Science Big and Small: Visiting the Ice Age through Miniature and Life-Sized AR Experiences

Benjamin D. Nye,[1] David Nelson,[1] Imogen Rose Herrick,[1] Gale M. Sinatra,[1] Alana Kennedy,[1] Matt Davis,[2] Molly Sjoberg,[2] Pranav Ghate,[1] William Swartout[1] and Emily Lindsey[2]

[1]University of Southern California; [2]La Brea Tar Pits Museum

Background & Theoretical Framework

The Tar AR project, a collaboration between the La Brea Tar Pits/Natural History Museum of Los Angeles (NHMLA) and the University of Southern California, explores how an AR experience can enhance:

- *Engagement*: promote visitor enjoyment and interest,
- *Learning*: increase understanding of scientific topics, and
- *Usability*: promote user's feelings of ease with AR technology.

This research is investigating AR across combinations of three design factors: Interactivity, Visual Immersion, and Scale of Experience (big/small). This has been studied in three designs: (i) a Pilot, (ii) the Pit 91 tabletop AR simulation, and (iii) the life-sized Field Experience.

Pilot (Headset, Low Interactivity)
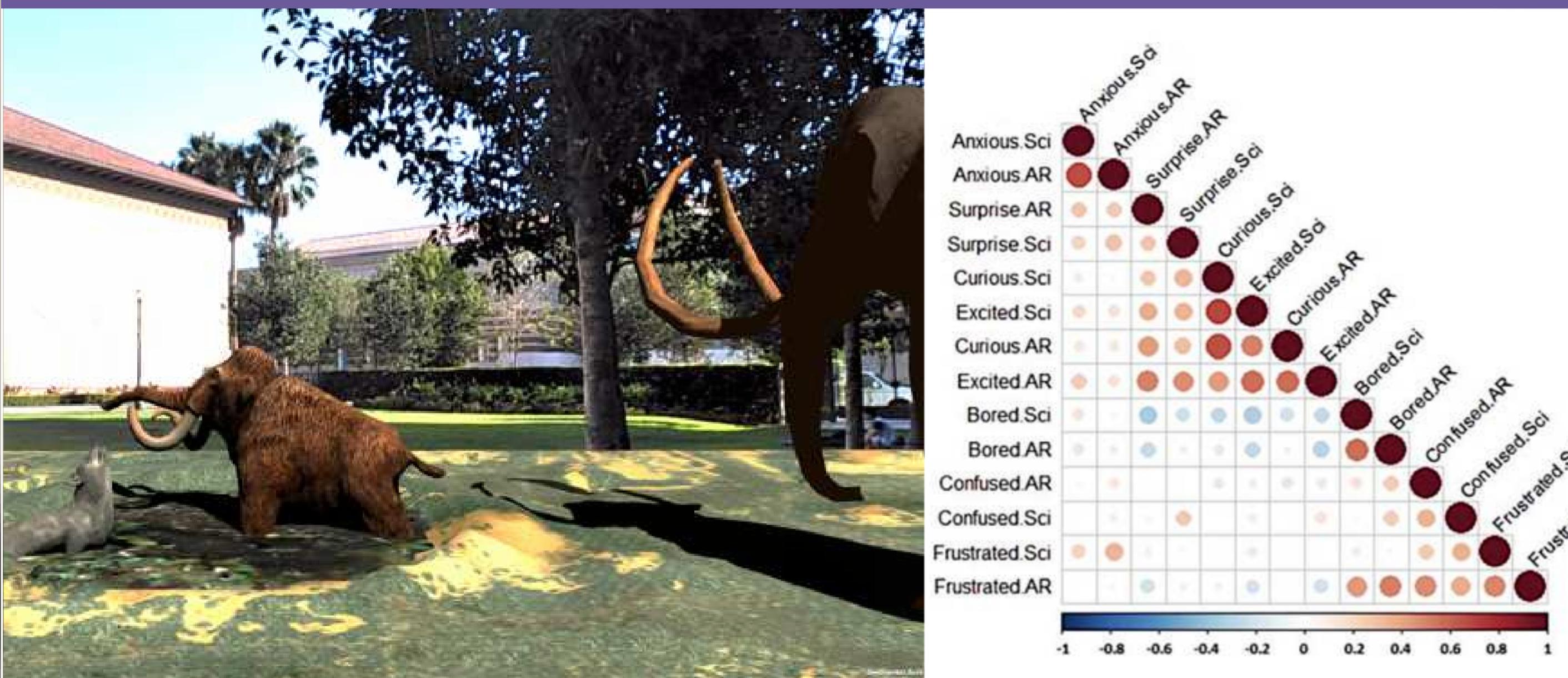
Model Design
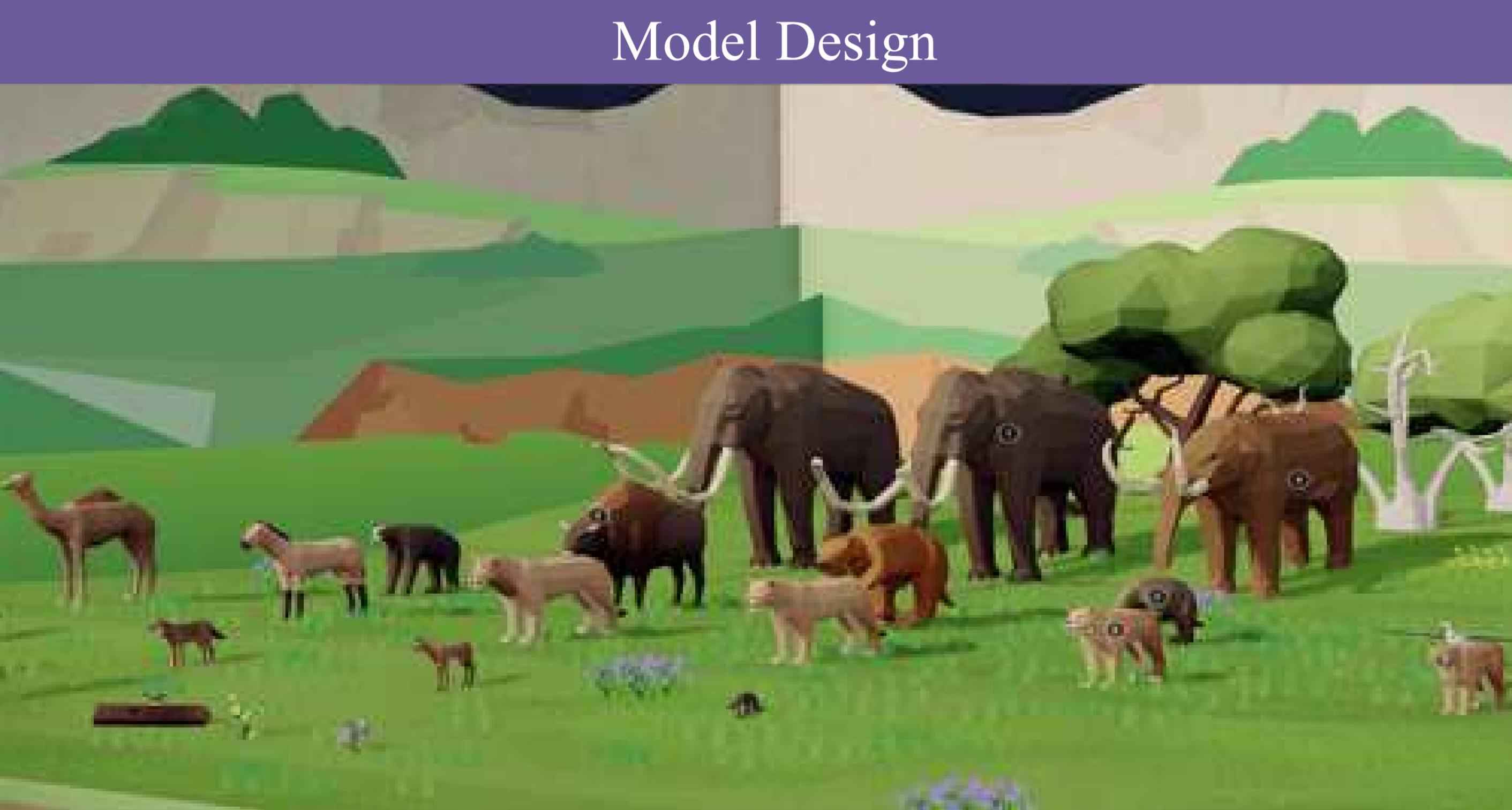
Design Implications:

- *Pilot (pre-award; N=62)*: Strong learning gains and engagement, which remedied misconceptions about entrapment rates and how entrapment happens. Higher knowledge gain when interested in science and curious overall.
- *Notable Takeaways*: Users ignore distractions in an AR scene (e.g., people walking through it). Across all conditions in all 3 experiences learners are focused.
- *Low Poly*: Action and narrative more important than realism. Supports scientific accuracy by focusing on general body structure, locomotion, and ecosystem roles.
- *Asset Design as Science*: Submitted manuscript documenting paleoart design.

References.: Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. IEEE Computer Graphics and Applications, 21, 34–47.
Macdonald, S. (Ed.). (1997). The politics of display: Museums, science, culture. New York, NY:Routledge
Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C (2013). Current status, opportunities and challenges of augmented reality in education. Computers & Education, 62, 41–49.
Saldaña, J. (2013). The coding manual for qualitative researchers. Los Angeles: SAGE Publications.

Email: nye@ict.usc.edu

Pit 91 - Small Scale AR

1. Does AR technology promote visitor enjoyment of an exhibit?
2. Does AR technology promote visitor learning of science content?
3. Do visitors find AR technology easy to use?

Pit 91 - Conditions

Low Interaction

Handheld

Immersive

High Interaction
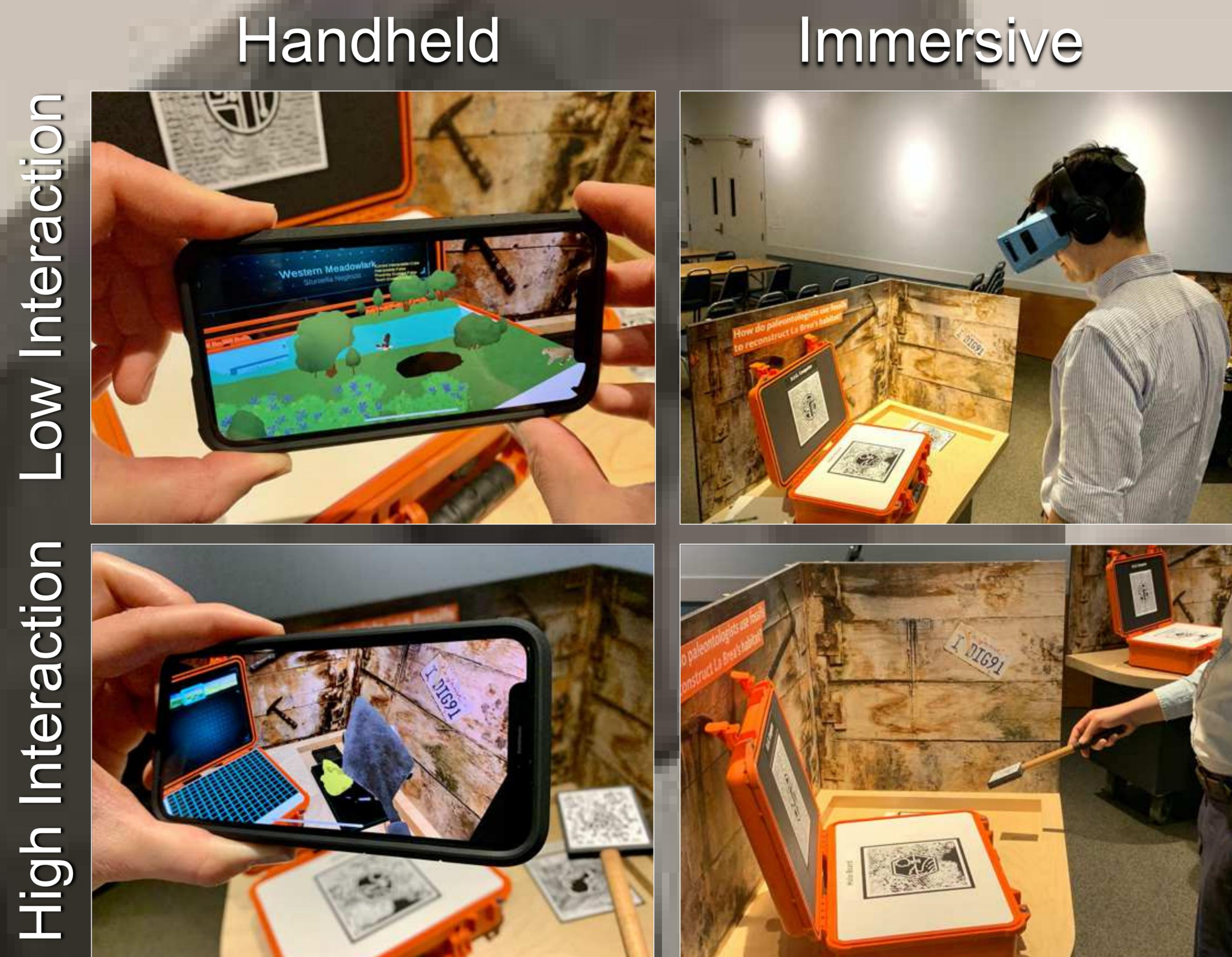
Pit 91 - Learning Gains by Condition

Condition	Number of Participants	Pre-Test Mean % Correct Score (SD)	Post-Test Mean % Correct Score (SD)
Control #1 (instructed)	30	0.66 (0.17)	0.76 (0.15)
Control #2 (naturalistic)	37	0.65 (0.18)	0.76 (0.16)
Manipulation Headset	42	0.68 (0.15)	0.71 (0.16)
Manipulation Phone	46	0.69 (0.17)	0.77 (0.18)
Selection Headset	40	0.63 (0.14)	0.73 (0.15)
Selection Phone	45	0.71 (0.13)	0.74 (0.14)

Pit 91 - Main Findings

Usability Studies (28 visitors and 40 museum staff)
- Dig AR fossils to populate ecosystem and revise climate hypotheses
- Interview Data Indicated: (a) surprise as an initiator for hypothesis revision, and (b) deepening understanding of fossil evidence

Randomized Controlled Trial (N=240 Adult visitors):
- Significant knowledge gains in all conditions (μ_{pre}=0.67; μ_{post}=0.74; t(239) = 7.30, p < 0.001)
- No significant effect of condition on posttest scores after controlling for pretest scores (ANCOVA F(5,233) = 1.94, p > 0.05).
- Usability Factors: Headsets took help to adjust. Manipulation tool hard to hold with phone at same time.
- Social (Selection Phone): Ineligible visitors (e.g., under 18 or just did Control condition) naturally used Selection Phone in groups of 2-3

Field Experience - Life Sized AR

1. Does life-sized AR follow similar patterns in learning and engagement across different conditions?
2. What unique usability factors may favor certain conditions?

Field Experience - Conditions

Handheld

Immersive
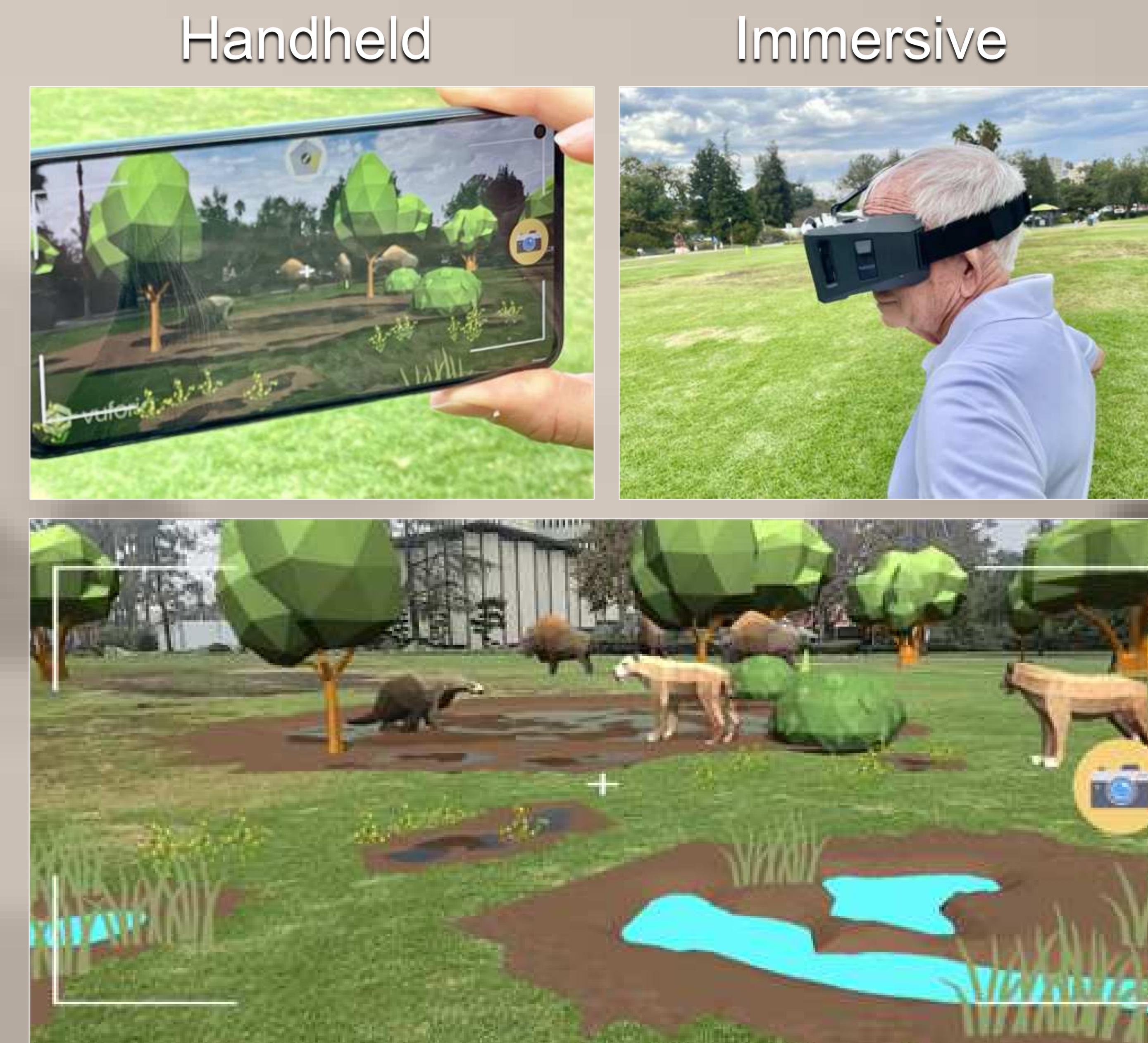
Field Experience - Design

Design:
- Field shows fossils in modern day, go back in time to scene where visitor observes (may take pictures) during entrapment events.
- No manipulation tool. Low-interactivity similar to Pilot (events triggered subtly by viewing). High interactivity take and select photos.

Initial Usability:
- First phase of usability testing in progress. All conditions appear enjoyable, but headset is slower to set up.
- Phone audio surprisingly clear without headphones outdoors

Summary

Main Takeaways:
- *Small Scale AR*: Surprise and curiosity associated with knowledge revision. No compelling advantage in learning or engagement to greater manipulation with a tool or with headset visual immersion. Options for social interaction favors handheld phone with no tool.
- *Life Sized AR*: This will investigate each condition to determine if same pattern holds. Pilot learning associated with positive emotions.
- *Static Graphics (e.g., Posters)*: Appear stronger on selecting a set of fossils in Pit 91, possibly due to large display (show all in set at once).