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Enhancing Art Gallery Visitors' Learning Experience using Wearable Augmented Reality: Generic Learning Outcomes Perspective

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Abstract
The potential of ICT-enhanced visitor learning experience is increasing with the advancement of new and emerging technologies in art gallery settings. However, studies on the visitor learning experience using wearable devices, and in particular those investigating the effects of wearable augmented reality on the learning experience within cultural heritage tourism attractions are limited. Using the Generic Learning Outcomes framework, this study aims to assess how the wearable augmented reality application enhances visitor's learning experiences. Forty-four volunteers who were visiting an art gallery were divided into two groups, an experimental group and a control group. Following their visit to the gallery, the volunteers, who had and had not used wearable computing equipment, were interviewed, and the data were analysed using thematic analysis. Findings revealed that the wearable augmented reality application helps visitors to see connections between paintings and personalise their learning experience. However, there are some drawbacks such as lack of visitor-visitor engagement and the social acceptability.

Keywords: wearable augmented reality, tourism learning, learning experience, generic learning outcomes, cultural heritage tourism

Introduction

Cultural heritage tourism attractions including museums and art galleries are increasingly looking for ways to enhance their visitors' learning experience (Hooper-Greenhill et al., 2003). More recently, research demonstrated that social and mobile technologies (Charitonos et al., 2012), virtual reality (Fowler, 2014) or augmented reality (Chang et al., 2014; Yoon et al., 2012) can be used to enhance the learning experience. However, tourism research has been slow to investigate the phenomenon of lifelong learning in the tourism context (Falk et al., 2012). According to Cucchiara and Del Bimbo (2014, p. 76), using mobile augmented reality applications within art galleries has a number of benefits including the potential of 'seeing what your eyes cannot reach…, seeing what your eyes cannot see…, telling you what you are seeing,… [and] seeing with more eyes'. In particular, augmented reality applications can provide additional information which cannot be displayed and hence is normally hidden from the visitor. For example the history behind the painting, photographs of the locations where the painting where painted (landscapes) or details of the sitter and their relatives not obvious from the portrait (Cucchiara & Del Bimbo, 2014).

Tourism research has identified the potential of augmented reality to enhance the tourism experience (Chung et al., 2015; Jung et al., 2015). Taking augmented reality into the art gallery context has the potential to add value to both, tourists' and residents' learning experience. The rapid advancement of mobile and wearable computing adds another dimension to the potential to enhance the visitor learning experience within museums and art galleries.

Wearable computing is generally defined as any technological equipment that performs some degree of on-device computation or data collection that can be worn on the body in a manner that is not overly obstructive and sometimes embedded in clothing (Jhajharia et al., 2014). One of the first wearable devices to facilitate augmented reality was Google Glass, which combines on-device computing in a head mounted display (Rhodes & Allen, 2014). Recently, academia and industry identified the potential of using Google Glass in art gallery settings to enhance the user experience (Ballard, 2014; Fiolet, 2014; Leue et al., 2014). However, in the context of cultural heritage tourism attractions, research studies on the visitors using wearable devices is scarce. In addition, there has only been limited research investigating the effects of wearable augmented reality on the learning experience within cultural heritage tourism attractions (Leue et al., 2015). Therefore, the aim of this study is to assess whether a wearable augmented reality application can enhance the visitor's learning experience; with particular focus on knowledge and understanding, skills, attitudes and values, enjoyment, inspiration and creativity as well as activity, behaviour and progression. In addition, the learning experience of wearable AR users is compared to those visitors who experience the same gallery without the technology.

To achieve this aim, the current study presents a review of literature on information communication technologies and augmented reality-enhanced learning experience in the tourism and museum context and the generic learning outcomes framework. Moreover, forty-four interviews are analysed with tourists trying the wearable augmented reality

application and tourists visiting without an application, to identify their learning experience using thematic analysis. This study will contribute to the current state of research by qualitatively examining the generic learning outcomes framework in the tourism context. Findings are then, discussed, and theoretical as well as practical implications provided. Finally, the model development will serve as a future reference point for industry practitioners and academia who are aiming to implement wearable augmented reality into the tourism experience.

Literature Review

ICT-enhanced Learning Experience in Tourism

Information and Communication Technologies (ICTs) are increasingly used to enhance the tourism experience within destinations and tourism attractions. According to Neuhofer et al. (2014, p. 344), these tourism enriching technologies 'range from interactive websites, interactive ordering systems (eTable technology) to interactive mobile platforms (iPads), diverse social media channels (Facebook and Twitter) and mobile applications'. More recently, augmented reality was found to enhance the overall tourism experience (Jung et al*.,* 2015). Learning is mostly associated with primary or secondary education however, tourism provides one of the most distinct contexts for lifelong learning, offering tourists opportunities to enhance and develop skills through experiencing different cultures, situations, places and people (Falk et al*.,* 2012). Although tourism was identified as a prominent enabler of life-long learning, the investigation of this phenomenon has long been 'neglected' by tourism scholars (Falk et al*.,* 2012, p. 908). Ritchie (2003) agreed that little research had focused on tourism and education and thus, the true potential of this area was still unexplored.

Recent research has started to explore life-long learning, there are still many areas to be examined in order to understand its full potential (Falk et al*.,* 2012). Nevertheless, learning can be both a motivation and a requirement for tourists to visit destinations showing the importance of this area for tourism research and industry practitioners (Prentice et al*.,* 1998). Ritchie (2003, p. 13) conceptualised where Tourism and Education merge and found four areas of educational tourism including 'schools tourism, university and college student tourism, adult study tours and senior tourism, as well as edu-tourism (ecotourism and cultural tourism)'. Ritchie (2003) suggested that tourists desire rewarding, enriching, adventurous and educational experiences while travelling and that there will be an increasing demand for edu-tourism in the future. This was confirmed by Falk et al. (2012) who showed how travelling and visiting new destinations and attractions can add to learning and found that visitors receive practical skills, knowledge and practical wisdom. Mortara et al. (2014) focused on the cultural heritage context and identified three key areas as part of the tourism industry that it is important to maintain and that people should be educated in: cultural awareness; historical reconstruction; heritage awareness. When visiting destinations, technology can help to educate tourists about the environment, culture, religion, traditions or historical events. Various forms of ICT can be used to

enhance the learning experience on these key areas in cultural heritage tourism. The next section will focus on the specific museum and art gallery context of this study.

ICT-enhanced Learning Experience in Museums and Art Galleries

Museums and art galleries are popular tourist attractions and cultural heritage tourism has increased in importance over the last decade (Abuamoud et al., 2014). In addition, there is an increased awareness of museums and art galleries as facilitators of lifelong learning (Packer & Ballantyne, 2002). According to Sheng and Chen (2012), a focus on visitor engagement can enhance the learning experience in museums and art galleries. The use of technology can enhance this learning process for cultural tourists using existing technologies, such as audio guides and mobile applications or recent augmented reality applications combined with wearable technologies (Leue et al., 2015; Linzer 2013). Since their introduction in the 1950s, audio guides have become widely used by many tourists around the globe (Linzer, 2013). Interactive displays are another form of technology used by museums in order to enhance visitors' experience. Interactive displays (e.g. simulation and models, micro worlds and games, multi-media) can facilitate collaboration between visitors and museums (Hawkey, 2004).

More recently, the increased ownership of smartphones has enhanced the availability of museum or art gallery mobile applications which adds other dimensions such as customisation and interactivity to the visitor experience (Chang et al., 2015). Mikalef et al. (2012, p. 559) tested a mobile application on students within a museum context and found that a 'mobile device in a learning game context benefits students' performance in a highly significant way'. Students who used mobile applications within the museum received higher test scores than students who were only equipped with paper information (Mikalef et al., 2012). Sung et al., (2008) and Chang et al., (2014) focused on lifelong learning within the museum context and found that there are differences in the learning experience between visitors who use mobile devices to explore artefacts and those visitors who visit the museum without technology. According to Sung et al. (2008, p. 67), 'students with the electronic guidebook had a longer holding time with exhibits than the students without supplementary materials … students with the electronic guidebook displayed more inquisitive and structural behaviors when interacting with the exhibits'. One of the ICTs that recently appeared on the research landscape as an enhancer of the learning experience is augmented reality.

Augmented Reality Learning Experience

Santos et al. (2014) examined the effect of augmented reality on students' performance and found that augmented reality has many uses in education and currently moderately affects students' performance in the classroom setting. Nowadays, technology can enhance knowledge and skills within the tourism industry. Mobile travel guides and augmented reality applications provide an opportunity for tourists to gather information instantly while travelling (Jung et al., 2015; tom Dieck & Jung, 2015). In particular, augmented reality, which overlays digital content onto real objects, will change the way tourists view historical buildings and sites (Yuen et al., 2011). These new technologies spark imagination and create an enjoyable and realistic learning environment directly at the tourism attractions

within destinations. The latest ICT developments bring further opportunities to the learning environment of museums and art galleries. For example, wearable devices that facilitate augmented reality add another dimension of interactivity, engagement and personalisation while at the same time being unobtrusive (Leue et al., 2015).

However, research acknowledging the opportunities provided by wearables for ICT enhanced learning in museums and art galleries is scarce. Klopfer et al. (2005) found that the characteristics of augmented reality foster collaborative learning, especially if different users play different roles within the application linking to augmented reality gaming and an enhanced collaborative experience. Gamification and location-based games provide a good and motivational platform to create engaging and efficient learning activities incorporating the 'fun' factor. Exploring augmented reality learning from the gaming perspective was also the approach of Dunleavy et al. (2014) who identified that augmented reality gaming developers have to provide sufficient space for physical engagement to offer multiple learning opportunities. Particularly in the tourism context, augmented reality and gamification can provide not only facts and knowledge but can also deliver realistic contexts and reconstructions of events, thus enhancing the entire learning experience and making it more applicable (Mortara et al., 2014).

Generic Learning Outcomes

The Generic Learning Outcomes (GLO) framework comprises the theoretical foundation of this study. Over the last twenty years, according to Brophy and Butter (2007), the European Union has strongly focused on the creation of an information society with a wide access to culture and education for its citizens. The European Union emphasised 'the needs of people for services which are engaging, interactive, localised and easy-to-use' (Brophy & Butters, 2007, p. 4). Also within the UK, Field (2000) observed an increased interest in adult lifelong learning among public institutions. One of the problems with quantifying this informal learning is that not all visitors considered art or museum visitations as a learning experience (Amosford, 2007). As a result, there is no straightforward method to measure and analyse the learning processes people have during art gallery visitations. In an attempt to overcome this problem, a number of different research frameworks have been used to determine what the learning experience is like for people in public organisations.

According to Falk and Storksdiek (2005), there were two prevalent approaches to learning frameworks within museums and art galleries. One approach was that proposed by Schauble et al. (1997) which covers a sociocultural learning framework intent on focusing on the process of learning itself as opposed to the outcome of the learning process. It specifically described how the process of learning is directly affected by the interrelationships between visitors and mediators in museums and art galleries such as providing signs or tools. On the other hand, Falk and Dierking (2000) proposed the Contextual Model of Learning with a strong focus on the 'interactions between an individual's (hypothetical) personal, sociocultural, and physical contexts over time' (Falk & Storksdiek 2005, p. 745).

In order to encompass all the relevant aspects and create a framework that can be implemented easily, Hooper-Greenhill et al. (2003) developed the GLO framework to explore the learning outcomes and visitors' learning experiences within UK museums, libraries and archives. Overall, the purpose of GLOs is to simplify the investigation of the learning experience through the introduction of simple factors that are dependent on the subjective opinion of visitors. The GLOs are directly based upon the assumption that the process of learning is active, in which visitors are engaged in the experience to make sense of the world around them. Based on these assumptions, Hooper-Greenhill et al. (2003) developed the GLO framework, proposing that learning has a number of outcomes such as 1. Knowledge and understanding; 2. Skills; 3. Attitude and values; 4. Enjoyment, inspiration and creativity and 5. Activity, behavior and progression. This concurs with ideas of Hawkey (2004, p. 9) who includes as part of the technological museum learning experience the 'encouragement of a wide range of behaviors, skills, dispositions and experiences'.

Parsons et al. (2007) introduced the theoretical framework of mobile lifelong learning and supported the idea that visitors' objective for lifelong learning encompass the improvement of current and the learning of new skills, the sharpening of social skills as well as the acquiring of teamwork skills. However, Parsons et al. (2007) also included other factors in the learning experience including social interaction, challenges, organised content as well as outcome and feedback. It shows how the interrelation of these factors leads to their final objective of enhancing visitors' skills, the ultimate learning objective. Hooper-Greenhill et al. (2003) however found that skills are only one part of learning outcomes. Similarly, Monaco and Moussouri (2009, p. 318) revealed that GLOs are 'the perceived benefits visitors … have from a museum visit … These benefits may include changes in knowledge or skills and so on but, more often than not, they are much more subtle. They may be about seeing something in a different light, making new links, or discovering that museums can be fun places'. Due to the applicability of the GLO framework for the UK, it is considered an appropriate foundation for studying how wearable augmented reality applications enhance the visitors' learning outcomes experiences.

Augmented reality has previously proven to facilitate the learning experience through the reconstruction of historic events and provision of overlaid information. This interactive way of providing knowledge has aided the learning process. However, there is a limited previous research which investigate knowledge and understanding, skills, attitude and values, enjoyment, inspiration and creativity and activity, behavior and progression. The GLOs encompass the aforementioned constructs and therefore provides a valuable framework to explore how augmented reality can be used to facilitate learning.

Methodology

Study Context

This study was conducted as part of the wearable augmented reality project at an art gallery in the UK. According to a large number of studies, museum and art galleries are considered tourist attractions (Carrier, 1987; DeJong, 2011) and fall under the category of cultural

heritage tourism (Han et al., 2014). In addition, Yu et al. (2012, p. 449) revealed that "a tourist is one that makes a tour for pleasure or culture". Therefore, participants in our study fit the definition of tourists. The gallery used in this study is one of the country's finest art museums and renowned for 19th century British paintings. It is a highly popular art gallery and attracts more than half a million visitors each year. The aim of the project was to enhance the visitors' experience when visiting an art gallery through the augmentation of information. The Museum Zoom augmented reality application was developed for this study and it consisted of numerous cards including information on the artist, painting, related paintings, location and sharing functions. The application included basic text information as shown in Figure 1 and provided the additional functionality to read-aloud further information.

Please insert Figure 1 about here

Study Design

Forty-four art gallery visitors took part in this study on two consecutive days in June 2014. The study was conducted using two different groups, an experiential Google Glass group and a control group. Participants in the Google Glass group used the wearable augmented reality application developed through Google Glass, during their visit to the art gallery. The second visitor group was a control group and participants in this group did not use any technological tool during their visit, however they were provided with a paper-based task. The study design followed the approach employed by Sung et al. (2008) and Chang et al. (2014) who examined differences in the behavioral patterns of visitors using mobile electronic guidebooks in a museum of history (Sung et al., 2008) and the effectiveness of mobile augmented reality systems for learning within art galleries (Chang et al., 2014).

For the present study, both groups were given a task that asked them to follow a pre-defined art gallery tour based on similar themes and mediums of paintings. The aim of this task was to evaluate the overall differences in learning experience between both groups. For the control group the task directions were provided on paper so that they could be taken on the art gallery tour. For the group with Google Glass, the paper-based task instructions were given solely in the form of pictures as the application provided all the additional information needed. However, tasks for the control group were more detailed, making the participants aware of the connections between paintings (same theme, same medium) in order to ensure that both groups received the same information on the connections as well as experiencing the same sequence. Afterwards, the interview aimed to identify which kind of information was retained, how enjoyable, inspirational and valuable the experience was, to what extent new skills were acquired, and how the experience might affect future behavior.

Data Collection

Participants were recruited by purposive sampling method. The 22 Google Glass group participants were selected over the gallery's social media and webpage. For the 22 control group participants, visitors were approached at the entrance of the gallery by researchers

and asked to participate in the study. Applying the purposive sampling method, participants were selected according to a 'specific purpose rather than randomly… [aiming] to represent a broader group of cases as closely as possible' (Teddlie & Yu, 2007, p. 80). The purpose of the sampling was to match the gallery's visitor profile which includes all age groups however, a large number includes visitors aged 20-40 due to the city being a young international tourism destination. Therefore, in order to get a good sample for both the control and the experimental group, purposive sampling was used.

Participants from both groups were regular art gallery visitors to other galleries across the UK, however, the majority was first time visitors to the gallery used in this study. Prior to starting the experiment, an explanation of the task was given to the control group participants. Participants from the experimental group were given a ten-minute introduction to the functionalities of Google Glass in order to facilitate the use of the Museum Zoom application. The experiment (both groups) lasted between 20-30 minutes and was followed by a 15-25 minutes interview.

A semi-structured interview design was adopted and the questions were based on previous research (Museums, Libraries and Archives Council, 2008) with questions asked based on the five GLOs (increase in knowledge and understanding; increase in skills; change in attitudes or values; evidence of enjoyment, inspiration and creativity; as well as evidence of activity, behavior, progression) categories. Both groups were asked the same questions with regards to the GLO framework, whereby questions asked to Google Glass participants included 'using Google Glass' to account for the experience with wearable augmented reality. A full list of questions can be found in Table 1.

Please insert Table 1 about here

Please insert Figures 2 and 3 about here

Data Analysis

The data were analysed using thematic analysis, a technique aiming at identifying and reporting patterns (Braun & Clarke, 2006). Patton (2002) confirmed that thematic analysis is useful for comparing control and experimental groups, as it enables the comparison and contrasting of patterns. Thematic analysis is, according to Braun and Clarke (2006), a flexible approach that can be either data-driven or theory-driven and can be performed manually or using software programs. In the present study, the approach used was theory-driven, using the GLO framework to form initial themes from which sub-themes developed during the coding process which was performed manually. Hughes and Allen (2008) supported the use of a thematic approach by comparing the perception of tourists who visited a destination and those who did not and used a 'theming' approach in order to compare and contrast perceptions. In addition, Lange and Frommer (2011) supported the use of thematic analysis when comparing control and experimental groups and suggested the identification of themes and sub-themes through the creation of a comparison table,

whereby each statement of a participant is allocated to a theme and compared and contrasted to statements from other participants to reduce redundancies and create a transparent analysis (Lange & Frommer, 2011).

Findings

Profile of Participants

The majority of participants in the experimental group were in the age range of 20-29 (nine participants) and 30-39 (ten participants) and three were between 40 and 59. Out of the 22 participants, 13 were male and 9 female. In terms of highest education, participants were highly educated with eight of them having a postgraduate degree and ten an undergraduate degree. With regards to the participants' profile from the control group, the sample was slightly more varied in terms of age, the majority of participants were in the age range of 20-29 (seven) and 30-39 (six), while three participant were aged 50-59 and two above 60. In addition, three participant were younger than 20. However, gender-wise, participants were equally distributed and the majority of participants had either an undergraduate degree (twelve) or a postgraduate degree (six) (see Table 2).

Please insert Table 2 about here

Generic Learning Outcomes

Table 3 summarises the key points raised by interviewees from the Google Glass (GG) experiment group as well as the control group (CG).

Please insert Table 3 about here

Knowledge and Understanding

The first interview topic focused on knowledge and understanding. Participants within the experimental group remembered specific details about the paintings as in one case:

> '*George Stubbs the first one with the Cheetah I remember that and it told me that George Stubbs was a painter of anatomically correct animals then it linked me to a painting of a lion by Sir Edward Leeston where the lions in the paintings were the model to cast the lions for the Trafalgar square' (GG3).*

Overall, the majority of participants remembered detailed information regarding the viewed paintings. However, interestingly the control group, who only had a task sheet with the painting's specific information, remembered much more detailed information, such as

colors or how social classes were painted differently which demonstrates a deep appreciation of the art (CG2, CG14). Overall, it was clear that participants from the experimental group remembered and understood information they were provided with by the application, however participants from the control group had a wider spectrum of knowledge after visiting. This might be linked to the novelty factor of the devices requiring more attention to operate by the experimental group. However, it should be noted that not all participants from the control group were able to remember the information as in one case

> '*I feel like every time I come to an art gallery I have to take in a lot of information at once and only retain a little bit of it' (CG6)*.

Nevertheless, a similar problem occurred within the experimental group where participants were not able to take in information due to the novelty aspect of the device (GG8, GG16). The ability to refer back to information instantly was considered a big advantage of using Google Glass in the art gallery as pointed out by GG1 'I think there is an advantage compared to an audio guide because obviously you can flip back and refer to what you have already looked at' which was supported by a number of participants (GG11, GG18, GG20, GG22). The control group on the contrary revealed that they like to take notes while visiting galleries in order to refer back to the viewed paintings when back at home (CG1, CG2, CG7, CG8, CG22). In addition, accessibility of content was considered an important element for understanding information (GG20). Participants from the control group revealed that they are relatively satisfied with the information on the plaques besides the painting however, they saw opportunities in using applications to enhance the accessibility of information. Finally, both groups agreed that either Google Glass or the availability of additional information enhances the learning experience. Participants from both groups found the experience educational due to the actual depth of information and took advantage of this information available to them (CG19, GG12). Therefore, not only information via the application but also on the label was considered important and beneficial.

Skills

Secondly, interviewees were probed about the enhancement of their skills. According to the GLO framework, the construct of skills is linked to learning of new intellectual, informational, communications skills; the sharpening of social skills as well as the acquiring of teamwork skills. Within the experimental group, participants remarked that they would normally 'bypass' or 'ignore' certain paintings when they visit art galleries saying,

> '*if I didn't have the Google Glass I would have looked at the picture and left but I got a more rounded understanding of the picture and the context' (GG18).*

This quote by GG18 links clearly to the increase in skills described by the GLOs as information management skills through the "locating and evaluating of information" (Hooper-Greenhill et al., 2013, p. 4). People from the control group also revealed that being provided with a task and additional information made them look more closely and read more about the paintings. In addition, using Google Glass provided a different way to see a gallery (GG2). While normally they chose centuries as a narrative, which is the traditional way the gallery is laid out, Google Glass enables visitors to not look at the whole gallery but focus on certain themes (GG2) and some participants from the control group reported that they liked the different way of viewing paintings. This demonstrates that the task provided for the control and experimental group added to the art gallery experience and the Google Glass application facilitates this approach of thematically viewing paintings. This is linked to the theme of enhancing intellectual skills such as critical and analytical thinking (Hooper-Greenhill et al., 2013). In fact, this new approach to visiting galleries is very unique to mobile applications and wearable augmented reality. The different way of thinking was also acknowledged by the experimental group (GG10, GG16). For instance, GG10 said 'it is interesting to see how they belong in a way I have not thought of before'. Within the Control Group, CG2 found the opportunity to compare and contrast paintings particularly enlightened her experience. Finally, while participants within the experimental group revealed that using the device made them appreciate the paintings more, control group participants found that the general provision of additional information enhances the appreciation and that applications should be available for those visitors interested in enhanced information. This concept links to the development of key skills discussed within the GLO framework and the idea of "learning how to learn" (Hooper-Greenhill et al., 2013).

Attitudes and Values

The third set of interview questions explored the participants' attitudes and values. Attitudes and values refer to "changes in feelings, perceptions, or opinions about self, other people and things, and the wider world" (Hooper-Greenhill et al., 2013, p. 15). With regards to attitude, Google Glass group participants had an overall favourable attitude and found that the experience created an engaging and interactive visit. On the contrary, control group participants were less favourable in their opinion and revealed that interaction is missing as part of their experience. The majority of participants from the experimental group revealed that Google Glass personalises the experience and thus adds benefits as participants were able to directly choose which information they are interested in. They enjoyed being able to 'stay in control' (GG14, GG15, GG5), creating a 'personal relationship' (GG7) and 'tailoring the journey' (GG18). Also five participants from the control group suggested that galleries should provide personalised tours (CG2, CG4, CG5, CG9, CG22) as 'it is up to the individual and you can't force anyone to be interested in something' (CG4). In addition, GG1 pointed out that the experience 'stimulated the mind' and GG7 found 'it was more of an intimate experience'. CG1 confirmed the importance of stimulation of the mind and revealed that the right amount of information has to be provided in order for the participant not to be overwhelmed by the experience. Finally, the experimental group revealed that using the device makes the journey and the learning process easier adding to the favorable attitude (GG1, GG14, GG18).

The Google Glass participants were found to have had a more valuable and rounded experience through additional information provided through Google Glass (GG1-GG4, GG6-8, GG12-15, GG17, GG20). They identified that Google Glass brings the experience to life, improves the visitor experience, adds value and deepens the experience (GG1-GG4, GG6-8, GG12-15, GG17, GG20). Within the control group participants agreed that additional information adds value to the experience but 'sometimes the information can be a little bit over the top (CG2)'. Therefore, it is essential to provide the right amount of information to offer a valuable experience. The thematic approach of visiting the art gallery was considered highly beneficial and produced a more interesting and valuable experience for both the experimental group and the control group. Three participants in the experimental group found their experience convenient as 'you could stand back and look at the painting (GG1)', 'not having to read the labels (GG3)' and 'speed up your experience (GG9)'. Although not convenient, the control groups considered their experience as overall satisfactory.

Enjoyment, Inspiration and Creativity

Participants from the experimental group found the experience to be 'exciting' (GG1, GG3), 'enjoyable' (GG1, GG8, GG18), 'innovative' (GG2, GG5), 'engaging' (GG2, GG3), 'interesting' (GG2, GG5, GG15) and 'comfortable' (GG3) which may be linked to the novelty factor of these new devices. GG3 revealed that 'it is much more exciting than walking around in the gallery with just a leaflet or relying on reading wall labels'. GG8 thought 'it was a good and innovative idea and perhaps something that is different from the conventional gallery experience' and one experimental group participant was 'most enthusiastic about seeing the interaction between modern glass and the old fashion gallery' (GG5). While enjoyment, inspiration and creativity were entirely linked to the experience with the Google Glass augmented reality application, participants from the Control Group felt more of an inspirational and relaxing experience coming to the gallery (CG4, CG6, CG7). In addition, they found it enjoyable to start looking at new details in paintings (CG6, CG12). In terms of emotional attachment, one stated that 'there is some enjoyment I get out of coming to galleries and finding things that surprise me, or move me' (CG6). In addition, CG22 counter-argued against the usage of technology 'I think your emotional response shouldn't be encumbered by technology… I think it is only there to add to your intellectual understanding'. Finally, one participant felt that he was relatively disappointed by the experience, as there were no wow-factors attracting his attention (CG1).

Activity, Behaviour and Progression

The last theme is related to what people do, and intend to do, as a result of the museum visit (Hooper-Greenhill et al., 2013). Within the context of the present study, this links to the usage of wearable augmented reality for future museum visits. In terms of a visiting activity, Google Glass participants found it to be a good experience and confirmed they would use the technology in the future (GG1, GG4) as 'Google Glass makes the journey a lot more seamless rather than just wandering around every single room' (GG1) and 'you don't have to break away from the painting to find the information, the information comes to you' (GG4). Participants from the control group, on the contrary, were interested in

using technology in their future visit for creating a seamless visit through the incorporation of technological tools. For a future museum visit, CG6 acknowledged the downloading of an application for the phone as an interesting way to enhance the experience and CG7 was interested in 'information in different ways…so you don't just have to read the thing at the side. It would make it more interesting'. In total, twelve participants from the control group acknowledged the potential of technology for a seamless museum visit in the future. Nevertheless, there were also negative comments on using technology in the art gallery context in both groups. Some participants revealed they will not use wearable augmented reality in the future due to disconnection from the art (GG10) and distractions caused by the technology (GG19). However, GG15 and GG18 remarked that disturbance to other people is limited due to the bone conducting speakers. Interestingly, CG20 (from the control group) found technology to be disturbing and that it therefore should not be introduced into the normal art gallery in the future. In addition, embarrassment and social acceptance were identified as issues arising in the experimental group and reasons for rejecting wearable augmented reality as an enhancer of the museum visit. This was confirmed by GG7 who felt a little embarrassed because [she] was the only one using Google Glass and people were looking and [she] didn't feel comfortable [as she] prefers to blend in. Gaudin (2015) agreed that Google Glass, being still in the development stage, often contributes to its users being mocked due to its design and limited usefulness and acceptance. GG21 feared that it will change the entire atmosphere in galleries with people standing isolated using their glasses. From the control group, it was confirmed that visitors can enjoy the experience without any technology (CG4). Inquiring about future behaviour, GG1, GG2, GG8, GG13 and GG18 declared or stated that they are interested in incorporating it into future gallery visits as it 'elevated the experience (GG1)'. GG13 considered that it would be particularly beneficial for the learning experience of children and GG18 stated that the availability of Google Glass is a reason to return to the gallery. For the control group, the thematic experience of visiting the gallery had different effects on their future behaviour. While CG2 confirmed that it will not change her future behaviour, others revealed that they will take more time to read the information and look at the paintings and to appreciate them (CG9, CG12, CG14).

Discussion

The aim of this study was to assess whether a wearable augmented reality application can enhance the learning experience and achieve outcomes such as improving knowledge and understanding, skills, changing attitudes and values, increasing enjoyment, inspiration and creativity as well as improving activity, behaviour and progression of visitors at an art gallery compared to visitors experiencing the gallery without access to this technology. Previous research used a similar approach and investigated the differences in the learning experience amongst visitors with mobile devices and without mobile devices (Chang et al., 2014; Sung et al., 2008). Both studies found differences in the learning behaviour between those two groups. Using the GLO framework as a theoretical foundation, the present study supported the assumption that there are differences in the learning experiences of visitors with and without wearable augmented reality. In terms of knowledge and understanding, the majority of participants who experienced paintings using Google Glass retained

information provided by the application. However, looking at the control group, participants recollected even more details than the experimental group, such as the way the painting was depicted. This might be explained by findings from McCall et al. (2011) who revealed that users of new and innovative technologies often place too much emphasis on the device itself instead of on their immediate environment. It might explain why participants from the control group had a stronger recollection of viewed paintings whilst participants from the experimental group were only able to remember information provided by the device. Nevertheless, the general attitude from the experimental group was that the Google Glass augmented reality application facilitated the overall learning process as information was instantly available and easier to remember. In addition, applications allow the provision of more content as interested visitors are able to dig deeper and gather more and more information which is overall beneficial for learning. Similarly, the control group felt that additional information, in addition pre-existing labels, should be provided to enhance the understanding of paintings. This confirms findings by Chang et al. (2014) on the acceptance of mobile augmented reality within art galleries. In addition, both groups confirmed that the availability of a thematic and personalised approach to visiting art galleries helps to improve the learning experience. The experimental group was generally satisfied with their art gallery learning experience and considered it to be seamless, while participants from the control group revealed that they are interested in a seamless experience and were recommending the implementation of mobile applications or other forms of technology to enhance the understanding and interactivity. Within previous literature, seamless experiences are described by Kneafsey (1994) as smoothly-running operations that guide visitors through museums and a "hassle-free interface among all elements of the total travel experience" (Woods & Deegan, 2003, p. 271).

There were also a few drawbacks discussed by the experimental group in terms of visitor engagement. A few participants felt disconnected from the art and feared that it will change the entire atmosphere in galleries with people standing isolated when using their glasses. This is a similar phenomenon observed with handheld devices such as mobile phones and audio guides (Tallon, 2008). A similar observation was made by Chang et al. (2011, p. 194) who stated 'visitors in the AR-guided group may have paid particular attention to the painting and its commentary, or the device may have offered useful and detailed observations in such a way that the visitors did not readily discuss the artwork with others, resulting in an isolated phenomenon'. In addition, although the majority of control group participants saw opportunities in the introduction of technologies in the Art Gallery, there were some who feared that it would interfere with their learning experience.

Monaco and Moussouri (2009, p. 318) suggested that learning includes that visitors' experience 'something in a different light, making new links'. This links to the thematic approach of visiting art galleries described in this study. If visitors choose a theme (e.g. all paintings created in Paris), technology could help to explore an art gallery in an entirely different way, visiting from painting to painting rather than gallery to gallery. Within the tourism context, there are different examples of creating thematic experiences, such as preparing food according to art or music themes (Tellström et al., 2003) or visiting regions according to a wine or literacy theme. According to Gao et al. (2016, p. 3), "a theme […] is

a strategic element in designing a destination that unites various other elements and directs visitors' attention and assists visitors to develop meaning from their experiences. Themes help visitors to organize their impressions, leading to increased memorability and creating value. Fouracre (2015) explored the concept of creating thematic museum experiences and found that it makes "things […] a bit more approachable to people". Finally, Solima et al. (2016, p. 290) explored a similar concept and found that applications can be used for "a logical framework of reference for the visit". It is believed, based on the data obtained, that this thematic approach is what the Google Glass wearable augmented reality application helped to achieve at an art gallery during this study. A large number of participants from the experimental group confirmed that they normally look at art objects individually, without making any connections; however the availability of Google Glass wearable augmented reality application helped them to see new links and to look deeper. The control group had a similar experience due to the paper-based task provided however, the wearable augmented reality application was considered an ideal aid for having a personalised, thematic and enjoyable art gallery visit. In addition, participants from the control group confirmed the benefits of using technology such as an enhanced and more interactive experience. Therefore, this is considered one of the major learning outcomes of the present study. This is particularly true as participants from the control group confirmed that the introduction of a thematic approach to visiting the art gallery based on themes would add value to the learning experience.

Nevertheless, if analysing the actual understanding and knowledge of the viewed paintings it could be argued that the control group retained information that is more detailed. However, generic learning outcomes are measured with regards to the overall process of learning rather than only the actual outcome (Schauble et al., 1997) and therefore, the use of Google Glass made the overall experience more personal, engaging and interesting. Particularly within the tourism context, museums and art galleries aim to create an enjoyable learning experience that attracts a wide range of markets and spreads positive word-of-mouth. Therefore, finding the right balance between creation of knowledge and interactive and enjoyable experiences can be considered essential which is supported by the findings in this study. Sung et al. (2008) made similar observations while comparing museum visitor groups exploring artefacts with and without mobiles. It was found that interactions and dwell times were much longer for those visitors who used a technological device (Sung et al., 2008). Overall, the majority of participants from both groups confirmed that using technology can enhance the understanding and value, improve skills, add to enjoyment and creativity as well as influence future behaviour.

Conclusion

This study examined how wearable augmented reality can be used to enhance the learning experience of visitors at art galleries. There are a number of theoretical contributions of this study. Within a tourism context, there has been a lack of studies focusing on lifelong learning (Falk et al., 2012) and therefore, the present study adds to the understanding on how tourist attractions such as art galleries can enhance the visitor learning experience. In addition, Falk et al. (2012) proposed that the tourism industry can contribute to the learning

experience through the provision of practical skills, knowledge and wisdom. The findings of the present study revealed that themed guides add enjoyment, inspiration and creativity as well as instigating possible changes in planned future travel and visit behaviour to the contributions of the learning experience in art galleries. Furthermore, a unique approach of applying the GLOs in the wearable augmented reality context was achieved by testing this methodological approach at an art gallery in the UK. A further contribution is the extension of the study by Chang et al. (2014) which looked at mobile augmented reality, to include data on the effects of wearable augmented reality on the visitor experience. In addition, this study extended previous research by Leue et al. (2015) which looked at the learning experience from the Google Glass perspective but did not incorporate a control group. Finally, this study lays the foundation for future research on museum and art gallery learning experiences through wearable augmented reality. In particular, the present study supported the proposal that all five GLOs categories are relevant and important for the wearable augmented reality learning experience, however the integration of further categories such as *Interaction* may be applicable in the future due to technological developments and their impact on the learning experience.

There are also a number of implications for museums, art galleries and cultural heritage tourism practitioners. The findings have shown how the integration of the latest technologies can enhance the appreciation and ultimate learning experience of visitors. Although, the control group had a high sense of appreciation, they remarked that guidance and personalisation is key to a seamless learning experience. Simply being provided with instructions made their art gallery experience more valuable and thus, using new approaches to visitor engagement and experience enhancement, is highly recommended. In addition, this study provided data for the design and implementation of wearable augmented reality in the future and for museum, art gallery and tourism practitioners as well as application developers which will have significant implications for the development of future wearable augmented reality applications. Finally, the findings of the present study provide also applications for the exhibition design within art galleries. While traditionally art galleries often group their paintings according to decades or centuries, the present study has shown that a thematic approach offers an interesting alternative to capture visitors' interest. Especially in the tourism context, art galleries could theme their exhibitions according to links with other countries in order to attract international tourists.

The present study examined and compared the learning experience of visitors who used wearable augmented reality to visitors who did not use technology however, the majority and most widely used form of technology remains smartphones. Chang et al. (2014) examined visitor experience comparing visitors with and without mobile devices, however, failed to incorporate the learning perspective. Therefore, future research should examine mobile augmented reality learning experiences in the context of the GLO framework. In addition, future research should compare the use of mobile versus wearable augmented reality in the museum and art gallery context to identify and compare how each technology influences the learning experience and to determine if there are differences in the two types of experience. Furthermore, research could examine how mixed reality (virtual and augmented) can be implemented to enhance the learning experience and to provide deeper

knowledge about opportunities for applying the latest technologies. In this study, we examined the individual learning experience however, considering the technological advances and the importance of social media, future research could explore the area of wearable augmented reality and the social learning experience. In the tourism context, it would be extremely valuable to identify the wearable augmented reality learning behaviour of international tourists as mobile and wearable devices are an ideal tool to facilitate multi-lingual learning. Therefore, future research should differentiate between day, national and international tourists visiting the art gallery.

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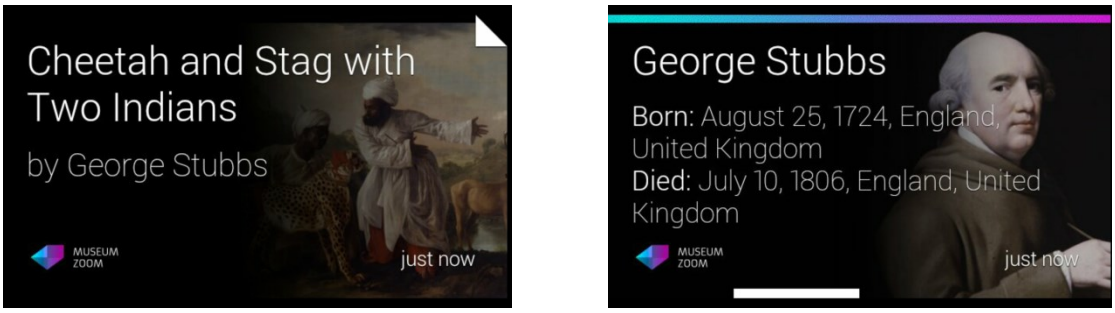

Fig. 1. Museum Zoom Application

Fig. 2. Participant with wearable AR application

Fig. 3. Participant without technology

Table 1. Interview Questions

Questions	Google Glass (GG)	Control Group (CG)
Warm-up	Can you describe your feelings when you heard we were using Google Glass in the Art Gallery? What did you expect?	Why are you here today?
	What do you normally expect to learn about the paintings in an Art Gallery during a visit?	What do you normally expect to learn about the paintings in an Art Gallery during a visit?
Knowledge and Understanding	What have you learned in the Art Gallery using Google Glass today?	What have you learned today in the Art Gallery?
	What do you remember about the paintings you have seen today?	What do you remember about the paintings you have seen today?
Skills	Did you learn a new skill today, such as looking at a museum object differently, or thinking in a different way?	Being provided with instructions, have you looked at the art differently?
	How did Google Glass improve the way you learned about the paintings?	
	How else can Google Glass help you to improve your information searching skills?	
Attitudes and Value	Has this visit using Google Glass made you feel any differently, or more strongly, about the paintings?	Has this visit made you feel any differently, or more strongly, about the paintings?
	What value do you see in experiencing paintings in the art gallery using Google Glass?	What value do you see in visiting this art gallery?
	Has using Google Glass today made you feel any differently about Manchester Art Gallery?	
Enjoyment, Inspiration and Creativity	What did you particularly enjoy today? Or find inspirational?	What did you particularly enjoy today? Or find inspirational?
	What do you think you've gained and can gain from using Google Glass in the Art Gallery?	What do you think you can gain from using technology in the Art Gallery?
Activity, Behaviour & Progression	Have you behaved differently using Google Glass to the way that you normally behave in an Art Gallery?	As a result of your visit today, what would you do at your next visit to this or other Art Galleries
	Will this visit using Google Glass change the way you think or behave in the future?	
Wrap-up	If you could choose just one thing what would you say was the most important value of using Google Glass today?	If you could choose just one thing what would you say was the most important value to your visit today?
	How should the Google Glass application be improved to enhance your learning outcomes in the future?	What could the art gallery do to enhance your learning outcomes in the future?

Table 2. Profile of Participants

	Gender	Age	Education
Experimental Group			
GG1	Male	20-29	Undergraduate
GG2	Male	30-39	Postgraduate
GG3	Male	40-49	Postgraduate
GG4	Male	50-59	High School
GG5	Male	30-39	High School
GG6	Female	30-39	Professional Degree
GG7	Female	20-29	Undergraduate
GG8	Female	30-39	Postgraduate
GG9	Female	30-39	Postgraduate
GG10	Male	30-39	Postgraduate
GG11	Male	30-39	Undergraduate
GG12	Female	30-39	Undergraduate
GG13	Female	30-39	Undergraduate
GG14	Female	20-29	Postgraduate
GG15	Male	20-29	Undergraduate
GG16	Male	20-29	Postgraduate
GG17	Female	20-29	Undergraduate
GG18	Male	20-29	Undergraduate
GG19	Male	30-39	Undergraduate
GG20	Male	50-59	Postgraduate
GG21	Female	20-29	Undergraduate
GG22	Male	20-29	High School
Control Group			
CG1	Male	60 and above	Postgraduate
CG2	Female	60 and above	Professional Degree
CG3	Female	20-29	Undergraduate
CG4	Male	30-39	Undergraduate
CG5	Male	30-39	Postgraduate
CG6	Female	30-39	Undergraduate
CG7	Male	20-29	Undergraduate
CG8	Female	30-39	Undergraduate
CG9	Female	20 and below	Undergraduate
CG10	Female	50-59	Postgraduate
CG11	Female	40-49	Postgraduate
CG12	Male	20 and below	High School
CG13	Female	20-29	Undergraduate
CG14	Male	20-29	Undergraduate
CG15	Female	20-29	Postgraduate
CG16	Male	20-29	High School
CG17	Male	50-59	Undergraduate
CG18	Male	30-39	Undergraduate
CG19	Female	20-29	Postgraduate
CG20	Male	30-39	Undergraduate
CG21	Female	20 and below	High School
CG22	Male	50-59	Undergraduate

Table 3. Summary of key points raised by interviewees

Experimental Group	Control Group
Knowledge and Understanding	**Knowledge and Understanding**
Remembered specific details about the paintings (e.g. anatomically correct animals, Trafalgar Square)	Remembered even more details than the experimental group (e.g. colors, anatomically correct animals, Trafalgar Square)
Difficulties remembering due to novelty factor	Difficulties remembering due to amount of info
Liked the possibility of referencing back immediately	Like to search for information after the visit
Liked the accessibility of information through Glass	Are happy with reading plaques however picked up on opportunities of apps
Google Glass facilitates learning	Getting additional information facilitates learning
Skills	**Skills**
Looked at paintings and details they would normally ignore	Looked at paintings in more detail
A different way to see the gallery	A different way to see the gallery
A different way of thinking	Made you compare and contrast paintings
More information to appreciate the paintings	More in-depth information made appreciate painting more
Attitudes and Values	**Attitudes and Values**
Favorable attitude to using wearable smartphone augmented reality	Favorable attitude to using technology for museum visit
More valuable and rounded experience through additional information	More detailed information would enhance experience
Thematic approach to experience enhances learning	Thematic approach made it more interesting
More convenient experience	Overall a satisfactory experience
Interactive way of experiencing paintings	Experience should be more engaging
More personalised	You should create a personalised experience
Stimulates the mind	Right amount of information should be provided
Makes the journey easier	-
Enjoyment, Inspiration and Creativity	**Enjoyment, Inspiration and Creativity**
Exciting experience	Inspirational experience
Enjoyable experience	Enjoyable to look at other details in the paintings
Engagement	Disappointed in experience
Interesting experience	-
More emotionally attached to paintings	Emotional response to visiting art galleries to relax
Innovative way of viewing paintings	-
Comfortable to use Google Glass	-
Activity, Behaviour and Progression	**Activity, Behaviour and Progression**
Wearable augmented reality provides seamless experience and leads to future intention to use	Interested in a seamless visit through apps or other forms of technology for future visit
For some it disturbed the entire experience	For one technology would disturb experience
Embarrassment and social acceptance	Would not pay money for technological devices, enjoy future visit without technology
Future changes in behaviour due to experience	Does not change future behaviour/Some changes
More likely to visit the gallery in the future	-