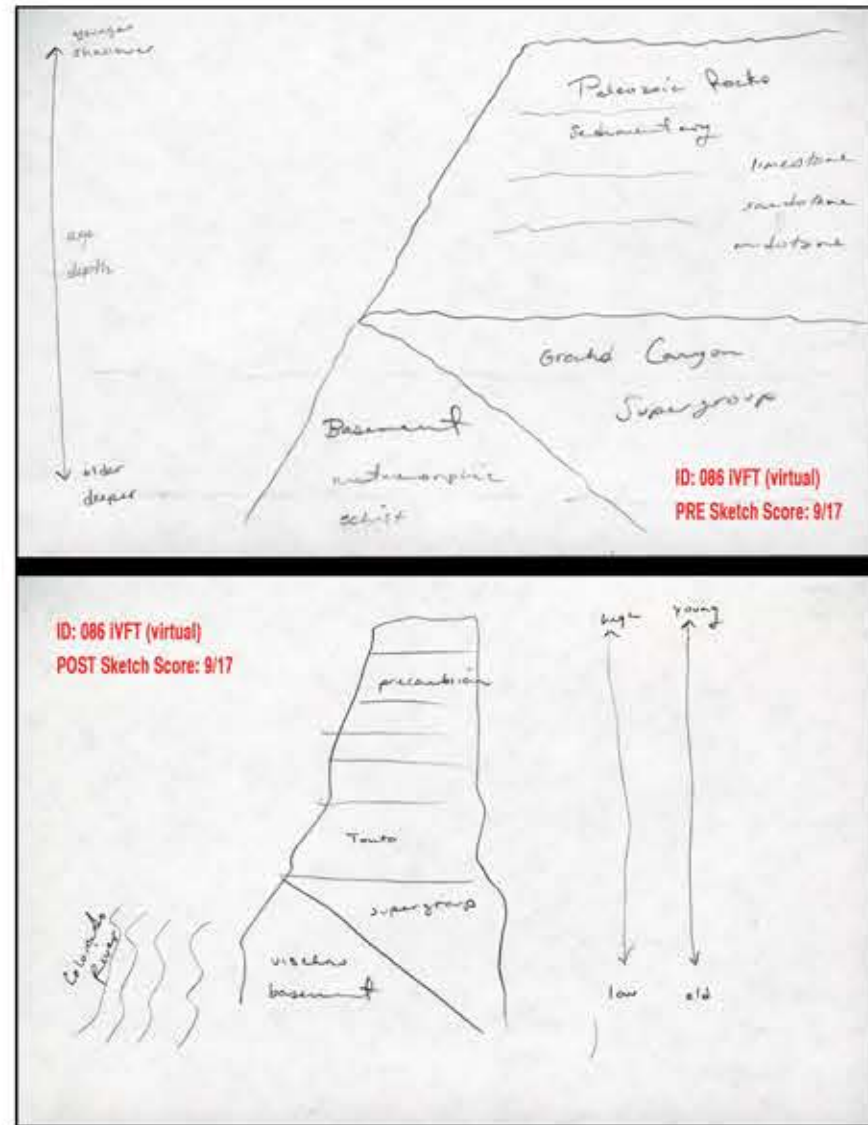
- However, in both classes, the iVFT group total score pre-post increases were approximately *three times greater* than those in the ipFT group, and were the only *statistically significant* increases.

Representative Examples of Scored Pre-Post Concept Sketches of the Great Unconformity

From
GLG 102
ipFT
group



From
GLG 102
iVFT
group



Take-away Message

Our results suggest that the more student-moderated focus on the Great Unconformity afforded by the iVFT led to greater retention of the visual aspects and the geological significance of the feature. We do not argue that the virtual field experience trumps the in-person trip, but rather that iVFTs can meet similar geological learning objectives.

Next Steps

We are triangulating these results with data from formative inquiry exercises and a pre-post survey of student attitudes and novelty- space factors using the PANAS instrument **[3]**. Emergent themes will be applied to enhance iVFT usability and ipFT accessibility alike.

References

- [1]** Karlstrom, K., Semken, S., Crossey, L., Perry, D., Gyllenhaal, E. D., Dodick, J., Williams, M., Hellmich-Bryan, J., Crow, R., Bueno Watts, N., & Ault, C. (2008). Informal geoscience education on a grand scale: the Trail of Time exhibition at Grand Canyon. *Journal of Geoscience Education*, 56(4), 354-361.
- [2]** Johnson, J. K., & Reynolds, S. J. (2005). Concept sketches: Using student- and instructor-generated, annotated sketches for learning, teaching, and assessment in geology courses. *Journal of Geoscience Education*, 53, 85-95.
- [3]** Watson, D., Clark, L. A., & Tellegan, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS survey. *Journal of Personality and Social Psychology*, 54(6), 1063-1070.

iVFTs are all freely accessible at vft.asu.edu
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