Blending the Material and the Digital: A Project at the Intersection of Museum Interpretation, Academic Research, and Experimental Archaeology

Jeffra, C.; Hilditch, J.; Waagen, J.; Lanjouw, T.; Stoffer, M.; de Gelder, L.; Kim, M.J.

Publication date
2020

Document Version
Final published version

Published in
The EXARC Journal

License
CC BY-NC-SA

Link to publication

Citation for published version (APA):
Jeffra, C., Hilditch, J., Waagen, J., Lanjouw, T., Stoffer, M., de Gelder, L., & Kim, M. J. (2020). Blending the Material and the Digital: A Project at the Intersection of Museum Interpretation, Academic Research, and Experimental Archaeology. *The EXARC Journal*, *2020*(4). https://exarc.net/ark:/88735/10541

Blending the Material and the Digital: A Project at the Intersection of Museum Interpretation, Academic Research, and Experimental Archaeology

exarc.net/issue-2020-4/int/blending-material-and-digital-project

Persistent Identifier
https://exarc.net/ark:/88735/10541
C. Jeffra,
J. Hilditch,
J. Waagen,
T. Lanjouw,
M. Stoffer,
L. de Gelder and
M. J. Kim (NL)
EXARC Journal Issue 2020/4

The power of digital technologies to communicate archaeological information in a museum context has recently been critically evaluated (Paardekooper, 2019). A recent collaboration between members of the Tracing the Potter's Wheel project, the 4D Research Lab, and the Allard Pierson Museum and Knowledge Institute illustrates the way that such collaborations can avoid or overcome a number of the pitfalls highlighted in that publication.

Introduction

In a recent issue of this Journal, Roeland Paardekooper raised several meaningful discussion points relating to the relationships between high-tech initiatives from the private sector and the low-tech approaches espoused by many open-air archaeological museums (2019). In the latter half of 2019, the authors collaborated on a project which aimed to build a bridge between low-tech and high-tech by using traditionally presented ceramic objects from behind the glass of a museum display within an augmented reality (AR) learning app. This project brought together members of the 4D Research Lab at the University of Amsterdam (Jitte Waagen, Tijm Lanjouw, and Markus Stoffer), the Allard Pierson museum and knowledge institute (Laurien de Gelder), the experimental archaeologist of the Tracing the Potter's Wheel Project (Dr Caroline Jeffra), MA-level archaeology students (Myung Ju Kim), and Amsterdam Centre for Ancient Studies and Archaeology (ACASA) pedagogical practice (Dr Jill Hilditch). In contrast to Paardekooper's paper, this collaborative project focused upon student users within a traditional museum. While this is not from a museum perspective exclusively it is instead an exploration of the pedagogy of intensification of learning within a museum setting. Despite this contrast, there are interesting implications for museums who host material ripe for further similar supplementary media. Chief among these implications is the democratisation of responsibility for learning outcomes, which is explored in greater depth below.

A Need for Blended Learning

Modern society is fundamentally audiovisual, and there is a growing expectation that complex information is made accessible in audiovisual formats. More importantly, as their education progresses, students become used to accessing that information in their own timeframe and on their own terms. The use of smartphones, tablets, and laptops as a primary means of notetaking in lectures has risen exponentially over the past 15 years, in tandem with the rise of digital presentations by instructors. This is an age of institutional digital study resources (Canvas is used at ACASA), where lectures are archived, assessments submitted and graded, specific topics discussed in chat forums, and links to further online resources (such as digital journals and e-books) are posted. Why then should the study of our past material culture remain as static as pots in a glass display case? Thanks to the Blended Learning funding initiative at University of Amsterdam (UvA), the authors were able to develop an app with the 4D Research Lab to allow Masters (MA) students to supplement their traditional learning via academic texts and lectures with a more visually immersive experience.

The Blended Learning initiative at the UvA is aimed at developing a sustainable and dynamic capacity for innovation in teaching. From within ACASA there has been a build-up through various innovation initiatives. One of these initiatives from 2016 to 2019, a tablet guided walk, was developed which made use of fast mobile internet (4G) and geographical information system software (GIS). This 4G GIS walk provides first year students with historical and archaeological maps and data in real time while walking to help them become acquainted with the city of Amsterdam and its historical layers. Building on this success, the possibilities provided by the Blended Learning initiative have been embraced by the 4DRL in a series of projects which experiment with incorporating 3D elements into 2D digital environments. The main goal of these has been to further enhance perception of the environment, buildings, or objects under study using digital augmentation, or augmented reality (AR) as it is called in the world of digital technology. AR is based upon detection of real space and generally works via so-called targets that are recognized by a medium (smartphone, tablet, AR goggles), after which digital data (termed augments, and usually in the form of 3D models) are inserted into the representation of the real world seen on the device's display. In some cases, target recognition is not needed, and the augment can be inserted into pre-mapped rooms or a suitably flat space. Often, some form of interaction between the augments and the observer is possible, and when there is interaction possible between the augments and the physical world around them, mixed reality (MR) is the preferred term. Various conceptualizations of AR enhancements have been tested as part of the exploration for improving student engagement and knowledge: reinserting since-demolished buildings in true scale to where they once stood (virtual reconstruction), offering complementary information on objects in view (virtual teacher), and allowing interaction and closer inspection of models through observer manipulation (virtual lab).

The app developed in this project integrates several types of content, including 3D models of the original objects, video clips showing experimental potting, a voice-over describing the experimental potting, and a short (text) glossary. The app is used with Microsoft HoloLens. Whereas all previous projects have been developed for use with a smartphone or tablet, the HoloLens app was specifically aimed at understanding the affordances, the effects, and the student reception of a high-end immersive approach. In premise, a user wearing the HoloLens looks at one of the objects, the HoloLens then recognizes the object, and presents the user with further options for interaction. The 3D model appears in their field of view, as well as the forming video clips (See Figure 1). The user can choose which forming clip to play, and while the clip plays, they hear the relevant audio clip explaining the process. Users can simultaneously manipulate the 3D model while the clip is playing, enlarging it and rotating it freely. The app allows the student to apply their growing theoretical knowledge of ceramic studies within archaeology to specific vessels from the Allard Pierson collections. Furthermore, as the HoloLens provides an AR experience, learning opportunities can be extended. Wearers can interact with app content while retaining the ability to observe the museum around them, as well as handle and examine replica objects which are the subject of in-app video footage. Taken altogether, this provides a valuable scaffold for the more abstract concepts that were discussed in class, such as technological choice, communities of practice and cultural encounters. Furthermore, the app represents a starting point for bringing these kinds of initiatives to a broader public. Students occupy an in-between status in terms of expertise and can reflect on how to effectively translate research-driven communications for consumption by a more general audience.

This is a report on the relationships built during the project, a reflection on the reception of the project, and discussion of future directions both for stakeholders and others wishing to take this approach. This contribution aims, above all else, to demonstrate that the collaboration that Paardekooper (2019) calls for is both possible and easy, if considered explicitly from the outset. To this end, each of the collaborators gives their perspectives on the BL project and how the results can be built upon for future initiatives.

Notably, since the close of this project, the importance of robust digital systems has been thrown into the spotlight as people limit social interactions and work from home in response to the COVID-19 pandemic. Though the app presented and reviewed herein was developed for pedagogical purposes and use in a museum context, both the authors and the students who used this app have gained significantly more experience in recent months with digital learning platforms, which will undoubtedly have an effect on future endeavors such as this.

Digital Perspective

The team of the 4D Research Lab (4DRL), consisting of Jitte Waagen, Tijm Lanjouw and Markus Stoffer, was responsible for driving the conceptual and functional design, some digital content production (such as 3D models, seen in Figure 2) and final app building. As mentioned earlier, the 4DRL effort in the context of this project was orientated towards developing a pilot using high-end equipment. For app-building, Unity and Vuforia software were used, and for content production photogrammetric 3D reconstruction was applied using AgiSoft Metashape. A desire to stimulate projects such as these is a critical way of evaluating digital technologies with all the involved partners. In practice, this means addressing questions such as: How can we implement AR as an added value to the existing education? How can we instrumentalize the role of location i.e. being in the museum (cf. Winter, 2016)? In what way can we enable and/or optimize student engagement and knowledge retention?

Horse Pyxis - Allard Pierson Amsterdam by 4D Research Lab on Sketchfab

The digital perspective has not prioritized app sustainability in terms of a functional application, which is usually a problem (Paardekooper, 2019, p.5), although there are other ways that this project overall contributes to sustainability goals, as explored in the discussion. Instead, the focus was on experimenting with the setup and learning from it to prioritise developing concepts for future use. The various concepts experimented with have one common denominator: get students out of the traditional pedagogical context and bring them closer to the actual material under study, such as a museum context.

The results have been encouraging, though not without critical points of reflection. An app was built successfully and evaluated overall favorably (albeit by small numbers, n = 12). The interaction in the project network has been lively and in constant discussion and reflection. One of the main learning points has been that the complexity of engaging with a, to the student unknown, MR interface using the HoloLens gestures was too time consuming. After the first session, the start-up presentation was elaborated with an onboarding section on how to use the HoloLens, which made an immense difference. Another point raised was that the space between the exhibition cabinets was too compact to accommodate the movement of users as they navigated the app. The project team asked: Was it necessary to be in the museum to effectively teach this subject matter? Leaving the pressing matter of a cost-effort analysis aside, almost all students appreciated the sensory immersive experience within the museum, including taking the digital object from the cabinet.

Although, admittedly, a significant amount of energy was expended on troubleshooting, there is a strong conviction that this experience has led to a better feel for the potential (and limitations) of this technology amongst all participants. This understanding can spawn future creativity and support more effective collaboration. Within the 4DRL, this has been an opportunity to optimize a production pipeline for AR projects in a network of stakeholders, which is very valuable in respect to future projects. Furthermore, it has been possible to experiment with conceptual approaches and have them critically evaluated. In this project, the 4DRL aimed to gain insight and technical knowledge in AR/MR in educational contexts, and the communication of its potential to museums and other interested parties (Augmented Blended Learning, 2020).

Museum Perspective

The Allard Pierson is the museum and knowledge institute for all heritage collections of the University of Amsterdam. The use of these collections for educational purposes by students and academics has always been high on the agenda of the museum, working in tandem with the curriculum of the archaeological department of the university (ACASA). Although the perspective of the Allard Pierson as an institution has broadened alongside its collections, one of its primary operational directives remains the same: education through engaging with collection material and facilitating research into the collections. Under this remit, the Allard Pierson played an active role by making the museum objects available for 3D-scanning and providing contextual information about the objects (See Figures 3 and 4). Additionally, the Allard Pierson aspires to be an experimental playground where innovative digital technologies can be tested and, in the longer term, sustainably implemented.

Two advantageous factors contributed to the successful outcome of this app in the museum setting: there was knowledge, awareness and understanding of the audience (the MA students), and there was a clear integration of the app with the syllabus of the course and the goals of the Allard Pierson. However, in the use of new media such as AR, the question remains where the added value lies for the engagement with the collection. In other words, "did we employ new media to perpetuate traditional narratives rather than capitalizing [upon] their transformative potential?" (Kalle-den Oudsten, 2016, p.209).

The answer is that for the museum, in this case, the app transformed the scope for engagement with the archaeological collection. The Allard Pierson has played a facilitating as well as an educational role for decades, though students were mostly limited to archaeological sherds and fragments from the depot which could only be handled under supervision by museum staff. The Blended Learning app creates the potential for students to (digitally) engage with all objects within the museum, including those on display. A traditional, hands-on learning environment is a high-risk environment for the museum. The app substantially reduces this risk; after an object has been incorporated into the app, there is significantly less need to directly handle it. As a result, the Blended Learning tool becomes effectively non-invasive, which is a big plus for collection management in the museum. The same objects can be used again in the future, for new initiatives and new techniques for both teaching and research alike.

Although the app encouraged exploration by 'picking up' objects from the showcase for closer study, this was simultaneously also a pitfall: the users studied the 3D-models and did not interact with the actual object. The replica vessels bridged this gap by providing the students the opportunity to engage with physical objects which are on display behind glass in the museum showcase. From a curatorial perspective, it is important to stimulate discussion on the storyline(s) of the museum and the role (archaeological) objects play in it. The app can play a role in stimulating discussions about these storylines, though at this stage the opportunity is under-explored; one consequence of students losing focus on the objects behind the glass was that the neighboring pieces within the displays (and the contextual information thereby communicated) were neglected. Paardekooper's (2019) article mentions that "The future is a sand box; the user can pick up those bits he wants and change the story as he likes. There are no story lines" which some might view as supplanting the curatorial perspective of presenting narratives. At the Allard Pierson, the public is encouraged to create their own meaning and narratives throughout the museum. It is, however, important that archaeology students can place the objects in the museum context, though this is perhaps more the responsibility of the teacher rather than the curator. This criticism aside, the app in the museum setting evoked interaction and discussion among students after they used the HoloLens. Comments were made not only on the app, but also on the context of the museum display, which will only be more fully explored when curatorial decisions in displays are further emphasized.

Experimental Perspective

The experimental component of the project was designed to establish the potting techniques used in the production of the three specific museum objects, while also providing a demonstration of the potting techniques for use alongside the 3D models within the app. By establishing the techniques used for production, it was possible to enhance the app contents; demonstration videos were given voiceovers explaining potting actions as they happened.

Archaeological experiment occupies a sometimes-awkward position in education which the app mitigates effectively; according to a traditional definition, an experiment must address a specific hypothesis. Once that hypothesis is tested, then subsequent instances of the experimental process are perhaps better described as demonstrations (unless those instances are actively positioned as replication experiments). The act of recording the experiment for later use as "demonstration" footage provides an opportunity to tailor interpretation of the experiment to the target audience without requiring further input by the experimenter. Furthermore, video recording of an experiment (or indeed, several experiments) allows for the experiment to continue yielding answers to new questions. Uncoupling 'experiment' from 'demonstration' in this way maintains the integrity of each. Throughout this experimental process, recorded as it was for subsequent demonstrations, the experimenter was freed from consideration of spectators and could continue with the experiment methodology without being concerned with the performative aspects essential to demonstration. Thus, the experiment itself can progress uninterrupted while also generating a valuable record for future study and demonstration purposes alike.

The objects featured in the app were selected by the experimental archaeologist with pedagogical needs in mind, as it was important to illustrate multiple pottery production strategies. It was also necessary to use Late Bronze Age and Early Iron Age Mediterranean material from the Allard Pierson collections, as these contexts were often used as examples for students throughout the course.

Two of the objects are open shapes: A Mycenaean bridge-spouted basin (inventory number APM6200) and a Geometric pyxis (See Figure 4, inventory number APM3535) which originally featured 4 horse figurines. The morphology of these two objects allowed for inner and outer surfaces to be captured, and the resulting models reflected the wall thicknesses as well as the overall shapes. The body and lid of the pyxis (Jeffra, 2020a), and the basin as well as its spout (Jeffra, 2020b) were all wheel-thrown in separate episodes, and the horse figurines were modelled using coils of clay. Finally, the painted decoration was applied to the pyxis using rotation to create concentric circles. The final object, a Terramare house urn (See Figure 3, inventory number APM12.000), is a closed shape. Because it is closed, the 3D model could not include precise morphology of inner surfaces. The house urn was formed using coils (Jeffra, 2020c), and the forming experiment is reported elsewhere (EXARC Journal submission, this volume). All of these actions were filmed from two to three different perspectives, and those recordings were separated into clips reflecting the different stages of the potting processes. These segments are the backbone of the experimentally generated media within the app. Furthermore, the replicas which were produced during the experiments were donated to the Allard Pierson collections so that they may be used as supplementary and accessible teaching material in the future (See Figure 5).

From the perspective of an experimental archaeologist, the practice of using video recording during experiments is well-supported. The multiple-perspective recording removes an interpretive layer which might be imposed by exclusive reliance on descriptive text or audio; the narrative perspective of the recording is instead derived from the choices in filming perspectives, and viewers may draw their own conclusions based on those perspectives. Similarly, students may follow their own lines of questioning by reviewing the clips alongside the 3D models within the app. While the experimental component sought to clarify details of production for the ceramic objects concerned for the experimenter, these potting clips can also serve as a future resource for other experimenters by physically illustrating the practices undertaken in the production process. Although the separate clips were each given a brief voiceover to summarize observable actions, these can be adjusted as necessary to suit the needs of different audiences. Regardless of the group targeted, like the 3D models and the original objects themselves, the video clips can be treated as source material subject to targeted interpretation in presentation.

Student Perspective

The Blended Learning project was developed for students of the Ceramics in Archaeology, an advanced course within the MA in Archaeology program at ACASA, of which the author was a participant. Over seven weeks of lectures there was a significant focus on the *chaîne opératoire*, a theory used to explain the relationship between the craft production processes, human behavior and social conditions or contexts in the past. In the last week of the course, the BL HoloLens app was introduced to the students by all the project partners. In the session, an introduction to the HoloLens equipment was given in relation to the experimental replicas of several ceramic vessels from the AP collection before moving into the galleries to investigate the actual artefacts (See Figure 6). As a student participant, the author also evaluated the experiences reported by other students using an online questionnaire adapted from the 4DRL.

The results of the student feedback had both positive and negative points, some of which are worth exploring here. The cutting-edge technology of the HoloLens and the 3D models caught the students' attention instantly, in effect changing the ambience of the lecture. The fresh perspectives that the 3D models brought to the three vessels under examination immediately invited interaction, through actions such as zooming in on the vessel, or rotating the model to see a new angle that is currently hidden from view for the object on display behind glass. In addition, the production videos of the experimental replicas demonstrated multiple pottery-making methods and presented the different choices that potters must make within the *chaîne opératoire*.

The HoloLens was also relatively easy to use, once adjusted to the new wearer and required only two simple hand gestures to operate the device and navigate the menus. The student survey did show some variation in these responses, however, with some individuals experiencing difficulties in mastering the gestures, delayed device response times and a sensation of motion sickness and/or headache. A negative aspect was that the HoloLens was felt to lack the shared experience of a regular class. Interaction with the HoloLens was an individual activity, with the wearer effectively cut off from reality while engaging with the models and videos and it hindered group discussion of the objects while within the classroom or the gallery. One aspect which may have mitigated this effect could be stronger integration of replica objects into the overall experience, which could have led to more opportunity for social learning.

Overall, the BL app for the HoloLens was a refreshing and stimulating experience for the students. This type of engagement with materials, beyond 2D images and texts, is much needed within archaeological studies, as physical interactions with many objects is not always possible; the HoloLens does provide increased possibilities for such interaction. On the other hand, many of the activities that the HoloLens affords may be possible using other digital devices, such as laptops, tablets or smartphones, and if this is the case then users may prefer to use their own devices rather than this kind of "wearable tech". Future developments for this experience should address the unique merits of the HoloLens and how this can be better applied to the subject, so that it can compete with existing technologies.

Pedagogical Perspective

The teaching of any theoretical concept is always challenging, as the active behaviors and processes that they relate to are often difficult to realize within a traditional classroom setting. For archaeology, which is fundamentally built upon the study of material remains, teaching needs to explore the theoretical and methodological aspects of how archaeologists reconstruct the dynamics of the past from objects found in the material record. As already highlighted, most ceramic objects from the past are still behind glass, inaccessible to even specialized students of archaeology, and difficult to appreciate (let alone study) with respect to these dynamic interactions that brought them into being. This is where augmented reality, as explored through the Blended Learning project, bridges this gap in the learning process. The app was conceived, used, and evaluated in tandem with the MA course Ceramics in Archaeology, which regularly explored the variability in ceramic forming techniques within the *chaîne opératoire* of ceramics. These techniques were chosen as the focus for the app and key vessels from the Allard Pierson were selected to provide a scaffold for studying these forming techniques and practices of ancient potters (See Figure 7).

The app, in the context of this course, can be seen as an intensification of learning through the layering of multiple datasets, derived from the videos, the 3D models, the replica objects, the audio narratives and the glossary of terms. No single ‘traditional’ teaching resource would enable this type of self-direction, where the students also have control over the pace, the line of questioning and the level of detail that can be accessed while using the app, effectively democratizing the learning process. The potential for repeated use, at the student’s discretion, is another valuable benefit. While testing the app, the MA students were split into two groups of 6 and 7 students, to allow sufficient access to the two HoloLens units. The second group was given a brief introductory presentation to the AR environment by the digital specialists. This brought significant benefit to the speed at which these students gained competency in operating the new technology of the HoloLens, as well as their level of comfort in navigating the interface and AR environment, compared to students in the first group. In other words, dedicated resources and activities are needed for onboarding or ‘learning the ropes’ when scheduling this type of new learning experience. Although the students were divided in groups and could reflect on their shared experience, only one could wear the equipment at a time, which made for an individual activity with group reflection.

From a pedagogical point of view, there is real benefit to allowing students to experience individual and shared learning experiences within the same session, as this can help create knowledge-building environments in which all participants progress in their learning (Tan and Tan 2014, p.29). This is also reinforced through peer-led reciprocal feedback: by using the app within a group of students, even though not all could use the HoloLens simultaneously, the communal discussion and sharing of user experiences provided a better environment for testing the potential of the app and intensifying the learning experience for all the students. Whether this will have implications for the use and effectiveness of such apps by individual museum users will probably depend upon the aims of the informal learning experience, as echoed by Paardekooper (2019).

Discussion

Innovation is often hampered by the element of risk; innovative behaviors are less likely to be enacted when their results are uncertain, and returns are unknown. By creating funding to support innovation in pedagogical practice, the Blended Learning initiative reduced the risks in undertaking innovative behaviors for developing the app discussed above. In a pedagogical setting, this opportunity to reduce risk to unleash innovation is relatively rare, and the case discussed above provides an excellent opportunity to evaluate the process more fully. By doing so, this team and others may be better equipped to overcome risks and hurdles which reduce their own innovation beyond exclusively those of access to funding.

All members of this project share archaeological training, allowing everyone to have an inside perspective on communicating heritage topics. This means that the general goals of promoting insights into the cultural past are well aligned with those of an archaeology museum, more so than in the case of other digital application makers. An added advantage was that partners within the project share a similar language, and digitally focused team members could more easily understand the concerns of an archaeology lecturer and museum, helping to translate concepts to digital applications.

The app was designed for intensification of learning rather than an informalization of learning, but perhaps the common feature of these learning modes is their self-directed and democratizing nature. Learners (whether MA students or museum visitors) choose the questions they wish to explore within the learning environment presented to them, which can facilitate self-guided questions of increasing complexity as desired, within the boundaries of the app's resources. While individualized experiences like this may not be best suited for pedagogical settings, in a museum setting this would in fact be an asset. Visitors typically explore museum spaces at their own pace and self-directed learning is embedded in existing approaches to signage and portable audio tours, for example. The Student and Museum perspectives described above offer differing views with regard to the learning environment created by the app: while wearing the HoloLens, students noted a greater sense of individual learning, often at the expense of the shared experience they expected of a traditional classroom environment. This can be contrasted with observations that the students participating in the session in the museum galleries, both after wearing the HoloLens and while waiting their turn, actively engaged in discussing the chosen vessels from a production perspective.

Digital approaches, and apps, are often seen as a means to widen accessibility. It is worthwhile to note that this is not always the case; apps are designed with minimum equipment requirements in mind and those using older devices are often unable to participate. This is certainly the case for adopting the HoloLens, a device which retails for nearly €4000, and as a result carries with it the very risk raised above which hinders innovation. The costs of the HoloLens aside, the opportunity to explore the boundaries of possibility using cutting edge technology are essential, as it is in this way that newer perspectives on communicating complex information can be tested and evaluated. Projects such as this must strike a balance between excitement with novel approaches to communication and affordability in terms of the costs of participation if they are to reach the widest possible audience. Furthermore, another important consideration in terms of accessibility is user comfort and usability. A section of people will never choose to make use of certain types of wearable technology (as is the case for one of this work's authors) because of headaches and/or motion sickness, or even physical disability. What then are the implications for truly widening accessibility and engagement?

The app itself can (and should) be considered in the wider scope of a particular course's teaching strategies. In previous years of teaching on the Ceramics in Archaeology course, students spent time learning potting in the ACASA pottery lab. The app supplanted this, bringing with it both benefits and drawbacks. By recording the potting for three different objects, students were given the opportunity to explore the full production process for each, which took several days in real time. With only a single session devoted to a potting practical in previous years, those students lacked the opportunity to see the larger-scale processes and multi-stage potting strategies which are often necessary, as was the case for each of the objects created for the app. The major drawback was, as might be expected, the loss of hands-on experience. Although students gained the ability to view these larger scale production processes from start to finish, they did not have the tactile experience of learning by doing.

Gaining familiarity with the HoloLens and the app required some dedicated training time, which was significantly less than the time devoted in previous years to a potting practical. During this 'onboarding', students were shown how to navigate the app's interface using the specific gestures necessary to operate the HoloLens while still in the dedicated classroom space. The onboarding experience was expanded for the second group, modified by the project team after listening to the feedback from the first group. During this time in the classroom, students were also able to examine the experimental replicas which featured in the videos. This interaction with the experimental material was not initially planned as a structured activity, but did provide a useful gateway for the students to better familiarize them with the app, while also allowing them to practice the gestures and the manipulation of the models.

One may be tempted to question whether physically attending the museum is necessary to benefit from this app, and indeed it is mentioned above, but the authors firmly believe museum attendance to be essential. Aside from the sensory aspects raised in support of museum attendance within the Digital perspective above, it is worthwhile to recall the nature of teaching material culture analysis in archaeology. Archaeological teaching has most often been supplemented by access to archaeological collections to allow students to handle artefacts, either within museums, cultural depots, or other heritage collections. The digital models, as presented in the app, are designed to augment the learning process by virtue of being manipulated and explored alongside the artefacts under study. By allowing students to interact with high-quality models at their own pace and following their own questions - while also presenting the original, physical objects at the same time - the students are able to create a fuller understanding of the individual objects themselves. Taking this AR approach to study has an added benefit to the museum, given that they act as long-term caretakers and custodians of material culture. The higher the direct engagement with objects, the higher the risk for damage to those objects, particularly over the history of an object's storage in the museum. Digital alternatives can reduce this risk to fragile objects by minimizing exposure while still enabling detailed study over the course of a student's coursework.

Two factors which Paardekooper (2019) describes are worth touching upon. The first of these is that information provided digitally should be visually attractive and serve its educational purpose. The student feedback confirmed that the app presented the material under study in a visually exciting way and helped them to achieve the learning goals of the course for investigating ceramic production. A second, larger factor raised by Paardekooper is that the operating device should be simple and approachable for everyone, as well as sustainable. A focus on making apps such as the one described above simple and approachable for everyone is essentially a focus on accessibility. This is a major issue, on which cutting edge technology has begun to make significant progress. By including a range of different information types, apps and AR/MR can create an environment suited to many different learning styles and needs. This is a starting point for greater accessibility and inclusiveness, and further projects can - and should - build on this further.

On the other hand, sustainability means many things to many people, but the UN has outlined 17 interconnected sustainable development goals in the 2030 Agenda for Sustainable Development (United Nations, 2015), which serve as a meaningful baseline for comparison. Even though this project did not explicitly seek to tackle these goals, there are several themes which this project has addressed which are directly related, specifically education (SDG goal 4: quality education), research and development (SDG goal 9: industry, innovation and infrastructure), protecting heritage (SDG goal 11: sustainable cities and communities), and building partnerships (SDG goal 17: partnership for the goals). The interconnected nature of these sustainability goals speaks to the remit of this project, which explicitly explores cutting edge mechanisms for bringing research-driven teaching of heritage issues to a wider target audience, by bridging traditionally closed academic pedagogical contexts with more open, publicly accessible heritage environments. The project team, enabled by the Blended Learning Initiative of UvA, focused on reinforcing and reimagining the partnership between ACASA and the Allard Pierson. For this endeavor, students provide essential insight, as they occupy an in-between status in terms of expertise, and their experiences with this app can indicate a path toward effectively translating research-driven communications for consumption by a more general audience.

Conclusion

Despite the fact that interactive technologies are an "immature market with high potential" (Probst, Pedersen and Dakkak-Arnoux, 2017, p.3), a point which was reiterated by Paardekooper (2019), projects such as this capitalize on existing practices and can help the market reach maturity. This project explored this potential through a multi-faceted team, bringing shared knowledge and expertise across the digital, heritage, and educational domains. The means of bridging between existing digital domain specific practices and other (pedagogical, heritage, experimental) practices is realized through the explicit inclusion of many perspectives within this project's team. In the absence of this collaboration, the pitfalls highlighted by Paardekooper are a significantly larger threat, where a power imbalance relegates museum learning goals to the back seat during the collaboration process. This easily can lead to outcomes which do not meet museum needs but instead meet another partner's assumptions. In collaborative initiatives such as this Blended Learning project, the funding tools can be placed in appropriate hands to drive innovation from within. Embarking on these efforts and sharing the results in this way can drive engagement with museum collections further in more inclusive and sustainable ways.

About Authors:

Caroline Jeffra, Jill Hilditch and Myung Ju Kim (ACASA, University of Amsterdam)
Jitte Waagen, Tijm Lanjouw and Markus Stoffer (4DRL, University of Amsterdam)
Laurien de Gelder (Allard Pierson Museum and Knowledge Institute, Amsterdam)

Bibliography

Augmented Blended Learning, 2020. *4D Research Lab*. [online] Available at: < http://4dresearchlab.nl/education/augmented-blended-learning/ > [Accessed 20 June 2020]

Jeffra, C. 2020a. Forming a Geometric Pyxis, perspective A. YouTube Playlist. [online] Available at: < https://www.youtube.com/playlist?list= PLqQRd2NyzNc61VcfBeLRPyzklm4Chwx1N > [Accessed 10 July 2020]

Jeffra, C., 2020b. Forming a Mycenaean basin, perspective A. YouTube Playlist. [online] Available at: < https://www.youtube.com/playlist? list=PLqQRd2NyzNc764vln2fgogi4UE5v3hhfT > [Accessed 10 July 2020]

Jeffra, C. 2020c. Assessing production of a house urn from Iron Age Central Italy - Making the urn, perspective B. YouTube Playlist. [online] Available at: < https://www.youtube.com/playlist? list=PLqQRd2NyzNc4vEeOlMlHGxYeX4dQDocle > [Accessed 10 July 2020]

Jeffra, C., 2020. Crafting Beyond Habitual Practices: Assessing the Production of a House Urn from Iron Age Central Italy. *EXARC Journal*, 2020/4, [online] Available at < https://exarc.net/ark:/88735/10536 > [Accessed 16 November 2020]

Kalle-den Oudsten, I., 2016. Digital Technologies in the Museum: Same Old, Same Old? In: M. Ioannides, E. Fink, A. Moropoulou, M. Hagedorn-Saupe, A. Fresa, G. Liestøl, V. Rajcic, and P. Grussenmeyer, eds. *Digital Heritage. Progress in Cultural Heritage:*

Documentation, Preservation, and Protection. Cham: Springer International Publishing, pp.209-213.

Paardekooper, R.P., 2019. Everybody else is doing it, so why can't we? Low-tech and High-tech approaches in archaeological Open-Air Museums. *EXARC Journal*, 2019/4. [online] Available at: < https://exarc.net/ark:/88735/10457/ > [Accessed 9 July 2020]

Probst, L., Pedersen, B. and Dakkak-Arnoux, L., 2017. *Digital Transformation Monitor: Augmented and Virtual Reality*, October 2017. Brussels: European Commission.

Tan, S.C. and Tan, Y.H. 2014. Perspectives of Knowledge Creation and Implications for Education. In: S.C. Tan, H.J. So and J. Yeo, eds. *Knowledge Creation in Education*. Singapore: Springer, pp.11-34.

United Nations. 2015. Transforming our World: The 2030 Agenda for Sustainable Development A/RES/70/1. [online] Available at: < https://sdgs.un.org/2030agenda > [Accessed 19 November 2020]

Winter, L., 2016. Playing with the Past? Or Saving Our Future? *EXARC Journal*, 2016/1, [online] Available at < https://exarc.net/ark:/88735/10228/ > [Accessed 9 July 2020]