Pers Ubiquit Comput (2017) 21:977–988
DOI 10.1007/s00779-017-1064-7

ORIGINAL ARTICLE

Experiencing sense of place in virtual and physical Avebury

Liz Falconer[1]

Received: 24 April 2017 / Accepted: 17 July 2017 / Published online: 11 August 2017

Abstract This paper discusses the findings from a project to construct a simulation of Avebury henge, a Late Neolithic/Early Bronze Age monument in SW Britain, in a 3D, virtual world environment. The aims of the study were to explore the archaeological research and interpretation necessary to plan and construct such a simulation in an interactive, online environment, to identify which aspects of visualisation and soundscape design appear to have the greatest impact upon users' sense of place in the virtual simulation and to explore the experiences of a small group of users in the virtual simulation and the effects of those experiences upon their sense of place at the physical site. The findings from this project demonstrated that in undertaking a simulation of an ancient site, a core set of sources need to be selected to create the main parts of the simulation. There is often much debate in archaeological literature regarding the way in which archaeological findings are interpreted, and a different virtual Avebury would be constructed if different interpretations had been chosen. Any simulation of an ancient site should therefore clearly recognise and state the basis upon which it has been designed. The evaluation showed that responses to virtual environments, and the resulting effect upon responses to physical environments, are complex and personal, resulting in a range of experiences and perceptions, suggesting that the range of users' experiences might be a more significant issue than attempting to find any general consensus on user reactions to simulated ancient sites.

Keywords Interaction · Virtual environments · Heritage · Virtual archaeology · Avebury · Phenomenography

1 Introduction

This paper discusses the findings from a project to construct a simulation of a Late Neolithic/Early Bronze Age (circa 2800–2000 BCE) monument in SW Britain in a 3D, virtual world environment. The aim of the study was to explore how experiences in the simulation might affect users' reactions to the monument in the present day. The research addressed this aim through the construction and evaluation of a simulated representation of Avebury henge, circa 2200 BCE, in a virtual world platform.

The specific objectives of the study were to:

- explore the archaeological research and interpretation necessary to plan and construct such a simulation in an interactive, online environment,
- identify which aspects of visualisation and soundscape design appear to have the greatest impact upon users' sense of place in the virtual simulation and
- explore the experiences of users in the virtual simulation and the effects of those experiences upon their sense of place in Avebury henge today.

There were two elements to this project. The first was the construction of the simulation, taking account of the evidence upon which it is based, how that evidence was interpreted in a 3D, virtual environment and the benefits and challenges posed by the virtual construction. The second element was exploring the experiences of a group of users in the virtual simulation, and then subsequently at Avebury henge today.

✉ Liz Falconer
efalconer@bournemouth.ac.uk

[1] Centre for Excellence in Learning, Bournemouth University, Bournemouth, UK

The paper begins with a brief description of present-day Avebury and the archaeological evidence for the virtual simulation. This is followed by a discussion of the approach used to construct the landscape and soundscape in an interactive environment. The findings of the evaluation study are then discussed and the paper concludes with recommendations for further research.

1.1 Avebury henge

Avebury henge is located approximately 20 miles north of Stonehenge in Wiltshire, UK and contains the remains of the largest known Neolithic stone circle in Europe (see Fig. 1). Its construction is estimated to have taken place in different phases and spanned approximately 2800–2000 BCE [1], although actual dating of the phases of construction is unclear. It is part of the Stonehenge, Avebury and Associated Sites World Heritage Site and is protected as a Scheduled Ancient Monument under UK legislation. The henge is a roughly circular earthwork with a ditch on the inside and a bank on the outside, measuring a maximum of 420 m in diameter between the outside edges of the banks. The earthwork is broken into four quadrants by interruptions in the ditch and bank system that have been interpreted as entrances to the inner area. Even today, the depth of the ditches and the height of the banks are impressive, but when first dug, the ditch was approximately 10 m deep, possibly as much as 14 m near to the entrances, and the banks were likely to have been between 6 and 8 m high [2]. The construction would have been carried out using animal and stone tools such as deer antler picks and flint axes. The earthwork enclosed three monumental sarsen (silicified sandstone) stone circles, one outer circle around the inside of the ditch which contained approximately 100 stones, with approximately 60 stones that constituted two inner circles surrounding large megaliths. At least two avenues lead from the henge, originally marked by standing stones along their length. These avenues were approximately 1.5–2 km long and led to other monuments such as the sites of wooden circles and standing stones, making the henge part of a much larger ritual landscape. As a present-day monument, Avebury henge is somewhat incongruous and hard to visualise as a whole, which makes it a particularly fitting location for investigating how experiencing a virtual interpretation of an ancient monument in the past, free of present-day context, might affect our understanding and interpretation of it today.

Fig. 1 Avebury henge NE quadrant looking towards north entrance

1.2 Virtual visualisation of ancient sites

Virtual simulations of prehistoric landscapes are essentially forms of constructed space, which draw upon aspects of the physical space of the present and the imagined space of the past. They can illuminate what is now imperceptible, contextualise what is now isolated and incongruous and can give us a means of connecting with people and cultures from which we are separated by thousands of years. As Pietroni [3: 232] states, the aim of virtual reconstructions of ancient sites is to '…multiply the communicative potentialities of cultural heritage, re-activating…relations in space, time and meaning'. Research into the distinction between 'space' and 'place' has given rise to a rich literature which explores that distinction from a range of viewpoints, including phenomenology, psychology and sociology [4, 5]. The common factor which applies to definitions of place from all these viewpoints is that place is space with meaning attached to it, a definition characterised by Harrison and Dourish [6] as 'place = space + meaning'. Gustafson [7] further identified three main themes in the meanings that are associated with places, viz.:

- self, including a person's emotions and self-identity,
- environment, including the physical features of the place and events that are experienced there and
- others, referring to the behaviours and characteristics of other people who share the place.

Ingold [8] argues that we live our lives not *in* places, but to, from, around and through them, disagreeing with Tilley [9] that humans are place bound. Ingold instead sees us as place binding; we move along paths that encounter places and people, becoming wayfarers who leave trails that intertwine with the trails of others. For Ingold, places are delineated by movement. In contrast, Malpas' [10] philosophical exploration of the nature of place stresses the importance of recognising the two-way nature of human relationships with places; we influence places and places influence us.

Online virtual world technologies, such as Second Life™ and OpenSim, and gaming technologies, such as World of Warcraft™ and Unreal Tournament™, all of which enable movement and interaction in virtual environments through the agency of an avatar, provide online environments which have been recognised as 'places' in sociological research [11]. But the nature of these places differs from physical places, as they enable what Ward and Sonneborn [12: 212] characterise

as individualised collaboration, where '…unlike face to face group activities in real world settings, in which the ambient conditions are largely the same for all participants, virtual worlds have properties that make it possible, in principle, for individuals to personalize their experience even whilst interacting with others in collaborative groups'. Virtual worlds have also begun to ignite interest as technologies that might provide enhanced opportunities to produce archaeological places, i.e. virtual spaces, where meaning grows through shared experiences and interactions with the environment to give a resulting sense of place. For example, in their review paper, Sequeira and Morgado [13] identified four different approaches to virtual archaeology and heritage that utilise virtual world platforms to create archaeological places, viz.:

- virtual world cyber archaeology, where the environments, landscapes and communities created within the virtual world take on their own value over time and become 'historical' sites that become imbued with their own cultural significance [14],
- reconstructive virtual archaeology, where physical world heritage sites are simulated within the virtual world to inform both the builders about the construction of these sites and the users about their physical configuration,
- virtual museums, in which replicas of artefacts and/or visual images of real world artefacts are displayed and visitors can view them and interact with curators and other visitors in the museum space and
- interactive virtual archaeology where users interact with the environment and each other. Sequeira and Morgado characterise this approach using a virtual world as an archaeological '…laboratory, where hypotheses can be put to the test and visually confirmed by having avatars interacting with the reconstructed space'.

This project aimed to develop the second and fourth approaches, focusing upon the creation of a simulation of Avebury henge and its surrounding ritual landscape, and the potential affordances of the socialisation facilities of online virtual worlds in helping us to understand some of the affective dimensions of a site such as Avebury.

It is important to recognise that using virtual technologies to create visualisations of archaeology and heritage sites has been a debated topic since the mid-1990s. Many archaeologists, historians and heritage professionals expressed concern regarding the dangers of hyper-realism, the dangers of reconstructions being based upon unclear evidence and the lack of an agreed protocol for demonstrating intellectual transparency in the design, construction and use of virtual reconstructions [15]. This led to the development of The London Charter for the Computer-Based Visualisation of Cultural Heritage [16] which is now recognised as the de facto benchmark to which heritage visualisation processes and outputs should be held accountable. The objectives of The London Charter are to provide a benchmark for the use of visualisation techniques, promote academic rigour in the processes of planning and construction, promote the use of effective methods for evaluating the outcomes of projects, encourage effective dissemination of the findings of evaluations and ensure the longevity and sustainability of project outputs. The objectives of this project followed both the spirit and requirements of the London Charter and are discussed at appropriate points in the paper.

The use of the terms 'virtual' and 'physical' is fundamental in this study and needs to be explained here, before the discussion of the project progresses. The antithesis of virtual is often expressed as 'real', but this is neither a useful nor an accurate expression. Experiences that are shared in virtual environments are real experiences, shared by people in the same way as they are shared in physical environments. The nature of the environment is, of course, different and virtual environments can be created that could never occur naturally, or would be impossible to construct in the physical world. The problem with using the term real as the antithesis of virtual is that virtual can then be inferred to mean unreal, a term that does not represent the experiences and understanding that can be gained from interactions in virtual simulations. For these reasons, physical is used in this paper as the antithesis of virtual, a distinction which relates to the nature of the environments rather than presupposing the reality or otherwise of experiences in them. The terms virtual Avebury and physical Avebury are therefore frequently used in this paper and are abbreviated to vAvebury and pAvebury, respectively.

2 Methods

The multidisciplinary nature of this project made the mixed methods approach, described by Creswell and Clark [17: 4] as '…multiple ways of seeing…', an appropriate method for the study. One of the most frequently used design approaches within mixed methods is convergent parallel design, described by Morse [18] as obtaining different but complementary data on the same topic. Creswell and Clark [17: 77] comment that this approach is particularly relevant when the researcher is interested in '…synthesising complementary quantitative and qualitative results to develop a more complete understanding of a phenomenon…'. As this project focused upon discovering what might emerge from the phenomena of constructing and experiencing a virtual simulation of Avebury, complementary data was drawn from archaeological research methods for the planning and design of the simulation, technological methods for its construction and qualitative social science research techniques for the evaluation elements of the study. These three approaches are discussed and justified below.

2.1 Technological methods for planning and constructing vAvebury

I created vAvebury in the virtual world platform OpenSim hosted by Kitely.com, using the Phoenix Firestorm viewer. The plan of Avebury in Pollard and Reynolds [2] was used as a full-size template for the simulation, from which a grey-scale plan was created and used to terraform a shallow depression and raise a low bank to give the outline of the henge. I then created the final henge and bank system by terraforming by hand to the original dimensions suggested by Pollard and Reynolds [2: 84], viz. the ditch approximately 10 m deep, increasing to approximately 14 m by the entrances, and the banks approximately 6 m high, rising to 8 m and widening by the entrances (see Fig. 2).

I placed small pyramids as moveable markers in vAvebury at each of the stone locations taken from the original plan and then created each of the stones individually as mesh objects in the 3D modelling program Blender. I exported each stone file in .dae format and then imported the file to the simulation and placed them according to the positions of the markers. Figure 3 shows how an object created in this manner is a mesh of interconnecting nodes, to which a texture is attached by wrapping to the contours of the mesh; the Firestorm interface for sizing, orientating and moving the stones is also shown. Regarding the archaeological plausibility of the simulated stones, each simulation of a stone that is still currently standing at Avebury was based upon the shape and texture of the stone in the present day, incorporating any major differences from historical descriptions by Alexander Keiller [19] and William Stukeley [20]. The sizes and textures of these stones were taken from high-definition still photographs I took of the stones, with a person of known height in the frame, as although I used the measurements suggested by Pollard and Reynolds [2], and these measurements could be replicated as true scale in the Firestorm viewer, apparent scale in virtual environments can appear different. This is partly due to the effect of viewing a 3D environment on a 2D screen, and to the camera angle generally being above and behind the normal human line of sight. Those stones which no longer exist at

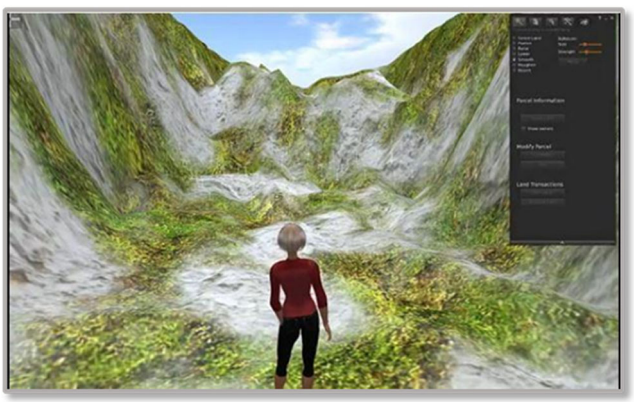

Fig. 2 Terraforming virtual Avebury

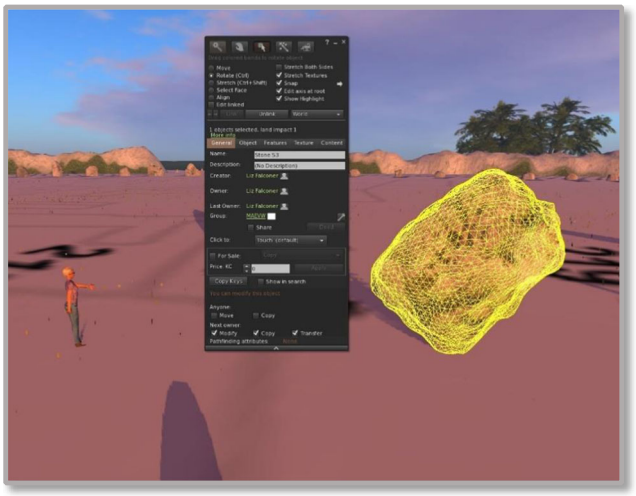

Fig. 3 Creating mesh stones

Avebury but for which there are dimensions and descriptions in Stukeley's historical work [20] were made according to those descriptions, e.g. The Obelisk, and Stone 47 which used to stand at the north entrance. The remaining stones in the outer and inner circles were consistent with Pollard and Reynolds' suggestions of the differing characteristics of stones in different areas of the henge. The stones of the two avenues leading from the henge were based upon those still standing at Avebury today.

Sounds in interactive virtual environments can be ambient, or can emanate from co-participants or specific artefacts, e.g. people's voices or the sound of flowing water in a stream. The sound architecture in vAvebury included both types; the ambient sound formed the base layer for the overall soundscape and was audible from any location, whereas located sounds and the voices of co-participants were only audible if the participant were close enough, and the sounds became louder or quieter depending upon the proximity of the avatar to the object or person. Sounds and soundscapes in vAvebury were diegetic, i.e. they were contextualised within the virtual space. Therefore, the ambient sounds of virtual Avebury created an imagined soundscape whose constituent parts would have been audible around 2200 BCE, comprising roe deer, wolf, buzzard and skylark calls [21], with background wind gusts. These sounds were taken from purchased pre-recordings, mixed and formed into a looped recording which was streamed into Kitely from a web service. The located sound effect was flowing water in the stream, which I recorded from a physical environment and attached as sound files (.wav) to the animated prims that created the effect of flowing water.

2.2 Phenomenographic method for evaluating virtual Avebury

Phenomenography is a subset of Heidegger's phenomenology [22], but whereas the latter is concerned with

attempts to understand individual experiences as they are, phenomenography looks to explore the variation in ways that things appear to people [23]. It was initially developed as an educational research method by Ference Marton and colleagues at the University of Goteborg in Sweden in the 1970s. Marton [24] describes phenomenography as an empirical study of the diverse ways in which people experience and apprehend various phenomena. Since the early 2000s, its use as a research method has broadened from education into a wider range of topic areas, such as mental health [25], information literacy [26] and counselling [27], where the purpose of the research is to understand the diverse ways in which groups of people experience phenomena. It is not a method that is apparent in information technology (IT) literature; research into user perceptions of IT has tended to concentrate upon methods that attempt to find consensus or majority views that relate to ease of use and usefulness of technology, such as the Technology Acceptance Model [28]. In this paper, I hope to demonstrate that a greater understanding of phenomenography amongst IT researchers might lead to a recognition of its value in understanding the nature of individual experiences, which can add richness to investigations of ease of use and usefulness.

In terms of the sampling strategy for choosing the phenomenography group, this was essentially opportunity sampling. This method is defined as inviting people from a target population available at the time and willing to take part [22]. It is based upon convenience and has the benefit of being quick and simple. However, the disadvantage is that the sample is unlikely to be representative of a population as a whole. In this case, as phenomenography is concerned with variation in individual experiences rather than attempting to find consensus in, or representation of, a wider population, I would argue that this was an appropriate sampling method. The four students who were studying the first year of the BA (Hons) History with a Heritage option at the University of the West of England, Bristol (UWE) were invited to take part in the study in the 2016/17 academic year. They all accepted and undertook 6 h of activities in the simulation in classes on 15th and 22nd February 2017, further activities in their own time and a physical site field trip to pAvebury on 1st March 2017. The field trip included the use of mobile devices to bring vAvebury into pAvebury, recognising that these are ubiquitous devices and visitors to heritage sites are already being encouraged to use them for guides and interpretive activities. I took 3D pictures in vAvebury from 12 vantage points and made these available for download to the group. During the field trip, participants had the opportunity to use these pictures on their phones, with Google Cardboard 3D viewers, if they so wished.

Data was gathered from the following:

- observing classroom interactions during the students' use of vAvebury over the 2-week period,
- a discussion group at the end of the period,
- observations during a visit to pAvebury in the following week and
- a discussion group at the end of the visit.

Observational research has been criticised for being overly subjective on the part of the observer/researcher, time-consuming and prone to result in interference with the situation under observation. However, in this case, the ability of observation to enable a researcher to experience a real-life situation rather than a hypothetical one, the fact that observation is effective in situations where non-verbal forms of action are important, and that the technique enables the researcher to see how a group interacts, were significant benefits [22]. One of the recommended ways of overcoming the bias risk of observation is to use other methods to elicit research data, which was done in this case through the use of discussion groups.

Classroom observations were undertaken by watching both the students' interactions with the virtual environment and with each other during their visits to vAvebury. Notes were made of the following:

- the way in which each student explored the virtual landscape,
- how they changed the look and feel by altering weather and lighting conditions,
- the extent to which they used their headphones to experience the soundscape environment,
- how they undertook group activities such as processing along the avenues leading to the henge and
- the nature of their conversations, both in-world through text chat (which was captured) and in the classroom through normal voice communication.

The observations of the participants at pAvebury differed from the classroom observations in that they were made as part of the group, rather than as a non-participating observer. The risk of bias is greater in this situation than in the classroom observations, but the size of the environment and the nature of physical interactions in the group made a disconnected form of observation impossible. The benefits of observing real-life interactions within the group counterbalanced the risks of bias and observer interference, but these risks are still recognised as a potential limitation of the research. My observations were recorded by taking photographs and making written notes during the visit.

A semi-structured, guided approach was used to facilitate the discussions in the groups, emphasising the research questions that related to visual and soundscape experiences, and the sense of place in both vAvebury and pAvebury. However, my role was as a guide only, as their experiences were best captured by what emerged from an open discussion, rather than trying to gain specific answers to particular questions. The discussion groups were recorded and the main points then transcribed.

The data from the observations and discussions were thematically analysed using the conceptually clustered matrix method [29 p.127]. As this study was an exploration of experiences, I took an empirical approach to the analysis, as recommended by Miles and Huberman. Using this approach, sources of data were initially examined to identify general trends that related to the research objectives, as opposed to the conceptual method where the analyst has some a priori ideas about themes which may emerge. As the focus group was small, I created a single participant-by-objective matrix, which constituted the four participants on one axis and the two research objectives relating to user experiences on the other. Data was entered in each of the cells of the matrix in the form of short summary phrases and ratings relating to each participant. Reading across the rows then enabled a summary view of each participant's experiences, and reading down each column showed how themes emerged under each research objective. These findings are summarised in Table 1 and discussed in Section 4.

Both content and construct validity have been considered during the design and execution of this study. The topics of archaeological interpretation of Avebury, technological issues in the construction of virtual simulations and the appropriate use of phenomenography have provided adequate coverage of the phenomena under study, and the methods chosen are appropriate for measuring what the study set out to measure, as discussed above.

As this study involved human participants, there were ethical considerations to be taken into account. I received full ethical approval from the UWE University Ethics Committee and the Student Research Ethics Committee at the Institute of Continuing Education, University of Cambridge.

2.3 Limitations

The complexity of creating a simulation of a site like Avebury has been discussed above, but the specific limitations of this project fell into two categories. Firstly, the technical limitations of the OpenSim platform and Firestorm viewer meant that the size of the sim was restricted to be just large enough to contain the henge and a narrow strip of land outside it. As a result, the scale of the surrounding landscape was not strictly correct and the position of the nearby stream was approximately 250 m too close to the henge.

The second limitation relates to the size of the group that experienced vAvebury. Four people is a small group and is in no way representative of the wide range of people who might experience such a simulation when used as an educational or orientation device. However, as phenomenographic methods are concerned with discovering variety in individual experiences, rather than looking for consensus, no attempt has been made to generalise to theory from this group's experiences, nor categorise the range of experiences possible in such a simulation. Also, Nielsen and Landauer [30] developed a mathematical model to establish the cost/benefit ratio for optimum numbers of test users in research into individual experiences of IT systems and found that the optimum number was between 4 and 5, which adds validity to the sample size used in this study.

3 Issues that arose from constructing virtual Avebury

3.1 Visual aspects

It can be tempting to see a monument such as Avebury as a single construction that was conceived, planned and built in the same manner as a construction project in the present day, leading to a 'finished' structure. But this is unlikely to be the case. Evidence appears to show that sites such as Avebury continually changed as beliefs, practices and cultures changed. Archaeologists suggest that acts of constructing monuments like Avebury were likely to be significant to the communities that built them, possibly more so than any sense of completing the monument [31]. So, questions such as 'what did Avebury originally look like?' are essentially meaningless. There is no 'originally'. Also, such questions are intended to explore what Avebury looked like at the time of a particular interpretation but, of course, interpretations may not be accurate; Avebury may never have looked any of the ways it is now imagined.

In one sense, the changing nature of Avebury is problematic, as there is no fixed instance against which to measure the accuracy of a simulation. But on the other hand, this uncertainty provides the opportunity to try different interpretations and to build fluid versions and timelines, rather than attempt a single, fixed reconstruction. Virtual reality technologies are well suited for this approach, as they facilitate creating a series of constructions that can be run as alternative timelines, rather than searching for a fixed view of the past. Whilst taking this into account, for the purposes of this research, the construction focused upon the ditch and bank system, the stone circles and the megaliths within them. But this was one imagined past and was not constructed as a true version of Avebury, but rather as an imagined point in time when the ditch and bank system was

Table 1 Summary of thematic areas and main comments from phenomenographic evaluation

Theme	Number of participants who expressed this view (out of 4)
Sense of place in vAvebury	
Freer to explore in vAvebury	4
vAvebury concentrates on vision and hearing so less immersive than pAvebury	4
Shifted perspective in vAvebury (camera behind head) detracts from first person feeling	4
Overall, vAvebury has more meaning as a place in the Neolithic than pAvebury	3
Sense of place in pAvebury	
Familiarity with pAvebury even though have not been there	4
Stronger sense of 'being' in pAvebury due to using all human senses	4
Greater sense of scale in pAvebury—don't get sense of largeness of stones in vAvebury	4
Overall, pAvebury has more sensory immersive quality than vAvebury	4
Low sense of historical immersion in parts of pAvebury due to houses, roads etc	3
pAvebury buildings detract from the sense of the Neolithic	3
Village is place to visit in its own right	1
pAvebury buildings 'grand' and 'overpowering'	1
Presence of houses etc. took away from feeling of the stones	1
pAvebury buildings seem 'out of place'	2
Recall of vAvebury in pAvebury	
Google Cardboard a good reminder of vAvebury	4
vAvebury henge feels bigger than pAvebury henge	4
Avenues do not feel bigger in vAvebury than pAvebury	4
Felt restricted in pAvebury	3
Some parts of pAvebury more immersive than vAvebury	3
Memories of walking in vAvebury avenue resurfaced when walking in pAvebury avenue	3
Virtual overlay of Google Cardboard helped to understand where we were	3
Effect of sounds and soundscapes	
Noticed sound in pAvebury and would be good to have more sound depth in vAvebury	3
Became more aware of pAvebury soundscape when looking through Google Cardboard	1
What Avebury might have been for	
Avebury doesn't feel defensive as a structure	4
Felt like some important event happened at pAvebury	3
Avenues make you feel guided into the henge in both pAvebury and vAvebury	3
Felt like banks were for viewing	2
Asked if ditch was filled with water, e.g. moat	1
Banks in vAvebury and pAvebury reminded of Roman amphitheatre	1
Future uses of virtual environments in heritage management	
Virtual environments good for improving understanding and navigation around sites like Avebury	4
Users should be able to set their height and perspective would adjust in the virtual environment	3
Virtual environments could be useful for maps for visitors	2
Could show where you are if GPS connected	2

at its greatest dimension and the majority of the stones were standing.

3.2 Sounds and soundscapes

Falconer and Green [32] comment that sound is often underused in virtual world simulations as the visual aspects of interactive environments can dominate simulations. In some virtual world platforms, including OpenSim, sound is subject to technical restrictions of file size and play length that can require looping of short sound clips resulting in repetitions that affect the realism of a particular sound, or a soundscape. Despite these drawbacks, research has shown that sound has a significant effect on participants' sense of immersion, particularly on the emotional and affective dimensions. For example, Dinh et al. [33] found that increasing the modalities of sensory input, particularly auditory cues, can increase a user's sense of both presence and memory for objects in a virtual environment. It is particularly noteworthy that in their study, increasing the level of visual detail did not result in the same increases in the sense of presence or recall of objects, demonstrating that virtual environments are not all about the visual. More recent studies have begun to focus upon the effects of different types of soundscape on aspects of recall and memory relating to awareness of detail in virtual environments. For example, Schmidt et al. [34] found that spatial audio cues in a 3D virtual environment can be constructed to guide a user's attention. As this project sought to investigate the interaction of participants with vAvebury, the affective dimension of that interaction was of particular interest, addressing the question of how sharing the experience of being 'at' vAvebury with others made the participants feel.

4 Results of the phenomenographic evaluation

The conceptually clustered matrix analysis identified six themes that emerged from the observations and discussions; these are summarised in Table 1, grouped under each thematic area and showing how many participants commented. It is important to stress that this research was not looking for agreement; there is no sense in which a greater validity is inferred from greater agreement as the study was concerned with the range of experiences. The following discussion of the results expands the six themes in Table 1.

4.1 Theme 1: sense of place in virtual Avebury

It was apparent during the classroom sessions that the group had, to varying extents, a sense of 'being in' vAvebury, as they began to explore the environment and refer to it as a place (see Fig. 4). This became more noticeable during the second week of interaction, when they experimented with the personalised

Fig. 4 Focus group class activities in vAvebury

collaboration facilities in the Firestorm viewer, each of them changing time of day, weather conditions and ambient light in their own viewer (see Fig. 5). Comments such as 'it's raining now' and 'the place feels different when it's sunny' demonstrate how vAvebury was being to be referred to as a place by three of the group; one participant felt that the lack of sensory perception in touch and smell detracted from the sense of place and found immersion difficult.

The term 'explore' was brought up early in the focus group discussion, and the opportunity for exploration in vAvebury was commented upon by all the participants. Their comparisons between vAvebury and pAvebury strengthened the sense that they considered vAvebury as a place in its own right, although the strength of that feeling still varied significantly in individuals. A sense of vAvebury having more meaning as a place in the Neolithic than pAvebury was felt by three of the participants. One of the most interesting factors of this sense of place was that it seems to have been a specifically historical sense in comparison to pAvebury today. Whilst pAvebury felt

Fig. 5 Some of the group as avatars in vAvebury

more real to all of the group, vAvebury felt more historically authentic, although one participant remained less sure about experiencing this sense of history, feeling that the lack of a full sensory experience prevented having a strong experience.

4.2 Theme 2: a sense of place in physical Avebury

A striking phenomenon during the visit to pAvebury was how individuals seemed familiar with the site. This observation was born out by the discussion in the focus group, where all members commented that they experienced a sense of familiarity. Two of the members of the group had last visited pAvebury several years ago, and two had never visited the monument or the surrounding landscape. All four commented upon experiencing a sense of orientation that was greater than they would have felt from studying a map prior to the visit. They also commented that they felt a greater sense of presence in pAvebury than they felt in vAvebury, but the strength of that sense varied in individuals. A significant element of the sense of presence in the two participants who felt this strongly was the sense of size and mass of the large stones, such as those at the southern entrance.

Three of the group commented that they did not experience a strong sense of pAvebury as an ancient place because of the houses and roads, and one of the three felt that the houses detracted from the ability to really get any sense of how ancient the Avebury monument is. This participant described the houses as grand and overpowering and also made the comment that Avebury village is itself a tourist destination, with attractions such as The Manor House and parish church confusing the historical context for visitors. These experiences appeared to result from experiencing vAvebury without modern-day constructions.

4.3 Theme 3: recall of virtual Avebury in physical Avebury

All four members of the group commented that they could recall vAvebury in pAvebury at the beginning of the field trip visit, but this effect was significantly heightened when 3D photographs of vAvebury were viewed through Google Cardboard viewers at equivalent vantage points at pAvebury (see Fig. 6). This method of mixing the virtual and physical experiences as a method of orientation in pAvebury was commented upon by three participants, particularly as a means of overcoming the sightline restrictions discussed above.

The differential sense of scale in vAvebury compared to pAvebury was commented upon by all the group, and there seemed to be little variation in their experiences of this. The stones in pAvebury felt larger than in vAvebury, the henge in vAvebury felt larger than in pAvebury and the avenues felt about the same in both places. The lack of sensory perception in a virtual world viewed on a screen was felt to be a major drawback in experiencing a sense of place, particularly on visiting the physical environment upon which the simulation is based and feeling the comparison between the two. Although some parts of pAvebury felt more immersive than vAvebury, three members of the group said they felt restricted in pAvebury. Part of this feeling appeared to be due to restricted sightlines and physical barriers in pAvebury henge, along with the current restrictions on accessing parts of the ditches and banks due to erosion prevention. In contrast, the view across vAvebury henge is unrestricted and participants have access to all parts of the vAvebury simulation. As well as the visual aspects, activities that the group had shared in pAvebury evoked memories of vAvebury, such as walking together from the henge along part of the West Kennett Avenue and climbing the banks to gain a better view of the henge as a whole.

Fig. 6 Some of the group using Google Cardboard views of vAvebury on pAvebury field trip

4.4 Theme 4: the effect of sounds and soundscapes

The sounds of modern-day life dominate pAvebury; the roads are busy and the village is a year-round visitor destination. During the summer months, light aircraft and microlights fly from a local airfield and flocks of sheep frequently graze the henge. With the possible exception of some sheep, none of these sounds would have been likely constituents of a Late Neolithic soundscape; despite this, one of the group commented that when looking through the Google Cardboard viewer at a 3D picture of vAvebury, he became more aware of the kinds of sounds he remembered from the vAvebury soundscape such as gusting wind and buzzard calls. Interestingly, this extended to sounds that did not feature in the vAvebury soundscape such as general birdsong, the effect appearing to be a heightening of sensitivity to the soundscape in general rather than recalling particular sounds. This is notable as, during observations of the groups' activities in vAvebury, the soundscape did not seem to feature as a point of discussion and superficially appeared to have little effect on their experiences. This suggests that virtual world

soundscapes may operate on a subtler level than visual stimuli, and this is an interesting area for future research.

Another member of the group commented that she noticed the way voices changed when people were standing inside the Cove stones, how the sound appeared to reverberate and be directed out from the stones into the northern circle. This led the group to discuss how sound and soundscapes in virtual environments add an important dimension to an otherwise predominantly visual experience. Three members of the group commented that they would like to have more depth of sound in vAvebury, including subtler directional and reverberation effects, which would begin to overcome the 'sensory deprivation' experiences commented upon by some of the group.

4.5 Theme 5: what Avebury might have been 'for'

All the group agreed that they felt that 'something had happened' at pAvebury in the Late Neolithic period. They did not feel that this was a defensive structure. Although they knew the ditch would normally be on the outside of a defensive structure in any case, they also 'had the feeling' that it was not a place of defence. However, one member of the group did ask if there had ever been water in the ditch, as the notion of a defensive moat had crossed his mind because of the depth and steep-sidedness of the ditches in vAvebury. Three of the group commented that the avenues in vAvebury gave them a strong sense of being guided to the henge rather than away from it, and this sense persisted in pAvebury. However, no member of the group had any particular view as to whether what happened there might be viewed as positive or negative, but two participants commented that they felt it was a place for spectators and the banks were for viewing, as both in vAvebury and pAvebury, the best views of the henge as a whole were to be had from the tops of the banks. One member of the group said that the banks in both vAvebury and pAvebury reminded him of a Roman amphitheatre, although he did not feel that the same kinds of activities would necessarily have taken place there.

4.6 Theme 6: future uses of virtual environments in heritage management

As the group comprised students of heritage management, they had a particular interest in how 3D, virtual technologies might be used in their practice in the future. All four shared the view that virtual technologies are likely to play an increasingly important role in heritage management at sites like Avebury, but how these technologies might be used was less clear. They felt that 3D virtual technologies are likely to have a particular role in aiding navigation and understanding of large sites like Avebury, which can be difficult for visitors to understand without spending significant amounts of time exploring them. Two members of the group commented that having 3D, virtual applications on mobile devices that were sensitive to both location and direction of gaze, could provide both orientation and interpretation experiences for visitors to large and complex sites like Avebury. They also discussed the opportunity for augmented reality (AR) as holo-lens technologies become more widely available.

Three members of the group commented that users should be able to set their height in the virtual environment so that the perspective would adjust accordingly, as they felt that the third person view from behind the head of the avatar detracted from the sense of immersion, and also accounted for the reduced effect of the mass and size of the stones in vAvebury. They felt that this, in turn, would help visitors to pAvebury using mobile devices to mix the virtual with the physical more effectively by retaining a more human perspective.

5 Conclusions and recommendations for further research

The first objective of the study was to explore the archaeological research and interpretation necessary to plan and construct a simulation of an ancient site in an interactive, online environment. A broad range of literature and data sources were consulted to inform the design and construction of the simulation. For practical purposes, it became clear that in undertaking a simulation of an ancient site, a core set of sources need to be selected to create the main parts of the simulation. With regard to literature, sources were chosen because they best represented some of the currently accepted interpretations of Avebury's development, based upon archaeological evidence. However, there was much debate in the literature regarding the way in which archaeological findings were interpreted, and whilst other data demonstrated quantifiable evidence of how Avebury appears today, e.g. the number and condition of extant stones, this simulation was based upon selected archaeological interpretations. A different virtual Avebury would have been constructed if different interpretations had been chosen. Any simulation of an ancient site should recognise and clearly state the interpretive basis upon which it has been designed.

The second objective was to identify which aspects of visualisation and soundscape design appear to have the greatest impact upon users' sense of place in the virtual simulation. In terms of visualisation, the greatest impact appeared to be absence rather than presence. The absence of modern structures in vAvebury and the visualisation of an imagined past affected each participant differently, but was felt to be one of the strongest senses overall and led to comments regarding vAvebury as a historical place. On one hand, this is an interesting finding, but on the other, it demonstrates the risks referred to by the London Charter that visualisations of ancient sites can take on a sense of historical authenticity not intended by their

creators. In this project, there was insufficient time for participants to learn how to move or manipulate stones and other objects in vAvebury, but further research might explore if this kind of experimentation with the environment might help to reduce the sense of authenticity in a fixed environment. Visualisation of the weather had different effects within the group, some feeling that bright sunny weather was too 'pretty' and choosing to be in vAvebury in fog and rain, whereas others preferred to choose the bright weather and the stronger colours that resulted. Whatever their choices, referring to the weather invoked a sense of place in their descriptions and reactions to vAvebury, and in their conversations with each other whilst exploring the environment.

The effect of sounds and soundscapes appears to be subtler. Members of the group did not comment on the sounds much when in vAvebury, but on the visit to pAvebury, two members of the group commented upon the sounds there, referring back to their experiences in vAvebury as the catalyst for provoking their recognition of the sound environment. The participants did not single out any particular element of the soundscape at vAvebury as having impact, but the overall ambient sense appeared to be the most evocative effect. The design of authentic ancient soundscapes, such as the Neolithic soundscape apps created for the South Dorset Ridgeway [35], is a developing field of research and practice that could benefit from experimentation in virtual environments, where the soundscape is under the control of designers and users and not subject to interference from sounds in the physical environment. This has particular resonance with experiencing a physical landscape in the UK, as road and aircraft noise are ubiquitous and can significantly influence the sense of immersion.

The sense of place at vAvebury was only beginning to develop during the relatively short period of this study, and this is an important issue. Sense of place takes time to develop, both in physical and virtual places. Spaces have to be imbued with meaning to become places, and this can take time. This project was of a relatively short duration, and further research could usefully explore the development of sense of place in virtual simulations of ancient sites over a longer period.

The third objective was to explore how the virtual simulation appeared to different users and how their experiences affected their responses to Avebury today. A phenomenographic method was used to achieve this objective, a presently little-used research method in IT for investigating user reactions and experiences. The major focus in user research appears to be on consensus regarding the ease of use and usability of systems rather than looking to widen the experience base by appreciating the range of experiences that people can have in using the same systems. Phenomenography is a method that takes account of differences in experiences, and exploration of its applicability to user evaluation of IT would be a beneficial area for further research.

The findings from this project demonstrated that responses to virtual environments, and the resulting effect upon responses to physical environments, are complex and personal. Some aspects, such as familiarity with pAvebury through their experiences in vAvebury, the sense of history at vAvebury and the parallel sense of modernity at pAvebury, and a greater sense of presence at pAvebury than vAvebury, were more generally shared. But there was significant individual variation in views on what pAvebury might have been for, and how it might have been used. The activities of walking the avenues together in vAvebury, of exploring the stones and falling into the ditches, of foggy weather and steady rain one afternoon, were shared experiences that began to produce a sense of place for the group, but the short duration of this part of the project left many questions regarding the kinds of shared experiences that might develop the sense of place there. Future research might extend the range of activities for larger groups in virtual simulations of ancient environments to explore these questions further.

Acknowledgements I would like to thank Aaron Griffiths for his enthusiastic help and support in the technical aspects of the construction of virtual Avebury, and Dr. Corinne Roughley, Dr. Josh Pollard and Dr. Mark Gillings for their advice and guidance on the archaeological aspects of the construction.

This paper is drawn from a dissertation written by the author in part fulfilment of the requirements of the Advanced Diploma in Archaeology at Cambridge University, UK.

References

1. Pollard, J. and R. Cleal (2004) Dating Avebury, in Monuments and material: papers in honour of an Avebury archaeologist—Isobel Smith. In: Pollard J, Cleal R (eds) Hobnob Press: Salisbury
2. Pollard J, Reynolds A (2002) Avebury: the biography of a landscape, 1st edn. The History Press, Stroud
3. Pietroni E (2013) Natural interaction in VR environments for cultural heritage: the virtual reconstruction of the Regolini-Galassi tomb in Cerveteri (with an Appendix by M. Sannibale and D. Pletinckx). Archeologia Calcolatori 24:231–247
4. Relph E (2008) Place and placelessness, 1st edn. Sage, London
5. Turner P, Turner S (2006) Place, sense of place, and presence. Presence Teleop Virt 15(2):204
6. Harrison, S. and P. Dourish (1996) Re-place-ing space: the roles of place and space in collaborative systems., pp67–76. in ACM conference on Computer supported cooperative work
7. Gustafson P (2001) Meanings of place: everyday experience and theoretical conceptualizations. J Environ Psychol 21(1):5–16
8. Ingold, T. (2009) Against space: place, movement, knowledge, in Boundless worlds: an anthropological approach to movement. In: Kirby PW (ed), Berghahn Books: New York p 29

9. Tilley CY (1994) A Phenomenology of landscape: places, paths and monuments. Berg 3PL, Oxford
10. Malpas JE (1999) Place and experience: a philosophical topography. Cambridge University Press, Cambridge
11. Moore R, Hankinson Gathman E, Ducheneaut N (2009) From 3D space to third place: the social life of small virtual spaces. Hum Organ 68(2):230
12. Ward TB, Sonneborn MS (2011) Creative expression in virtual worlds: imitation, imagination, and individualized collaboration. Psychol Aesthet Creat Arts 3(4):211–221
13. Sequeira LM, Morgado LC (2013) Virtual archaeology in second life and opensimulator. J Virtual Worlds Res:**6**(1)
14. Harrison R (2009) Excavating second life: cyberarchaeologies, heritage and virtual communities. J Mater Cult 14(1):75
15. Earl, G. and D. Wheatley (2002) Virtual reconstruction and the interpretative process: a case study from Avebury, in Contemporary themes in archaeological computing. In:Wheatley D, Earl G, Poppy S (eds) Oxbow Books: Oxford, p 5–15
16. London, C (2009) The London Charter for the Computer-based Visualisation of Cultural Heritage. 24/5/2016; Available from: http://www.londoncharter.org/introduction.html
17. Creswell JW, Clark VLP (2011) Designing and conducting mixed methods research. Sage, Thousand Oaks, California
18. Morse, J.M. (2003) Principles of mixed methods and multi-method research design, in Handbook of mixed methods in social and behavioural reseach. In: Tashakkori A, Teddlie C (eds) Sage: Thousand Oaks, California p 189-208
19. Smith IF (1965) Windmill Hill and Avebury: excavations by Alexander Keiller 1925-1939. Clarendon Press, Oxford
20. Stukeley W (1743) Abury, a temple of the British druids, with some others described...Volume the second, 1st edn. Gale ECCO Print Editions, London
21. Serjeantson, D. (2011) Review of animal remains from the Neolithic and Early Bronze Age of Southern Britain (4000–1500 BC), in Research Department Report Series. Portsmouth
22. Savin-Baden M, Major CH (2013) Qualitative research: the essential guide to theory and practice. Routledge, Abingdon
23. Cibangu SK, Hepworth M (2016) The uses of phenomenology and phenomenography: a critical review. Libr Inf Sci Res 38(2):148–160
24. Marton, F. (1994) Phenomenography, in The international encyclopedia of education. In: Husen T, Postlethwaite TN (eds) Pergamon: Oxford.
25. Cutler, N., L. Moxham, and M. Stephens (2014) Forward thinking: using phenomenography to explore the meaning of safety in acute mental health inpatient units
26. Whitworth, A. (2014) Nurturing information landscapes: networks, information literacy and the need for a critical phenomenography. in Proceedings of the 9th International Conference on Networked Learning
27. Kettunen J, Tynjälä P (2017) Applying phenomenography in guidance and counselling research. Br J Guid Couns:1–11
28. Venkatesh, V. and D F.D (2000) A theoretical extension of the Technology Acceptance Model: four longitudinal case studies. Manag Sci
29. Miles MB, Huberman AM (eds) (1994) Qualitative Data Analysis, 2nd edn. Sage, Thousand Oaks, California
30. Nielsen J, L TK (1993) A mathematical model of the finding of usability problems. in Interact '93 and CHI '93: Human factors in computer systems. ACM, Amsterdam, The Netherlands
31. Barrett JC (1994) Fragments from antiquity: an archaeology of social life in Britain 2900–1200 BCE. Blackwells, Oxford
32. Falconer L, Green J (2015) Exploring the learning potential of acoustic design in 3D virtual environments. Literacy Inf Comput Educ J 6(1):1273–1276
33. Dinh, H.Q., et al. (1999) Evaluating the importance of multi-sensory input on memory and the sense of presence in virtual environments. in Virtual Reality. Proceedings., IEEE. 1999. IEEE
34. Schmidt, M., S. Schwartz, and J. Larsen (2012) Interactive 3-D Audio: enhancing awareness of details in immersive soundscapes? in Audio Engineering Society Convention 133. Audio Eng Soc
35. Satsymph (2017) Sound apps on the South Dorset Ridgeway; Available from: http://satsymph.co.uk/projects-and-events/interpretation/southdorsetridgeway