**Abstract**

**Keywords**

Augmented Reality, Cultural Heritage, Interaction techniques, Tangible Object

**Introduction**

**Learning with AR**

**Emerging Technologies for Culture Heritage**

**Learning with Tangible Objects**

**The Study of the Learning**

**Input Goals and Research Questions**

The goal of this comparative study is to explore how different interaction techniques with tangible objects based on Augmented Reality impact learning effect. In particular, we explored the following questions:

RQ1. How do differences in interaction techniques impact learning intrinsic motivation?

RQ2. How do differences in interaction techniques impact learning engagement?

RQ3. How do differences in interaction techniques impact the learning outcomes?

**Summary the Experiment**

In view of these questions, we conducted a comprehensive user study of 40 students that incorporates questionnaires, test and interview to explore the impact of the above three interactive technologies on learning effect.

**Background**

1. **Learning with AR**
2. **Learning with Tangible Objects**
3. **The Study of the Learning**

**Methodology**

We conduct a between-subject experiment to evaluate the learning effect under three different conditions: non-AR system and tangible interaction technique; AR system with no tangible object interaction technique and AR system with tangible object interaction technique.

1. **Hypotheses**

We are more interested in the user experience of the AR system with tangible object interaction technique. Therefore, we propose the following hypotheses:

H1. Users are more motivated to learning with objects of which greater interactivity is afforded.

H2. Users are more engaged with objects of which greater interactivity is afforded.

H3. Users achieve the best learning outcomes when tangible interactions are afforded.

1. **Materials**

To facilitate a valid comparison, we used the same six artefacts implemented in each implementation. These collections are chosen with a variety of time periods and materials.

Table 1. Overview of six artefacts

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **#** | **Name** | **Picture** | **Size** | **Time Period** | **Museum** | **Category** |
| 1 | The Bronze Mask with Protruding Pupils |  | Height: 66cm  Width: 138cm | Shang  1600-1046 BC | Sanxingdui Museum | Bronze |
| 2 | Vajrasattva Bronze Status |  | Height: 58.5cm  Width：46.5cm | Western Xia  1038-1227 BC | Ningxia Museum | Bronze |
| 3 | Tri-coloured camel |  | Height: 87cm | Tang  618-907 AD | Nanjing Museum | Ceramics |
| 4 | Pottery Figure of a standing Lady |  | Height: 138cm  Width: 26.6cm | Tang  618-907 AD | National Palace Museum, Taipei | Ceramics |
| 5 | Imari Covered Bowl with Floral Sprays |  | Height: 32cm  Width：28cm | Qing  1622-1795 BC | Palace Museum | Ceramics |
| 6 | Eight Corners Case (Black) |  | Height: 31cm  Width: 27.3cm | Ming  1368-1644 AD | Zhejiang Museum | Lacquerware |

1. **Study Design**
2. **Leaflet**
3. **Magic Book**
4. **Magic Cube**
5. **Participants**
6. **Procedure**
7. **Measures and Indicators**
8. **Research Tools**
9. **Pretest and Posttest**

In our test design, we measured some knowledge of the relics across all three interaction techniques, including: material, color, size, history, location and description.

1. **Questionnaires**
2. **Interviews**
3. **Data Analysis Tools**

**Results**

1. **Participant Profile**
2. **Quantitative Results**
3. **Intrinsic Motivation**
4. **Engagement**
5. **Learning outcome**
6. **Qualitative Results**

Based on Observations and Interview

**Discussion**

1. **Assessing Learning Intrinsic Motivation**
2. **Assessing Learning Engagement**
3. **Assessing Quantitative Learning Results**
4. **Implications for Design**
5. **Limitations and Future Work**

**Conclusion**

**Acknowledgement**

**Reference**