Innovative archaeological learning using Mixed Reality

Potentials and limitations

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Introduction

Visualisation is an integral part of the field of archaeology and is entangled in many archaeological essential practices, such as documentation, interpretation and presentation. The visualisation of archaeology has developed overtime as the field evolved. The past few decades have witnessed a special devotion in the archaeological documentation research to the now-available digital tools for research and the development of the produced large 3d data sets (Averet et al., 2017). Methods vary for creating and/or producing 3d models of excavated trenches, surviving archaeological structures or for the reconstructions of finds, however, the average model contains millions of points. Although the vast data created is in a 3d form, it is still processed, worked on it and analysed using two-dimensional mediums, such as screens and printed publications. In archaeological higher education, one main reason for the employment of 3d models is the consideration of spatial complexity as a main component of archaeological structures' understanding. Nonetheless, 3d models have not been a substantial part of archaeological education, which is still instead largely distinguished by flattening the examined 3d objects to 2d images, architectural drawings and slides. This is partially due to the lack the appropriate infrastructure to ensure the adequate transfer of this research information.

The project "Mixed and Augmented Reality in Blended Learning Environments, MARBLE" was conceived with the background thinking of developing the best possible strategies for utilizing the immense 3d digital data in a model. MARBLE has mainly been concerned with testing the efficacy of employing modern 3d visualization methods, with a special focus on Mixed Reality (MR), in archaeological higher education. The aim of the project is to understand the impact of using this new technology on students' learning gains, motivation and engagement. The project's development is mainly based on users' feedback (learners and academic body) to further develop and promote the MR learning scenario as a complementary method to the traditional archaeological higher education. It also aims at correlating these results with findings of other studies in the field of cultural heritage and beyond.

MR in archaeological higher education

The project's focus has been consciously diverted from Virtual Reality (VR), where the design of the Head Mounted Display (HMD) is isolating the users in virtual space to a large extent. Instead, the project takes advantage of the new MR technology used in HMDs (in this project's case the HoloLens 2, released in 2019), which offers the learners the opportunity of a social learning experience. The MR learning scenario goes beyond AR, in a sense that virtual objects are not superimposed on the real environment (The way they are in AR). MR technology expands the range of tasks and activities to include joint action in space, and offers experiential learning that was previously not possible in this dimension. Hence, the learners can collaborate with each other in the MR learning scenario, which allows for a flexible and interactive discussion while observing the objects studied. Moreover, the learners are able to choose their own perspective of the model and don't have to deal with per-fabricated perspectives, which supports the learner's interpretation of information in the context of their own experiences (constructivist didactics). According to the current Horizon Report (2022), the added value of MR lies in the possibility of authentic learning experiences through the unification of the physical with the imaginable and in the interactivity with the digital object, as well as among the learners themselves.

Several sessions and users' tests were planned with archaeology students so far, as seen in Fig.1. The number of sessions was unfortunately less than originally planned due to the restrictions on in-person sessions during COVID-19 pandemic. The students have unanimously reported finding the use of the holographic devices and the MR learning scenario interesting and motivating. They also reported feeling gradually more comfortable using the technology, as this was the first MR experience for most of them. The students largely praised the self-regulated experience with the model and the better understanding of spatially complex structures in comparison to the traditional learning methods. This is mainly because of a set of developed tools that allow manipulating and interacting with the model. One specific tool (clipping tool) that creates plans and sections in real-time was among the most positively rated tools, since "one can better understand the spatial relations between the outside and the inside of a structure" as one student pointed out in one of the users' tests like in Fig.2.

a *b*

Fig. 1. a) Sessions and b) users' tests with archaeology students within the framework of MARBLE (© Jasmin Rolke).

Discussion on digital and content

The project has shown great potentials to be explored and further developed using the modern digital technologies in enhancing and promoting archaeological content in higher education.

3d models have been criticised for representing lively objects and architectural structures in an arbitrary digital stasis, in which the lively content is not properly disseminated to the recipients (Reily, 2015). MR technology exhibits a considerable scope to show the liveliness of archaeology, and to transmit architecture in to multidimensional, multi-sensory, self-governed experience in the real environment. Thereupon, averting from the like-wise scrutinised virtual solitude of a fully-immersive VR experience. However, this great potency is accompanied by a number of limitations mainly relating to the digital-content dichotomy. The project was initially conceptualised with the aim of making use of the abundance of produced 3d models of archaeological structures. The HL2, being an HMD with a built-in processing unit, has restrictions on the number of polygons in a processed model. This has narrowed down the number of models that can be displayed using the device.

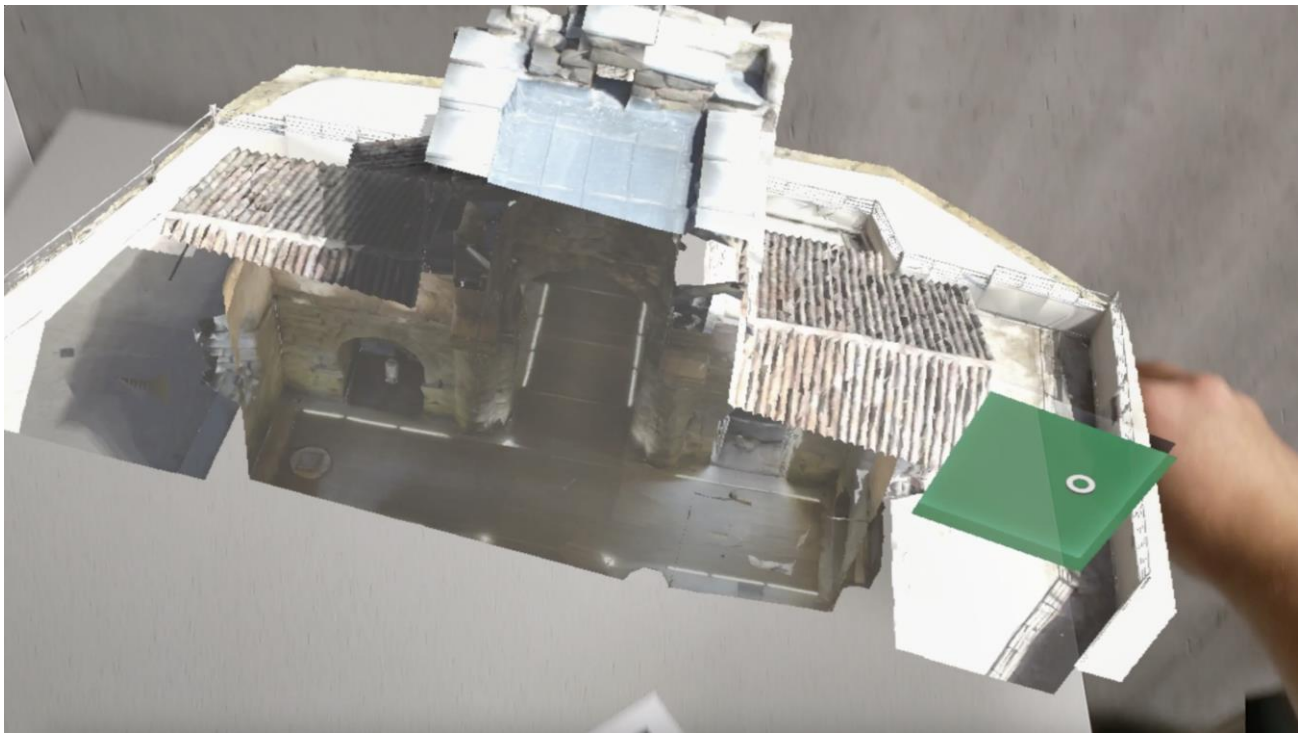

Fig. 2. The model of Santa Maria Santa María de Melque, while producing a cross-section with the clipping tool (© Marc-Alexander Lohfink, 3d model created by Global Digital Heritage. Available at: https://sketchfab.com/3d-models/santa-maria-de-melque-toledo-spain-36cacabf9f364f8cbd45ff659a6144d4).

The project's team is also actively working on a follow-up project focusing on remote rendering, which allows visualising models with a sophisticated level of details at a high graphic quality. Additionally, the fairly limited field of view of the HL2 (52 degrees) has also confined the choice of suitable models. The project's team has also found after experimenting with a variety of models, that models retaining a relatively higher level of spatial complexity are the models mostly benefiting from the visualisation possibilities offered in this technology. Moreover, investigations have revealed that using a double-shell models offering data both from external geometries as well as internal structures are significantly more promising for such a learning experience. That said, the regularly generated archaeological 3d data is confined to a small number of double-shell models. Therefore, the anticipated providential learning content would require paying special attention to this problematic while producing new digital archaeological data.

Extended realities have been widely adopted in museums and cultural heritage institutions for the purpose of non-formal education (Orr et al., 2021). However, it has rarely been explored in the field of archaeological higher education. The challenge for higher education lies in keeping the content informative and authentic, while benefiting and simultaneously moving a step further from the novelty and the entertainment effect of

the extended reality experiences. Feedback from users' test has revealed that for an utmost benefit of the technology in formal education, these technologies should be not merely used as a simple visualisation tool. The didactic content needs to meet a certain level of complexity to surpass the cool gaming effect and contribute to sustainable knowledge.

MARBLE has been a multi-disciplinary cooperation between byzantine archaeologists and digital media scientists. The experience of communicating different perspectives on the MR learning scenario has been fruitful and very rewarding so far. However, it has shown that the consilience can only be realised with technical and terminological skillsets that are yet to be mastered by the archaeological research community.

Conclusion

MARBLE is an innovative learning initiative that aims to promote and enhance archaeological higher education. Investigations has shown that the technology is holding great potential for being a promising complementary to traditional learning methods. Nonetheless, the technology in the smart glasses is still to a large extent the bottleneck for further developing these learning scenarios. The implementation of this technology into higher education can only be profitable if considered together with a strong didactic approach. Such new media are only successful when they have a similar to traditional mediums in changing people's perspective on a certain learnable concept (Azuma, 2016).

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Conflict of Interests Disclosure

The author declares no conflict of interests.

Author Contributions

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