Imagining technology-enhanced learning with heritage artefacts: teacher-perceived potential of 2D and 3D heritage site visualisations

Abstract

Background: National and world heritage sites need to be supported in sharing their resources with a wide and international public, especially within formal education. 2D and 3D heritage site visualisations could serve this need.

Purpose: We describe how a group of UK teachers perceive the potential of cross-curricular learning around an Italian world heritage site. We discussed with them 2D visualisations of artefacts from this site as well as the design of a 3D immersive environment to serve educational purposes. We consider: (1) How the cross-curricular teaching potential of such resources is perceived, and (2) what design features of a 3D immersive environment teachers suggest are needed for educational explorations.

Sample: We recruited 10 teachers from the Midlands region of the UK and carried out semi-structured interviews.

Methods: Interviews were transcribed and a thematic analysis applied to the conversations. Questioning was grounded in the examination of 2D and 3D visual resources. This provoked cross-curricular and educational design thinking.

Results: Teacher responses highlighted a wide range of cross curricular possibilities. However, they expressed a more 'assimilative' than 'accommodative' attitude when relating these rock art resources to the curriculum. Such 'assimilation' involved seeing the site artefacts as raw material for more instrumental 'curriculum activities' (e.g. within art and design, geography, maths or literacy) rather than a more accommodative effort whereby curricular disciplines were exercised to make meaning from the artefacts. In relation to 3D technology design, most teachers highlighted three technology features that would render it well matched to educational practice and three educational benefits over non-3D immersive environments.

Conclusions: Teachers can easily imagine a rich range of opportunities to recruit 2D and 3D heritage site artefacts into curricular concerns. However, the largely assimilative nature of this cross-curricular appropriation suggests the value of providing more guidance and support to teachers in the interpretation and application of artefacts. Their design suggestions can usefully inform construction of educational features within 3D immersive technologies that support heritage site experiences.

Key words: cross-curricular, heritage sites, 3D visualisation, immersive environments, educational technology design, technology-enhanced learning

Introduction

Sharing and exchanging heritage data should be seen as a necessity: both for the general public and, more particularly, in education (Carman, 2001). Furthermore, not just world heritage sites but *all* heritage sites need to be viewed beyond the boundaries of the 'national'. While they may tell ancestral stories and connect to the past of their local people, those sites and museum artefacts tell stories about all of us: stories which should connect us by finding a

common thread from the past. Heritage sites can support a global, unifying education which connects cultures and nations, thereby contributing to cross-national tolerance and understanding (Messenger and Enloe 1991; Shields, 1991).

As Carman (2001, xiii-ix) rightly states:

> …any heritage or heritages that we create should enhance our understanding of who we are and what we do, and increase our enjoyment and delight in the world we jointly inhabit. If it serves to separate us from the wider environment – by seeking to mark us out as "special" or "different" and "superior", or indeed as "inferior" – then it is failing in its purpose (…) Failure to share the heritage – and thereby ourselves – is to deny the heritage its purpose.

Therefore, heritages are always 'ours'. They belong to the world, to human civilization. On the other hand, heritage sites can be a source of healthy 'national pride', although some authors do note the use of national heritage to support nationalism (Dietler, 1994) and call for caution relating to the political implications of interpreting and presenting past (Baram and Rowan, 2004).

Therefore, it is of great importance to support world-wide heritage site organisations and museums in drawing connections between heritage sites, while teaching audiences and learners a critical anthropology: understanding that the past is always subject to interpretation. More opportunities for interpretation are needed to enrich the meaning of heritage (Carman, 2001). This represents a turn towards heritage not only as national treasure but as something public and as a 'world-good'.

The present paper arises from an ongoing European programme of research involving institutions in the UK, Italy, Austria and Germany. The work involves early rock art in Valcamonica, Italy. The unique property of rock art in comparison with rock drawings lies in their three-dimensionality. That is, this art has properties of height and width but also depth. Advanced technology is being developed in order to scan and represent this 3D character and to map and annotate the site in the form of 3D graphical visualisations and immersive virtual environments.

The project includes recognition of the need for greater visibility and sharing of heritage: one of its strands considers the potential of heritage site sharing for educational purposes, locally and internationally through 2D and, importantly, 3D resources. This paper focuses on the challenge of identifying resources and practices that might meet curriculum needs across subjects - as evaluated and reflected upon by teachers. Schools in the UK and elsewhere organize museum and national heritage site visits, commonly as part of an extra-curricular activity. In addition, many museums offer a variety of online resources and narrative formats to "communicate, interpret, facilitate meaning making, encourage a questioning attitude, stimulate the imagination, make learning fun and facilitate interaction" (Glover-Frykman, 2009, 318).Yet, there is a scarcity of studies looking at how museums and heritage site's resources can support teaching and learning inside the classroom (ibid.; Merchant, 2010).

When dealing with 3D technology, how can 3D technology bring the experience of a heritage site to students in their learning environment - not as a substitute for the first-hand experience but to be complementary? The present paper explores those challenges.

Heritage, archaeology and education

Archaeology and pre-history in formal education

Archaeology is not a part of the UK National Curriculum but it can be taught at any level in formal and informal education. It is a subject that students can select for 'AS', 'A level' or GCSE[1] and schools can integrate it in their own curriculum[2]. In pre-14 education, this integration depends on the teacher - if the teacher sees any benefits and has access to resources[3]. For example, Canterbury Archaeological Trust offers resources for primary schools (Key Stage 1 and 2 teaching). Finally, archaeology can be studied as a tertiary education discipline, placed within the field of humanities.

There are organisations which provide examples of how archaeology can be useful for teaching across subjects: 'Scottish Analytical Services for Art and Archaeology' and 'BBC primary history curriculum' both provide examples of creating an 'archaeological dig' in the primary classroom. They suggest activities related to the archaeological dig which can be connected to learning objectives across subjects (e.g. maths, history, geography, art and design)[4]. In addition, the Surrey County Council web site suggests how archaeology is a versatile field which can fit the national curriculum and offer possibilities for teaching literacy, numeracy, science, history, geography, design and citizenship[5]. In North America, Jeppson and Bauer (2007) mention a successful implementation of archaeology in primary and secondary curriculum in a Baltimore County Public Schools programme, where archaeology was a compulsory subject at primary and secondary level.

As Henson (2008, 60) notes :

> Although archaeological evidence can be used in the school curricula in the United Kingdom from the ages of 5 to 14, the earliest opportunity anyone has to study archaeology as a subject in its own right is at the age of 16. Until recently, students could take archaeology at 14-16.

Table 1 shows the growth of popularity of archaeology between 1975 and 2005 based on the number of students aged 14+ taking archaeology exams.

Insert Table 1

[1] http://www.aqa.org.uk/subjects/archaeology/a-level/archaeology-2010
[2] http://www.wnc.ac.uk/Courses/Archaeology-and-Egyptology
[3] http://www.archaeologyuk.org/education/study
[4] http://www.sasaa.co.uk/activities%202.htm; http://www.bbc.co.uk/schools/primaryhistory/hands_on_history/dig/
[5] http://www.surreycc.gov.uk/recreation-heritage-and-culture/archaeology/education-and-archaeology/how-archaeology-fits-into-the-national-curriculum

Table 1. Numbers of students taking archaeology exams at 14+ (from Henson, 2008, 60)

This paper supports the view that although there might not be a need for archaeology inclusion as a 'regular' school subject, there is a need to better understand the value and possibilities that teachers see in archaeological resources for teaching and learning. Archaeology-related topics are already a part of the history curriculum. The newly reformed national curriculum for England includes the teaching of "prehistory" within the subject of history, with three thematic units under "Changes in Britain from the Stone Age to the Iron Age". These might include "late neolithic hunter-gatherers and early farmers, for example Skara Brae, Bronze age religion, technology and travel, for example Stonehenge and Iron Age hill forts, tribal kingdoms, farming, art and culture."[6].

Arguing for archaeology/heritage informed education and citizenship, Stone (1997, 27) states:

> ..if access to the evidence of archaeology is not available to all, through its inclusion in formal and informal educational programs, then society runs the risk of the interpretation of archaeological evidence being biased... (…) the failure to include archaeological interpretation in curricula can be argued to have contributed to the lack of understanding on the part of the general public, with regard to the archaeolog-ical-cum-educational-cum-political importance of sites.

In addition, Smith (2009, 8) reports the results of a national public survey (N=1,016 in total) in the US commissioned by the Society for American Archaeology done by Ramos and Duganne (2000)) which demonstrated that:

- 90% supported archaeology inclusion in the school curriculum
- 99% felt that physical remains of the past had educational and scientific value
- 94% saw application to their personal heritage".

In short, archaeology exists as an elective rather than a National Curriculum subject but nevertheless offers opportunities for teaching and learning across subjects, if carefully integrated in compliance with the curriculum objectives. Another potential of archaeology in schools is that it can serve to connect teachers and students internationally when they exchange knowledge and resources from local heritage sites in their country. An important condition for the inclusion of prehistory and archaeology-inspired cross-curricular programmes at school level is that such programmes need to be drafted by a team consisting of teachers, heritage organisations, educational experts and archaeologists in order to capitalize on the strengths of each perspective (Jameson, 2000). As Jeppson and Bauer (2007, 236) argue, referring to the US archaeology implementation in education:

[6] http://www.keystagehistory.co.uk/KS2/teaching-stone-age-to-iron-age.html

> ...(c)ollaboration between educators and archaeologists is needed to stem a growing tide of materials that are less useful for implementation in schools due to excessive jargon or to content that is only marginally suited to curricular needs.

Therefore, archaeology for teaching across subjects needs to meet the needs of the curriculum across subjects in order to be successfully implemented in teaching and learning (Jeppson and Bauer, 2007).

Accordingly, the research question underpinning his paper concerns how found artefacts and the exploratory technology tools of archaeological inquiry can function as a stimulus for productive cross-curricular educational practice. In the next section, we review the nature of such practice.

Cross-curricular teaching and learning

The idea of cross-curricular teaching and learning is hardly new, although it has gained both supporters and opponents. Commonly, opponents fear the erosion of singular disciplines and question the educational effectiveness of cross-curricular thinking. For example (adapted from Kelly, 2012), common strands of criticism have been:

- Lack of rigour, weakening the development of essential subject specific skills (Muijs and Reynolds, 2011)
- Subject identity loss (Parkinson, 2010; Barnes, 2011)
- Learning is superficial and fragmentary (Alexander, Rose and Woodhead, 1992)
- Tenuous links are made between subjects (Laurie, 2011).

Problems seem to arise from not developing a clearly-defined educational purpose for the implementation of cross-curricular teaching and learning (Kelly, 2012). As this author states, there is no clear message as to how to achieve success. There might not be enough support and encouragement for teachers to develop such approaches from the outset. What might contribute to a weakening in the appeal of cross-curricular teaching is programmes that are not planned well enough with clear educational goals: there can be a lack of coherent and sustainable strategies which clearly relate to the curriculum (Alexander et al., 1992). Cross-curriculum teaching can easily fall prey to "the lack of rigour, superficiality and tenuous subject links" criticism if not executed with care, support and planning. However it is possible and it can be successful and inspiring, supporting pupils to develop essential skills for the 21st century (e.g. creativity and innovation as argued by Dede, 2010). Unfortunately, a division between "fun and enjoyable (=creative) learning" and "serious (=developing subject knowledge) learning" still prevails.

The benefits and potential of cross-curricular practice are noted by many. Its point is to promote the view that all knowledge is related (Carr, 2007) and that phenomena do not occur within disciplinary boundaries but invite interdisciplinarity, as first argued vigorousy by Dewey (Dewey, 1997). This approach is certainly not to overthrow disciplines, but to point to

where they may overlap and inform each other. Otherwise, students might have partial knowledge without gaining the ability to connect subjects - although such connection arguably exists outside of classroom distinctions (Kerry, 2011). The UK inspection agency Ofsted (2002) recognised that thematic and cross-curricular teaching was a feature of successful schools. Thus the ideal strategy is likely to be a balanced approach, wherein teaching and learning of subjects is integrated with cross-curricular exploration (Rose, 2009).

Corbishley, Forham, Walsley and Ward (2008) give examples of a programme which encourages cross-curricular teaching related to heritage and archaeology, but on a field site, not on school premises. In the example of our own case study, we explored the possibilities of teaching various subjects arising from a heritage site located in another country – specifically, teaching in the UK about a site in Italy – something which excludes on-site teaching but provides opportunities for linking distant heritage with local heritage and teaching across subjects mediated by technology. We describe this case study more fully next.

The case study for cross-curricular heritage education: Valcamonica's "Pitoti"

Situated among the peaks of the central Alps in the Italian region of Lombardy lies Valcamonica (or Camonica Valley), a UNESCO world heritage site, with the greatest collection of rock art in Europe. It features approximately 300,000 petroglyphs which have been named locally as "Pitoti", dated from epipaleolithic to the middle ages. Petroglyphs can be found around the world: they are a common human heritage. They manifest the unique human ability and motivation for representational expression, hence documenting such expression at particular points of historical time.

The Valcamonica site is indeed listed under UNESCO's 'world heritage sites', hence it explicitly belongs to all world citizens. Yet it is questionable how many world citizens have heard of and visited the site or how many European schools have heard of it outside Italy. The same applies to many heritage sites elsewhere - they often remain known and mentioned only within the national borders.

3D artefacts and immersive environments for teaching and learning

As argued so far, national heritage and archaeological sites need to 'step out' into the world. A way to celebrate and share them with wider populations may be to consider technology as a mediator. New technology has been developed in the project reported here, primarily for archaeology and museum end users. Yet these same technologies offer educational promise. This possibility along with the potential of the artefacts themselves will be explored in the research reported below. A particular technology – generating 3D immersive environments - will be illustrated in this section.

A 3D immersive technology is any technology that offers 3D object and environment visualisation and engagement. Virtual immersive environments are those offering an

experience of 'being' in a virtually created space, similar to the recreational spaces of computer worlds such as "Second Life". When more advanced, users can have special sensory tools to experience the environment, such as gloves and goggles. Some researchers have reflected on the potential of 3D technology in education (Savin-Baden et al., 2010; Elliot, Adams and Bruckman, 2002; Mintz et al., 2001), but the field is still poorly developed.

Our project teams are developing advanced technology for rock scanning and visualisation. This paper considers one major technology developed at the Bauhaus-Universität Weimar: a 3D immersive virtual environment representing the valley and "Pitoti". A user can explore the 3D environment by putting on specialised goggles. The technology is unique in the possibility of allowing five users to be in an environment while seeing it from their own angle (Figure 1 below). Previously, individuals in an exploring group could only see one person's perspective. However, this new development allows each person to explore the environment and objects in it from their own (correct) perspective (see pictures bellow illustrating the mentioned technology).

Insert Figure 1-4

Some of the innovative properties of the system environment include: petroglyphs that are marked by flags (Figure 3) andusers can "teleport" themselves to a particular point (Figure 2); they can use digital torches to cast light on petroglyphs and users can extract and lift a part of the environment in a 3D cube for closer scrutiny (Figure 4).

The above figures and other resources that explain the developed technology (a video of 3D panorama[7]), as well as educational resources developed at the site (petropglyph and prehistoric community pictures and maps), were all shown to teachers in order to evaluate their educational potential and, in particular, to identify possible features of 3D technology that might enhance an educational impact.

Methodology

Data collection

We asked a selection of primary school teachers for their perspective on the educational potential of rock art 2D and 3D artefacts for cross-curricular school-based teaching and learning (2D= rock art pictures, prehistoric community drawings and valley maps; 3D= 3D virtual environment – examples shown in Figures 1-4). The lead author contacted 35 UK teachers based locally in the area of Nottinghamshire. The sources of contacts were e-mail lists that identified teachers who had participated in University programmes along with personal contacts from the research community. Gaining access to teachers to obtain an hour

[7] http://www.airpano.com/

of their time has always been challenging for researchers. However, we obtained a positive reply from 10 teachers (the names provided in the table below are fictional to preserve confidentiality).

Insert Table 2

Table 2. Participants' details

The interviews took place at each teacher's school premises and lasted between 45 minutes to one hour. They had two objectives: 1) to understand the potential of rock art visualisations in general for cross-curricular teaching and learning in order to meet curriculum needs, and 2) to understand the potential of 3D resources (notably the 3D immersive environment) for cross-curricular teaching and learning to meet teacher's needs (interview schedules and timetables are provided in the Appendix). The teachers were first asked to suggest how the shown visual resources could be related to teaching and learning and, then, to position themselves in the role of technology development advisors so as to suggest those technology features they perceived as helpful in realising educational goals. The teachers were shown pictures (such as the ones shown earlier in this paper) and a video which illustrated an immersive 3D environment (3D panorama[8]) in order to understand better the technology in question. They were also shown educational picture cards and maps provided by the Archeocamuni organisation which operates on the site in Italy[9]. We obtained clearance from a University Ethical Committee to conduct this study. Interviews lasted between 45 minutes and 1 hour depending on the teacher's availability.

Data analysis

The interviews were transcribed *verbatim* and a thematic analysis was applied (Braun and Clarke, 2006), defining themes in accordance with the objectives of the study and the interview schedule. The interviews were analysed in relation to the two topics that framed the discussion: (1) Cross-curricular potential of rock art heritage for teaching and learning, and (2) The educational potential of 3D immersive technology. The first topic was then divided into subject-relevant examples (e.g., related to maths, history etc.) and the second topic into two sets of themes: 1) Technology design and 2) Technology benefits, each consisting of 4 sub-themes in accordance with most frequently occurring design suggestions and benefit identifications.

[8]http://www.airpano.com/
[9] http://www.archeocamuni.it/about.html

Findings and discussion

Cross-curricular potential of rock art heritage for teaching and learning

All teachers were uniformly enthusiastic about the possibility of using 2D and 3D rock art visualisations relating to these artefacts originating outside the UK. They all welcomed resources for teaching and learning which could provide new challenges, experiences and insights for their students. Each teacher was able to imagine a range of examples of how to connect the prehistoric rock art theme to the needs of the curriculum.

With respect to a possible 'big theme' that might be an umbrella for teaching and learning across subjects, some suggestions were: "the human tree", "communication through art", and "human life now and then". Within those big themes and related to the rock art in general, various subject concepts and activities were identified, as summarised and represented in Table 2.

Insert Table 3

Table 3. List of nine subjects and relevant possibilities for teaching and learning concepts and objectives for each subject

In particular, doing "comparisons" and "creative writing" were frequently referred to as a potential of the rock art theme and technology by all teachers, the latter being most frequently mentioned (by 9 teachers).

Curricular practices with heritage artefacts: from assimilation to accommodation

Although Table 2 systematises the conversation in terms of subjects or disciplines (Art, Maths, etc.), the rock-art theme was more generally linked with what might be termed "curricular practices" rather than disciplinary knowledge. These were indeed sometimes discipline-specific practices (e.g., "measurement of angles and shape") but they could also be generic. The latter might be instrumental (e.g., "report writing" – relevant to various disciplines) or they might be more cognitive (e.g., "exercising the imagination"). Moreover, a further variety of curricular practice was invoked that related more to mode of learning engagement. The three forms of engagement that came up in those conversations were: learning outdoors, learning from visiting experts, and learning from collaborative projects with other schools or classrooms. In sum, the particulars of the rock-art project were readily

related to a wide range of curricular practices. However, the manner in which this relationship was formed in conversation does deserve closer consideration.

The artefact/curriculum relationship seemed to be expressed in two ways: assimilative and accommodative. To explain this distinction, the terminology of assimilation/accommodation (as used by Piaget) is borrowed here. So, analyses of the interview conversations suggested the following pattern. First, the artefact (some aspect(s) of the rock art archaeology) was discussed as potentially being *assimilated* by some curricular practice. Or, second, some curricular practice was discussed as potentially undergoing an *accommodation* to the artefact. What are the educational consequences of these two relationships? In the first case, assimilation of an artefact serves to exercise or rehearse a curricular practice. The artefact functions as an example for (or an input to) the practice - such that the practice enjoys further consolidation or development. In the second case, accommodation of the artefact to some curricular practice serves to generate new understandings. We can summarise this distinction by saying that 'artefact assimilation' is in the interests of exercising or developing acts of "*knowing*" and "skills" while 'accommodation to the artefact' is in the interests of generating or extending "*knowledge*".

Concrete examples may help further clarify this distinction. However consideration of examples tends to encourage this 'distinction' as more of a continuum. Often teachers would frame an illustration in terms of one side of this distinction and then develop it towards the other. Thus, it may be helpful to say that examples the teachers provided differed according to the extent to which they emphasised one side or the other of this assimilation/accommodation distinction. First here are some examples that are more assimilative in character (As):

> As1: Literacy particularly…that would be good for the formative assessment because they have to do things like information leaflets and so on. And so we could use that as our writing assessment at the end of term (Linda)
>
> As2: And then in Maths, there's loads. The first thing I thought about was lines, like perpendicular lines, diagonal lines, horizontal, vertical, cos that's all in the curriculum. They need to know that horizontal is there, perpendicular, they need to know those technical names of the lines (John)
>
> As3: We're quite keen on outdoor learning so at the moment there are all things drawn on the playground so I would.. have drawing some of them out on the playground and then them actually measuring them or, you know for the younger ones, physically measuring with rulers or metre sticks, so that they are actually doing it and, if you can, you know if the sizes are there and to do them to scale as well…that links to coordinates as well (Roger)

In As1, "Pitoti" artefacts are assimilated to the curricular practice of a particular literacy genre – in this case the production of information leaflets. In As2, "Pitoti" is seen as an opportunity to rehearse the basic practices of measurement and terminology in mathematics. In As3, "Pitoti" is assimilated first to a practice of "outdoor drawing" and then to the

measurement practices of Maths. There are also examples of "Pitoti" as a resource for stimulating the more abstract curricular practice of imaginative thinking or problem solving and effective communication through visual representations.

On the other hand, in the following examples there is a greater sense of some curricular practice accommodating (Ac) the "Pitoti" by stimulating new understandings:

> Ac1: You can do comparison with other engravings around the world, and then go on to the different cultures so find out you know all the background of Italy (Linda)
>
> Ac2: You could have a look at the pictures and see if they thought there was anything that represented anything, them doing any form of exercise, or whether that was just part of their life (John)
>
> Ac3: And there are lots of pictures of the drawings for the children to create their own narratives and that goes onto drama as well: cos they can act them out and then look at empathy with the characters. (Mary)

In Ac1, a practice of 'comparative archaeology' is applied to "Pitoti" in order to reveal more of Italian history (and/or geography and so on). In Ac2, the curriculum area of 'physical exercise' accommodates "Pitoti" in order to understand the likely meaning of the representations and relevance to everyday life. In Ac3, the curricular practice of 'drama' accommodates the "Pitoti" in a way that helps build historical understanding through acts of empathy. The line between practice assimilation and interdisciplinary accommodation can be often blurred: the assimilative maths' measurements can be accommodated into understanding mathematical principles and their occurrence in real life. Teachers can provide many examples of how rock art theme can be related to subjects, but it is challenging to go beyond, into interdisciplinary knowledge creation. That is where they would need support.

Technology design: Teachers as advisors on 3D educational technology

Participants discussed the potential of the 3D Valcamonica immersive environment in relation to the kind of features that might satisfy their teaching needs. The features identified to support and enhance an educational experience were coded into four sub-themes:

1. Possibility to be guided (e.g. virtual guides and prompt questions)
2. Possibilities for active exploration, trail and record leaving (e.g. note pads, brushes)
3. Possibilities to increase sensory experience (add sound (e.g. birds, fire), animation (e.g. day/night contrast, rain), include "time-line" starting from dinosaurs to modern times scenes and events within the same environment)

Possibility to be guided – virtual guides and prompt questions

Interaction with virtual guides who would provide information or ask questions was seen as particularly useful, especially if those guides could set tasks for children while leading them

through the petroglyph valley. This would help in creating an educational game experience with an "archaeologist" role play.

> Hanna: I would add the virtual people speaking…
>
> Kathy: Someone explaining to the students about different things that they do.
>
> Roger: They could be led through that world by a local of the time who would give you instructions or facts.
>
> Natalie: I would perhaps add prompt questions about what they can see and what does it tell them... And also somebody to answer their questions. So you're being an archaeologist discovering the site for the first time.

Possibilities for active exploration: trail and record leaving

It was stressed by six teachers that in order to create an educational experience, the children needed to create an artefact or leave a record of what they were doing with a particular educational goal, so that they can reflect on the activity. The following extracts show teacher imagination through their suggestions for "trail and record leaving" activities that could be done in the immersive environments: such as treasure hunt, search games etc. This idea supports the need to interact actively with the environment by changing it temporarily and having a record of such changes (picking things, leaving carved imprint, discovering petroglyphs, writing notes).

> Jonathan: If the person with the goggles on could actually pick something and leave some sort of imprint on the virtual world which could be saved and looked at again...
>
> Mary: You have the flags, they could set a flag that perhaps had their names on it and then another group that came and put the goggles on they could do their own …and then they could discuss …
>
> Roger: You could have a list of icons of a typical archaeologist's kit to use; so you might have a torch, a magnifying glass, a brush...

In particular, as illustrated by the excerpts above, teachers emphasised the usefulness of tools of interaction, hence the need for providing children with exploration tools (brush, archaeologist tool kit, flags) once they are in the environment and subsequently share (report on) their experience.

Possibilities to increase sensory experience (adding sound, animation, time line)

Many teachers thought that providing more realistic and vivid sensory experiences within the environment would enhance children's experience. We selected three excerpts as an illustration:

> Roger:..a screen shot which, if you click on it, loads it up on the screen and it might straightway go to the viewpoint of somebody who is sat around with the people playing music.
>
> Natalie: At the side you could have something to move them around like a teleport site. Wouldn't it be good for chronology and you are going back in time?
>
> Clare: I'd like them to be able to touch something; I'd like to have something that would be big and would have lots of questions and then they can just touch wherever they want for the answer and it would be there. Or they could have things that they could just move around with their finger.

Importantly, the teachers noted that technology and heritage-site-informed themes need to be embedded into a pedagogical cycle of preparation and post-tasking or homework. This view reflects one of the reasons why educational technology can fail in the classroom: it is not implemented in a pedagogically sound and sustainable manner: Savin-Bade et al. (2010) note that "the literature on immersive virtual worlds and e-learning to date largely indicates that technology has led the pedagogy" (Savin-Baden et al., 2010). Our teachers' views resonate with the argument that embedding digital literacies and multiliteracies in the curriculum for teaching and learning enhances the learning potential of immersive "virtual worlds" (ibid).

Technology benefits: Perceived educational advantage of the 3D immersive environment

Eventually, the teachers reflected on what this kind of technology brings, in comparison to current teaching with more familliar technology (e.g., whiteboards). All teachers agreed that the success of technology depends first and foremost on teaching practices rather than technology *per se*. Hence communication and children's goal-based interaction with the environment was seen as crucial. This is in line with existing criticism of technology implementation in the classroom, where technology is often judged to fall short of its potential in actual practice (Livingston, 2009).

Four particular benefits of the 3 D immersive environment were most frequently referred to in all interviews, in comparison to teaching without such technology:

1. Relevance (fits with children's everyday use of technology)
2. Scaffolded immersiveness
3. Teaching paradigm benefit (more constructive learning experience, guide-on-the-side)

Relevance (fits with children's everyday use of technology)

Teachers recognised the relevance of the technology to students' informal life and interests.

> Jonathan: I think it definitely adds to it (children's learning) because the children are really good with technology and they are inquisitive.

The 3D technology discussed here could provide a tool for more engaging history and cross-curricular teaching. In relation to this engagement, one of the main challenges for teaching history and archaeology is to make it 'relevant' to students: as Haydn (2005) reports, almost half of pupils aged 11-14 enter secondary school with negative perceptions of history. Their report also showed that 2/3 of pupils would drop history at the age of 14, characterising it as 'hard' due to an excess of memorising and essay writing, boring with little or no relevance, and therefore seeing little point in studying it. Pupils are reported to have difficulties in defining why learning history was useful (Haydn, 2005; Haydn and Harris, 2010). The same attitude could possibly be expected for prehistory. Therefore, a well-planned introduction of technology that recruited history and archaeology data, if supported by explanations and experiential demonstration of subject's purpose could enhance students' motivation and enthusiasm (Haydn and Harris, 2010). It could also support students' understanding across subjects and topics, seeing their inter-connectedness. Importantly, cutting edge technology can make student experience more relevant to their everyday life – 3D immersive environments relate to their use of technology, especially in relation to video games and the growing popularity of 3D films.

Scaffolded immersiveness

The 3D environment was characterised as providing a more life-like experience, hence being more immersive. However, immersion could possibly be elusive since children, and perhaps teachers, might expect too great a hyper-realism and if that fails - it might lead to early disappointment (Elliott et al., 2002).

Interactivity and collaboration within the environment were seen as important factors for the "meaningful and educational" immersiveness. These were expressed mainly through teachers' creative tasking and managing of group work and their recognition of the potential of 3D environment and object manipulation (illustrative excerpt bellow):

> Jonathan: It might be quite good because you could put them into groups and you could link it with drama and they could lay down and wake up in this valley and then look for these artefacts, sort of treasure hunt, and you could give them a diary entry to write at the end of the day about what they found and where they found it.

The idea that interactivity and collaboration are important factors for the success of immersive environments is supported by the findings of a study by Tost and Economou (2009) that compared learning benefits of three different media for learning about heritage within a museum context: two virtual environment settings and a traditional exhibition, as evaluated by visitors. On the whole, virtual environment settings were not evaluated as being better for learning (by comparison with traditional texts) and the authors argue that one of the major factors behind such outcomes is the lack of interaction and collaborative exploration

(Tost and Economou, 2009) within those environments. Furthermore, in support of scaffolded immersiveness, Salmon et al. (2010) suggest that an educational activity within a virtual world requires a structured model of student scaffolding in a virtual environment (Second Life in their case).

Teaching: more constructive learning experience, guide on the side

When asked what such technology brings to them as teachers, there was an understanding of how technology helped in the paradigm change from transmission to guidance.

> Emily: I think it can make me more of a guide. I don't want to say facilitator because that is an antiquated word now but more of a guide to say 'look at this and look at that' and allow the experience to teach them; it allows those activities to teach the children and to help them to know what to do and where to go.

In short, the teachers identified possibilities for cross-curricular teaching and learning, a useful and informative set of suggestions for educational re-design of the 3D immersive environment and benefits that such an environment brings.

Conclusions

We have explored the possibilities of 2D and 3D immersive visualisations for teaching and learning with a selection of UK teachers. In relation to integrating the artefacts themselves, we find that such material can take part in both assimilative and accommodative relationships with curricular practices. Discussions tended to be dominated by more assimilative relationships. This is perhaps not surprising given that accommodating curricular practices to these artefacts (and thereby stimulating new knowledge) depends on more teacher confidence with subject-specific themes and familiarity with rock art resources. This implies that what researchers should pass over to educational practitioners is not just a rich illustration of heritage artefacts, but also guidance and support on how to position these artefacts in an enterprise of wider disciplinary inquiry and exploration.

In relation to integrating the 3D technologies, we were conscious that this was a speculative conversation, because direct experience with such technologies was not yet in place. We positioned teachers in the role of advisors on 3D educational technology. These teachers identified a number of preferred design features for simulations of this kind – if they were to be imported into some future classrooms. They stressed the need for carefully embedding such experiences in a pedagogic cycle, for providing scaffolding and metacognitive prompting, and for creating rich resources for reflection and record-keeping.

The immersive 3D technology potential explored here has great promise but is no panacea for teaching and classroom related problems and challenges. It is important to acknowledge teachers' needs when designing educational technology. The findings also encourage us to welcome new literacy paradigms and to support teachers' professional development.

Opportunities and possibilities for all stakeholders in this case (teachers, students, technology developers, archaeologists, museums, and heritage sites) are many. However, if the aim is to meet teachers' needs, then their voice will be important in planning, designing and evaluating technology.

Teachers have not been encouraged to be curriculum developers (Thomas, 2012) and there seems to be a reluctance to seek teachers' opinions or evaluations while designing educational technology. Our interviews provided examples of how teachers can enhance technology design to suit their educational needs better, so that all stakeholders reap greater benefits. However, students also need to have their say, together with teachers, in order to construct a better-rounded picture. 3D immersive environments could play a role in quality learning, providing there is enough planning across subjects. Importantly, they can help in bringing heritage sites to wider, international public and educational settings.

References

Alexander, Robin, Jim Rose and Chris Woodhead. 1992. *Curriculum Organisation and Classroom Practice in Primary Schools: A Discussion Paper*. London: Department of Education and Science (DES).

Baram, Uzi, and Yorke Rowan. 2004. "Archaeology after Nationalism: Globalization and the Consumption of the Past." In *Marketing heritage: Archaeology and the consumption of the past,* edited by Uzi Baram and Yorke Rowan, 3-23. Walnut Creek, California: Altamira Press.

Barnes, Jonathan. 2011. *Cross-Curricular Learning 3–14*. Second edition. London:Sage.

Braun, Virginia, and Victoria, Clarke. 2006. "Using Thematic Analysis in Psychology". *Qualitative Research in Psychology* 3(2): 77-101. doi:10.1191/1478088706qp063oa

Carman, John. 2003. *Archaeology and Heritage: An Introduction*. London: Continuum International Publishing Group.

Carr, David. 2007. "Towards an educationally meaningful curriculum: epistemic holism and knowledge integration revisited." *British Journal of Educational Studies* 55(1): 3–20.

Corbishley, Mike, Jennie Fordham, David Walmsley, and Julie Ward. 2008. "Learning Beyond the Classroom: Archaeological Sites and Schools." *Conservation and Management of Archaeological Sites* 10 (1): 78–92.

Dede, Chris. 2010. "21st Century Skills: Rethinking How Students Learn." In *Comparing Frameworks for 21st Century Skills*, edited by James Bellanca and Ron Brandt. 51-76. Bloomington, IN: Solution Tree Press.

Dewey, John. 1997. *How We Think*. New York: Courier Dover Publications.

Dietler, Michael. 1994. “”Our Ancestors the Gauls”: Archaeology, Ethnic Nationalism, and the Manipulation of Celtic Identity in Modern Europe”. *American Anthropologist* 96 (3): 584–605.

Elliott, Jason, Lori Adams, and Amy Bruckman. 2002. “No Magic Bullet: 3D Video Games in Education.” In *Proceedings of ICLS*, 23–26.

Glover Frykman, Sue. 2009. ‘Stories to Tell? Narrative Tools in Museum Education Texts’. *Educational Research* 51 (3): 299–319. doi:10.1080/00131880903156898.

Haydn, Terry. 2005. *Pupils’ perception of history at Key Stage 3: Final report 2005*. QCA.

Haydn, Terry and Richard Harris. 2010. “Pupil Perspectives on the Purposes and Benefits of Studying History in High School: a View from the UK. *Journal of Curriculum Studies* 42(2): 241–261.

Henson, Don. 2008. “History and Archaeology at 14-18.” *Research in Archaeology Education* 1: 60-65.

Jameson, John, 2000, “Abstract: Giving the Public It’s Due: New Horizons in the Public Interpretation of Archaeology”. In *Program: 33rd Conference on Historical and Underwater Archaeology*, edited by Reginald Auger and William Mos. Quebec City : Society for Historical Archaeology.

Jeppson, Patrice, and George Brauer. 2007. ‘Archaeology for Education Needs: An Archaeologist and an Educator Discuss Archaeology in the Baltimore Country Public Schools’. In *Past Meets Present: Archaeologists Partnering with Museum Curators, Teachers and Community Groups*, edited by John H. Jameson and Sherene Baugher . 231–248. New York: Springer. Accessed 10 January 2014. http://link.springer.com/content/pdf/10.1007/978-0-387-48216-3_15.pdf.

Ketelhut, Diane Jass, and Brian Nelson. 2010. ‘Designing for Real-world Scientific Inquiry in Virtual Environments’. *Educational Research* 52 (2): 151–167. doi:10.1080/00131881.2010.482741.

Kelly, Lois. 2012. “1 Why Use a Cross-curricular Approach to Teaching and Learning?” In *Enhancing Primary Science: Developing Effective Cross-curricular*, edited by Lois Kelly and Di Stead, 1-13. Maidenhead: Open University Press.

Kerry, Trevor, ed. .2011. *Cross-Curricular Teaching in the Primary School: Planning and Facilitating Imaginative Lessons*. London: Routledge.

Laurie, Judith. 2011. “Curriculum Planning and Preparation for Cross-Curricular Teaching.” In *Cross-curricular Teaching in the Primary School*, edited by Trevor Kerry, 125-141. London: Routledge.

Messenger, Phyllis, and Walter Enloe. 1991. "The Archaeologist as Global Educator." In *Teaching Archaeology in the Twenty-first Century*, edited by, Susan J. Bender & George S. Smith, 157-166. Washington D.C.: Society for American Archaeology.

Merchant, Guy. 2010. '3D Virtual Worlds as Environments for Literacy Learning'. *Educational Research* 52 (2): 135–150.

Mintz, Rachel, Shai Litvak, and Yoav Yair. 2001. '3D-virtual Reality in Science Education: An Implication for Astronomy Teaching'. *Journal of Computers in Mathematics and Science Teaching* 20 (3): 293–305.

Muijs, Daniel, and David Reynolds. 2011. *Effective Teaching: Evidence and Practice*. London: Sage.

Parkinson, Eric. 2010. "Where Next in a World of Cross-Curricular Primary Education?" *Design and Technology Education: An International Journal* 15(1): 14–23.

Ofsted. 2002. *The Curriculum in Successful Primary Schools*. London: Ofsted.

Ramos, Maria, and David Duganne. 2000. *Exploring Public Perceptions and Attitudes about Archaeology.* , Washington, D. C.: Prepared by Harris Interactive for the Society for American Archaeology.

Rose, Jim. 2009. *Independent Review of the Primary Curriculum: Final Report. London: DCSF*. Accessed 14 January 2014. https://www.education.gov.uk/

Salmon, Gilly, Ming Nie, and Palitha Edirisingha. 2010. "Developing a Five-stage Model of Learning in Second Life." *Educational Research* 52 (2): 169–182. doi:10.1080/00131881.2010.482744.

Savin-Baden, Maggi, Lesley Gourlay, Cathy Tombs, Nicole Steils, Gemma Tombs, and Matt Mawer. 2010. "Situating Pedagogies, Positions and Practices in Immersive Virtual Worlds." *Educational Research* 52 (2): 123–133. doi:10.1080/00131881.2010.482732.

Shields, Rob. 1991. *Places on the Margin: Alternative Geographies of Modernity*. London: Routledge.

Smith, George. 2009. "Teaching and Learning Archaeology: Skills, Knowledge and Abilities for the Twenty-first Century." *Research in Archaeological Education Journal* 1(1):6-14.

Stone, Peter. 1997. "Presenting the Past: a Framework for Discussion." In *Presenting Archaeology to the Public: Digging for Truths*, edited by John Jameson Jr., 23–34. Walnut Creek, California: Altamira Press.

Thomas, Louise. 2012. *Re-thinking the Importance of Teaching: Curriculum and Collaboration in an Era of Localism*. London: RSA. Accessed February 2 2014.

http://www.thersa.org/__data/assets/pdf_file/0008/570716/RSA-Rethinking-the-importance-of-teaching.pdf

Tost, Laia, and Maria Economou, 2009. "Worth a Thousand Words? The Usefulness of Immersive Virtual Reality for Learning in Cultural Heritage Settings." *International Journal of Architectural Computing* 7(1): 157–176.