# Chapter 18
# Augmented Reality in Environmental Humanities Education


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**Abstract** Environmental humanities is an emerging multidisciplinary field of research focused on identifying the impact of modern human (including cultural) activities on the environment, as well as of environmentally friendly solutions. Environmental damage can have serious consequences for the present, as well as for the past, as in the case of archaeological sites, whose investigation becomes difficult and whose process of decay is accelerated. As these issues have not yet been addressed through effective and systematic educational solutions, this chapter proposes, as part of the environmental humanities strategy a digital humanities educational solution centred on the technology of Augmented Reality (AR). The IT application proposed aims to identify the areas of ecological risk and provide detailed information on the destruction processes, as well as the ability to connect with networks of specialists. The authors' aims are to stimulate critical thinking focused on environmental issues, provide a solution for continuous learning for both specialists and the public, thus contributing to the protection of the environment and of archaeological subjects, and to further the development of sustainable activities through education and awareness.

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## 18.1 Introduction

The recently emerged, new perspective on the changing world, the Anthropocene (Edgeworth et al. 2014), as well as the ecological perspective, point to the fact that we are living in an era of continuous site formation and taphonomy (Edgeworth 2013).

This process is unfolding under our very eyes and sometimes with adverse effects on the historical past. We are referring here to those heritage sites, whose destruction is brought about both by humans and Nature (Micle 2014), thus becoming a mere source of material which contributes to the stratigraphy process of the Anthropocene.

Sites at risk, whether natural or man-made, are subject to destruction through conscious action or neglect (Spiridon et al. 2017) and require for their salvation a holistic approach that Environmental Humanities (EH) can provide (Hutchings 2014).

## 18.2 Environmental Humanities

EH represents a synthesis of science and the humanities, involving both critical heritage studies (Witcomb and Buckley 2013), the merging of natural and cultural heritage pedagogies (Hutchings 2014), as well as community building (Bird-Rose et al. 2012). It is a perspective that combines both technological, ecological and pedagogical approaches in a unifying vision.

In the case of monuments at risk, this relational perspective between Nature and culture puts archaeology in relation to various ecological, environmental and pedagogical approaches.

It is well-known that archaeology itself connects humanistic disciplines with science (Parikh and Hall 2012) and that in the last decade there has been a propensity of this science to art (Gheorghiu and Barth 2019) due to similar cognitive structures (Gheorghiu 2020), the contribution of art to science nowadays being obvious (Malina 2016).

The educational value of art can help make EH's message more accessible to local communities, while environmental art (or eco-art[1]) will become a current tool for shaping a new mindset.

[1] https://www.plushbeds.com/blog/green/what-is-eco-art/ [accessed 20.11.2019].

## 18.3 Archaeology: Bridging Social and Natural Sciences

From an EH perspective archaeology must become even more a holistic science, imposing a "cross-epistemological dialogue" between high culture and local communities (see Domańska 2015). And this dialogue must have a pedagogical component, especially in regards to the contemporary attitude towards Nature.

We will try to illustrate this new attitude of archaeology in the case of monuments at risk, bringing into discussion two diametrically opposed cases of the relation of culture with Nature.

The examples relate to two archaeological sites located on the banks of the Danube River, in the south of Romania. The first case, the Palaeolithic site of Malu Roşu, is the one of an anthropic destruction of Nature, and the second, the Byzantine site Păcuiul lui Soare, illustrates the damage caused by Nature itself, when the sites are left neglected in the wild.

The Palaeolithic settlement of Malu Roşu is located on a lower terrace of the Danube River and was excavated in the 1980s and 1990s. Although the site revealed a rich Aurignacian lithic industry, in the 1990s Malu Roşu was transformed into the garbage dump of the nearby city (Păunescu and Alexandrescu 1997), which not only put an end to all subsequent archaeological campaigns, but also produced a very dense stratigraphy of very un-perishable materials, such as concrete, plastic or glass. This archaeological site in which prehistoric layers have been overlapped by contemporary recycled materials and domestic garbage is an obvious example of continuous site formation in the Anthropocene, due to an aggressive attitude towards Nature.

An opposite case, that of the aggressive attitude of Nature towards culture is that of the site Păcuiul lui Soare. Situated on a small island on the Danube River, the tenth century Byzantine fortress with walls of ashlar blocks positioned on deep oak beams foundations (Caraivan et al. 2016) is attacked by both aquatic erosion and the dense vegetation of the island. The river annually destroys the masonry on the shores, but a more effective destruction is caused by the vegetation that dislocates the blocks in the areas untouched by water.

How could EH get involved in these cases? First of all, by triggering an alarm signal, to create awareness both within the scientific community and the local communities.

Using contemporary IT technologies, educational applications can be created that visualize the respective sites, and with the help of AR and visual art one can promote awareness raising messages focused on the destruction processes.

For example, in the case of the Malu Roşu site, we propose to present in the AR application, in the form of an animation, a visual scenario in which the contemporary site will be completely covered by garbage. The visual result, which resembles Edward Burtynsky's photographs, such as "Oxford Tire Pile # 8" (see Giesecke and Jacobs 2012, p. 106), has a strong impact on the viewer.

For Păcuiul lui Soare, we present with the help of the AR application the process of destruction produced by the vegetation that has grown uncontrolled over the ruins of the fortress.

Consequently, this chapter proposes the development of an application with educational value, designed to alert the user to the existence of monuments or sites at risk and then to present through different visual narratives the issues confronting them. In addition, the application allows the creation of a network of different organizations or bodies dealing with EH problems around the world, to inform the user about this phenomenon. In the case of the "monuments at risk" described we have chosen the journal *Ecocene: Cappadocia Journal of Environmental Humanities*, with which we collaborate.

For the AR application, called EnviHum.AR, we have used a symbolic logo, that of a junction between "environment" and "humanities".

## 18.4 Augmented Reality State of the Art

### *18.4.1 New Technologies in Education: Augmented Reality*

Augmented Reality (AR) is a computer-mediated reality, i.e. standing in between reality and virtuality within a "continuum" (Milgram et al. 1994). Due to the technological advancements toward smarter and more powerful mobile devices, AR glasses or headsets, AR is currently more interactive and immersive and closer to the term of "mixed reality". Author Ashford-Rowe (2019, p. 36) considers that mixing reality is not a new concept as "[it] plays into a deep and longstanding capability of the human mind to aggregate the physical and the imagined".

Despite the fact that AR is currently an affordable and popular technology among creators and users, the traditional paradigm according to which AR as an informal education technology providing contextual and experiential learning is not sufficiently explored and it is not yet extended to a mainstream level.

On the other hand, the way in which AR technology can be used in relation with other technologies or with new societal challenges has changed. Azuma (2015) considers that "ultimate uses of mixed reality (MR) and augmented reality (AR) will be to enable new forms of storytelling that enable virtual content to be connected in meaningful ways to particular locations, whether those are places, people or objects" (p. 259).

### *18.4.2 Augmented Reality Technology and Tools*

Augmented Reality is both a concept and a technology. The concept refers to enhancing the perceived reality by adding artificial or simulated content. The concept was

first demonstrated by Morton Heillig who, as a cinematographer, patented in 1962 a simulator called Sensorama, mixing visual, acoustic, vibration and smell information and creating a simulated reality.

As a technology, AR refers to different technical means to overlap the simulated content on top of a real worldview, in an interactive manner, with the purpose to provide missing and explanatory information. By unifying the real and the added information, a new and information-richer reality is created having a higher cognitive impact, i.e. the understanding of the reality being thus much improved.

An ideal AR process is the one that clears the differences between the real world and the created world. The placement of the digital information is not a trivial process but one mediated by computer devices and sensors, respectively by means of the AR-tracking process. The technical advances, such as miniaturisation and the development of the mobile devices, which could integrate video camera and sensors, defined a new range of AR category, i.e. the mobile AR (MAR), which is today the most popular and affordable AR-enabled device. The main component is the video camera which fusions information from other sensors, such as the accelerometer, gyroscope, GPS, and employs advanced techniques, such as computer graphics or computer vision, to augment the content on the camera view in real-time and correlated with the user's moving status (Azuma 1997; Azuma et al. 2001).

The earliest usage of the AR, still a typical one, is concerned with augmenting the vision of a surrounding reality or of a static image, which is called either *marker* or *marker-less image-recognition AR*, including *location-based AR*, in which case the targets are geographically defined.

Available tools for marker or marker-less AR relying only on a digital camera are the software library kits (SDK) such as OpenCV (https://opencv.org) for computer vision, ARKit (https://developer.apple.com/documentation/arkit), Vuforia (https://developer.vuforia.com/), AUGMENT (https://www.augment.com/), Google ARCore for Unity3D and Android (https://developers.google.com/ar), Wikitude (https://www.wikitude.com) for Android, iOs, Unity 3D and web, ARGON4 a web browser (https://app.argonjs.io/).

*Location-based AR*, as another category of AR, allows augmented visualizations in pre-defined points-of-interest (POIs), which define geographic contexts. This type of AR is supported by fewer commercial tools, among which Wikitude and Layar (www.layar.com).

One of the most revolutionary AR scenarios is based on techniques to perform recognition and mapping of spatial data, i.e. of an entire environment, not only of specific POIs or images. Recently, this technique was advanced by means of a 3D depth sensing camera and graphic algorithms, able to analyse and map spatial environments. The technique is called *simultaneous localization and mapping* (SLAM) and has as a result a set of data points called "point clouds". This technique was first performed by robots but currently was made available by AR software tools, for regular AR-enabled devices and platforms. Even if currently discontinued, Metaio AR platform was one of the first to offer to public users such advanced AR features (Gheorghiu et al. 2014, p. 21). Currently, Google ARCore is able to perform SLAM,

nonetheless it requires at least Android 7.0 and more powerful and expensive mobile devices.

The AR technology has greatly advanced while facilitating for users the creation of AR applications. Users can concentrate on designing the AR application and content, since the SDKs take-over the challenges of dealing with advanced hardware of the current mobile devices and also on features included in the main mobile operating systems, i.e. Android and iOS.

### *18.4.3 Augmented Reality Current Status in Education*

There is almost no domain in which AR not to be taken into consideration, from digital cockpits as navigation tools, anatomy, medical field and emergency, travel and tourism, art and museums, history, engineering, astronomy, geography, military, entertainment, advertising, television, games and recreation. Almost all categories of AR projects have an educational purpose, even if not declared.

Due to the fact that educational technologies have to be addressed from a multi-disciplinary perspective and theories and styles, it can be considered that education is the most relevant and complex domain in which AR to be applied.

The AR technology currently supports more complex scenarios, mainly as a "mixed-reality", including headsets and special AR/VR equipment. These diverse scenarios rely on mobile and experiential learning, learning by doing (with tasks and activities), learning by playing, collaborative learning, self or peer assessments.

To be effective for formal learning, AR and MR have to "be integrated into teaching and learning [process] and become familiar to the instructional designers and instructional technologists […] so that they can help instructors integrate MR into their pedagogy (Horizon Report 2019).

On the other side, authors such as Radu and MacIntyre (2012) researched "how can children's developmental psychology be used to the design and usability of the AR applications".

Radu (2014) made a meta-analysis "comparing AR versus non-AR applications [and] identifies a list of positive and negative impacts of AR experiences on student learning, and factors that may cause them", considering that "although previous research has shown that AR systems have the potential to improve student learning, the educational community remains unclear regarding the educational usefulness of AR and regarding contexts in which this technology is more effective than other educational mediums".

Location-based AR scenarios resulted in many and very popular implementations, in domains such as heritage and archaeology (Gheorghiu and Ştefan 2012, 2014, 2015, 2016, 2017, 2019). Pokémon GO (Zsila et al. 2017) is a special and successful case of location-based AR application, even if its educational level is not relevant.

### *18.4.4 Augmented Reality in Archaeological Education*

In contemporary archaeology AR is mainly used as a research tool for reconstruction and interpretation. The importance of digital technologies lead to the creation of a new discipline called Virtual Archaeology (Barceló et al. 2000; Niccolucci 2002).

Archaeologists can take advantage of the AR applications to visualize and analyse different information in their real context and on a just-in-time basis (Trapp et al. 2012; Papagiannakis and Magnenat-Thalmann 2007).

AR/MR technologies are taken into consideration due to their capability to create "presence" and "immersion" (Heeter 1992; Wagner et al. 2009; Witmer and Singer 1998; Zahorik and Jenison 1998).

Eve (2012) considers that AR in archaeology "provide[s] a timely way to combine the strengths of a computer-based approach (reproducibility, experimentation, computer reconstruction) with archaeological phenomenology (embodied experience in the field)".

## 18.5 EnviHum.AR—An Application for Education and Environmental Awareness

For our research, three main AR capabilities were taken into consideration, along with a creative design of the educational content: (a) location-based information and alerts; (b) recognition and augmentation of a defined natural environment; (c) immersion of the users in a 3D animated simulation.

Using a mixture of AR technology capabilities, an AR application was designed as an educational tool able to alert and inform people on endangered archaeological sites and make them more aware on the impact of different factors of human or natural negligence that may put in danger the overlooked archaeological sites.

EnviHum.AR is an educational application that can identify the areas of ecological risk, provides immediate information under the form of augmentation, as well as the possibility to connect with networks of specialists.

To implement the proposed application the authors took into consideration Wikitude AR toolkit (SDK) for Xamarin framework.

Xamarin framework (Xamarin website) is a Microsoft open-source framework that facilitates the development of cross-platform mobile applications, i.e. which can function both on Android and iOS.

### *18.5.1 EnviHum.AR Functionalities*

In EnviHum.AR marker-based AR processes are used. An image-recognition of the two considered sites can trigger specific augmentation, i.e. information on the


**Fig. 18.1** EnviHum.AR logo and mobile application

evolution in the state of the sites. Alternatively, the geographic coordinates were used as special location-based AR "markers" that can be shown in the AR view and trigger the same augmentations.

Motion tracking, as the fundamental AR process, is supported by Wikitude SDK, in order to correctly position the augmentation within the user's surrounding space while the user is moving the camera (Fig. 18.1).

### *18.5.2 Malu Roşu—Augmented Content*

The augmentation is triggered when the user either scans an image or is coming into the site's premises, i.e. two types of targets are used—images and POIs.

This augmentation was designed as an animated GIF and represents the deposition of garbage on the surface of the site.

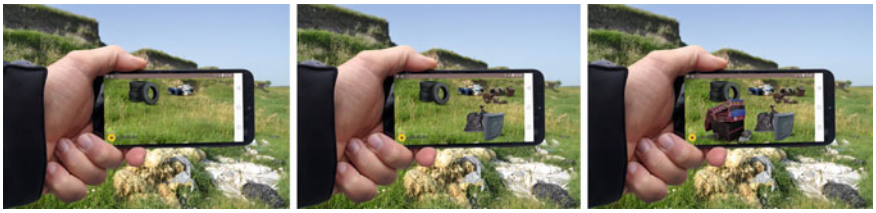

**Fig. 18.2** Augmentations for Malu Roşu

The animation takes place in a frame with dimensions: 2208 pixels × 2208 pixels; the aspect of the frame is in the ratio 1:1 and has been chosen to respond more easily to different formats (landscape or portrait).

All the visual elements (images of worn objects) are placed randomly on a transparent background and are positioned in the frame so as to create the feeling of depth.

The difference between the near and the far plane is given by their size, so the visual elements in the near plane have larger dimensions and those in the far distance have smaller dimensions; the elements appear successively in the frame and multiply until they occupy all the visible space.

From a technical point of view, the entire visual construction is made of layers that become visible at 1-s intervals; the animated GIF was created with Adobe Photoshop CC 2019.

As the AR does not support animated GIF, this was split in several frames that were put into the AR view with delays, thus suggesting a progressive deterioration of the site, covered by garbage.

Alternatively, when the user is coming into the site's premises, a POI is displayed with a label "Malu Roşu -endangered site. Turn the camera towards the clay terrace" (Fig. 18.2).

### *18.5.3 Păcuiul lui Soare—The Augmented Content*

The augmentation is triggered when the user either scans an image or is coming into the site's premises, i.e. two types of targets are used—images and POIs.

This augmentation was designed as an animated GIF and represents the site deterioration by the vegetation.

The animated GIF is made of four images presented in the form of a slideshow with 2-s interval between frames; the animation was realised with Adobe Photoshop CC 2019.

As the AR does not support animated GIF, the animation was converted into a video.

**Fig. 18.3** The Byzantine fortress Păcuiul lui Soare

**Fig. 18.4** Augmentations for Păcuiul lui Soare

A special motion-tracking feature supported by Wikitude was implemented, called video snapping, i.e. the video is attached to a visual element of the camera and it continues to run even after the image target is no more in front of the camera.

Alternatively, when the user is coming into the site's premises, a POI is displayed with a label "Păcui -endangered site. Turn the camera towards the fortress walls" (Figs. 18.3 and 18.4).

### *18.5.4 Networking*

Near the augmentations a button is displayed with the message "LEARN MORE". When clicked, a web page is opened, with the link of the *Ecocene: Cappadocia Journal of Environmental Humanities* (Fig. 18.5).


**Fig. 18.5** The link of the Ecocene Journal

## 18.6 Conclusions

The experiments performed with the users of the EnviHum.AR application have demonstrated the pedagogical value of this tool, which has created an awareness among the urban population for the communities with sites at risk and an awareness on the relationship between culture and Nature in the communities near the sites in question.

The application aims to achieve a state of entanglement (in Hodder 2012 sense) between people and the local heritage and to create an inter-community and international solidarity regarding the risks to the environment. Our intention is also to launch an e-network that supports EH ideas.

Last, but not least, the application aims to be an efficient contribution to the eco-art, which will produce a reaction in this regard towards the perception of the relation with Nature.

In conclusion, the authors intend to stimulate the holistic EH spirit, to offer a continuous learning solution for both specialists and the public, to contribute to the protection of archaeological or natural objectives, and to the development of sustainable activities through education and awareness.

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