Digitally-empowered learning: teaching archaeology through virtual reality and game-based learning

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INTRODUCTION

Archaeology has an inherent physical component and deals largely with three-dimensional objects, making it challenging to present in a traditional classroom. Like many natural sciences, a critical component of archaeology is field work. But field experience is not an option for most students.

- Participation requires travel, time, financial, or logistical resources not available to many students
- Burden is greatest on low-income, minority, and non-traditional students
- Many sites or field schools inaccessible for students with limited mobility

With little exposure to archaeological research, fewer students are entering archaeology, particularly minority students (Smith, 2004; Wilson, 2015).

These challenges are well met by virtual reality (VR), which creates a simulated three-dimensional environment where a user can interact in a real and physical way, thereby transforming data analysis into a sensory and cognitive experience.

PROJECT GOALS

Creation of an immersive, interactive, room-scale VR archaeological site that will:

1) Teach methods & principles that are challenging to present in a traditional classroom using **sensory and cognitive immersion and game-based learning**;
2) **Allow wider access** to a field science that has previously been limited to select students.

Fig. 1. Left: Student using Vive headset and hand controllers in VR cave site. Right: Student view of VR cave site with shovel (far right) excavating in hanging grid.

Fig. 2. View of VR prototype cave site as seen in virtual reality. Hanging grid system in the middle of the image indicates where a student can dig.

INNOVATION & CLASSROOM INTEGRATION

- HTC Vive VR platform: wireless headset, 2 hand controllers, and two base stations
  - User's hands and head are tracked in 3-dimensions
  - User has freedom of movement within a 4x4 meter space
- VR environments developed using Unreal Engine 4, an open source gaming engine
- 2 virtually simulated archaeological sites:
  - **Learning site: Carson Mounds, Mississippi**
    - Site created using Lidar, photographic, and field data provided by J. Mehta
    - Archaeologically accurate, including site- and time-specific objects created using photogrammetry
    - Teach field methods, basic concepts
  - **Game site: Fictional abandoned mining cave (figs. 1, 2)**
    - Archaeological concepts embedded in game narrative
    - In-game challenges let students solve successively more abstract problems rather than accumulate and memorize facts
    - Game tasks develop ability to test theories empirically, i.e. develop a scientific approach to problem solving
- Game-based, VR module set into archaeology curriculum for undergraduate students with the following learning objectives:
  - Teach the physical methods of archaeological excavation by providing a virtual setting and tools to allow any student to actively engage in field work;
  - Teach archaeological concepts using a scientific approach to problem solving by couching them within a role-playing game.

BENEFITS OF VR FOR EDUCATION

Recognized benefits of VR for Education (Hedberg & Alexander, 2017; Salomon, 1979; Winn & Briken, 1992):

- Physical interaction and manipulation of objects through intuitive interactions
- Presentation of abstract concepts with concrete experiences
- Opportunities to repeat actions or revisit situations for better understanding
- Increased retention through active learning, sensory and cognitive immersion

ADDITIONAL BENEFITS OF VR FOR ARCHAEOLOGY

- Opportunities outside a student's normal experiences (excavating human remains or prehistoric artifacts; constructing a building from archaeological ruins)
- Interaction with rare, fragile, or otherwise inaccessible material in a no-risk setting
- Participation in otherwise inaccessible activities (underwater sites, sites in war-torn countries, sites that no longer exist)
- Realistic recording and measuring of data (i.e., documenting artifacts *in situ)*
- Relay concepts and activities that are challenging to present in a traditional classroom
- Wider access to a field science previously limited to select students.

FUTURE GOALS

- Game-based VR module integrated into UIUC undergraduate curriculum in Spring 2019
  - Assess efficacy of technology and its integration
- Expand prototype for maximum flexibility: additional sites, tasks, learning objectives
- Generalize prototype for use with other subject matter and disciplines

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