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## **Google Glass Augmented Reality: Generic Learning Outcomes for Art Galleries**

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**Abstract** Art galleries are increasingly asked to provide evidence of their efforts towards facilitating visitors' learning experience. Augmented reality (AR) and wearable computing has the potential to create a realistic learning environment. Using Google Glass allows art gallery visitors to receive augmented information while looking at paintings. The Generic Learning Outcomes (GLO) framework was specifically designed to investigate visitors' learning experience in museums and art galleries however, research on art galleries visitors' learning experience through wearable computing and AR applications is scarce. This study aims to assess how Google Glass enhances visitors' learning outcomes within the art gallery environment. Twenty-two visitors participated in a test of the Google Glass Museum Zoom application. Visitors were interviewed and the data were analysed using thematic analysis and revealed that Google Glass helps visitors to see connections and enhance the knowledge and understanding of paintings.

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# Google Glass Augmented Reality: Generic Learning Outcomes for Art Galleries

**Abstract** Art galleries are increasingly asked to provide evidence of their efforts towards facilitating visitors' learning experience. Augmented reality (AR) and wearable computing has the potential to create a realistic learning environment. Using Google Glass allows art gallery visitors to receive augmented information while looking at paintings. The Generic Learning Outcomes (GLO) framework was specifically designed to investigate visitors' learning experience in museums and art galleries however, research on art galleries visitors' learning experience through wearable computing and AR applications is scarce. This study aims to assess how Google Glass enhances visitors' learning outcomes within the art gallery environment. Twenty-two visitors participated in a test of the Google Glass Museum Zoom application. Visitors were interviewed and the data were analysed using thematic analysis and revealed that Google Glass helps visitors to see connections and enhance the knowledge and understanding of paintings.

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## 1 Introduction

Increasingly, art galleries and museums are asked to provide evidence of their efforts towards facilitating visitors' learning experience (Hooper-Greenhill et al., 2003). Augmented Reality (AR), which overlays information into the real environment, has the potential to create a realistic learning environment through the projection of enjoyable and interesting content in front of art objects (Chang et al., 2014). Traditionally more utilised on smart-phones, the launching of Google Glass will allow art gallery visitors to receive augmented information while looking at paintings. The use of Google Glass and other wearables enables art gallery visitors to have a unique experience. Leue et al. (2014) conducted an exploratory research and confirmed that art gallery visitors have an enhanced experience while using the device to explore paintings however, called for research to examine the cultural learning experience. The Generic Learning Outcomes (GLO) framework was specifically designed to investigate visitors' learning experience in museum, archives and libraries as well as art galleries (Hooper-Greenhill et al., 2003). However, research on art galleries visitors' learning experience through wearable computing and AR applications is scarce. In addition, the trend of Google Glass only started recently and therefore only limited research that incorporates these new devices exists (Rhodes and Allen, 2014). Therefore, the aim of the study is to assess how Google Glass enhances visitors' learning outcomes within the art gallery environment. This research will contribute to a gap in the literature by investigating the opportunities of using a novel and innovative technology to enhance the learning outcomes within art galleries. Therefore, this study aims to assess whether Google Glass can enhance the knowledge and understanding, skills, attitude and values, enjoyment, inspiration and creativity as well as activity, behaviour and progression of visitors at Manchester Art Gallery.

## **2 Literature Review**

### **2.1 Augmented Reality and Wearable Computing**

AR is the concept of superimposing or adding digital information over the real world environment (Lucero et al., 2013; Mann, 2013). Although AR can be performed on mobile devices such as smartphones and tablets, better-suited devices are those that enable the wearer to experience the AR in a more immersive and intuitive setting removing the need for a device to be held in front of the user (Mann, 2013). Therefore, wearables, in particular head mounted displays (HMD), are considered to be superior choices for the use of AR (Rhodes and Allen, 2014). Wearable computing in the technical sense refers to any device that can perform computation within the device that is worn (Rhodes and Allen, 2014). In the context of consumer goods this refers to anything from activity trackers, smart watches, sensor bands or similar devices that either perform some form of computation on the actual device, but the term wearable is also used for any digital technological gadget that can be worn. Therefore, there are numerous levels of sophistication of computational devices that can be worn and are therefore called wearables with varying degrees of flexibility. For example, sensor band generally fulfil only one purpose, to collect data from the sensors that are embedded within it, therefore only collecting this information without the ability to be used for anything else. In contrast, there are more flexible devices that resemble more general purpose such as smartphones. These are essentially mini wearable computers and therefore provide a higher degree of flexibility (Hoellerer and Feiner, 2004). For the present study, Google Glass, a wearable HMD which incorporates many elements one would find in a smartphone therefore making it relatively flexible, was used. Although other devices are in development and some commercially available, Google Glass is the first device to incorporate significant amount of components into a relatively small, lightweight and unobtrusive device (Kahn, 2013).

### **2.2 Learning Experience in Art Galleries**

According to Packer and Ballantyne (2002), there is an increased awareness of art galleries and museums as facilitators of public lifelong learning. Since the 1990s, the European Union had a strong emphasis on creating an information society with a wide access to culture and education for its citizens (Brophy and Butter, 2007). According to Brophy and Butters (2007, p. 4), this entails “emphasising the needs of people for services which are engaging, interactive, localised and easy-to-use”. However, measuring this kind of informal learning is difficult and problematic as visitors have different purposes for visiting art galleries and “not necessarily seeing their experience as learning” (Amosford, 2007, p. 128). Therefore, there is no simple way to determine and examine learning experiences. Nevertheless, there are a number of research frameworks, which aimed to evaluate the learning experience within public organisations. According to Falk and Storksdiel (2005), originally there were two schools of thought with regard to learning frameworks within museums and art galleries. For instance, Schauble et al. (1997) discussed a sociocultural learning framework that focuses more on the learning process than solely its outcomes. They emphasised that the learning process involves the interplay between visitors and the

mediators (e.g. provided signs or tools) (Schauble et al., 1997). On the other site, Falk and Dierking (2000) proposed the Contextual Model of Learning with a key focus on the “interactions between an individual’s (hypothetical) personal, sociocultural, and physical contexts over time” (Falk and Storksdiel, 2005, p. 745). However, in order to provide a holistic framework that is easily understood and implemented by organisations, Hooper-Greenhill et al. (2003) developed a framework to measure the effectiveness of the learning environment within UK museums, libraries and archives councils. This Generic Learning Outcomes (GLO) framework aimed to simplify the identification of the learning experience through the introduction of simple measures (e.g. How much did you enjoy your visit to our museum today?), which are dependent on the subjective opinion of visitors. The GLO is built based on the idea that learning is an active process where visitors engage in their experience in order to make sense of the world. Hooper-Greenhill et al. (2003) furthermore believed that learning includes the development and enhancement of skills, knowledge and understanding as well as values and idea and ultimately should lead to change and further development. Based on this, Hooper-Greenhill et al. (2003) developed and formulated the GLO (see Figure 1) framework which proposed that learning has different outcomes including 1. Knowledge and understanding; 2. Skills; 3. Attitude and values; 4. Enjoyment, inspiration and creativity as well as 5. Activity, behaviour and progression.



**Fig.1.** Generic Learning Outcomes (Hooper-Greenhill et al., 2003)

Monaco and Moussouri (2009, p. 318) defined generic learning outcomes as “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 relevance of the GLO for the UK art gallery context and its easiness to measure and apply outcomes it is considered an appropriate framework to assess how Google Glass enhances visitors’ learning outcomes.

### **2.3 Manchester Art Gallery and Museum Zoom Application**

Chang et al. (2014, p. 186) acknowledged, “AR not only promotes participation and motivation, but also creates a realistic and novel learning environment via the combination of the real and the virtual”. The implementation of AR further enhances the learning outcomes as it enables to learn in a rich sensory context which makes learning and the gathering of information more enjoyable (Wojciechowski and Cellary, 2013). In addition, the novelty factor of using AR within the learning environment was assessed to positively influence the attitude (Wojciechowski and Cellary, 2013). The initiative to utilise Google Glass as a learning tool for visitors at Manchester Art Gallery, an important cultural heritage attraction for local residents and tourists, started in 2014 as a cooperation between Manchester Metropolitan University, Manchester Art Gallery and 33 Labs. This project evolved out of a previous limited smartphone based trial in Dublin, whereby MMU carried out AR feasibility testing and user interaction research in collaboration with the Dublin City Council and the Dublin Institute of Technology. Being among the first in Europe to test Google Glass in an Art Gallery environment the second test of the Museum Zoom application in June 2014 aimed to explore visitor’s learning outcomes when using Google Glass within the art gallery environment. The possibility to develop, test and iterate on the application through the close collaboration with the Manchester Art Gallery and developers at 33Labs means that requirement changes, content, functionality and user interaction amendments can be carried out throughout the project. Preliminary results indicate that the potential of personalised information delivery and interactive learning opportunities could significantly increase the visitor experience, and drive more people to visit art galleries, museums or exhibitions while simultaneously increasing dwelling time within these venues.

## **3 Methods**

The aim of the study is to assess how Google Glass enhances visitors’ learning outcomes within the art gallery environment. The Museum Zoom application was tested in two stages. The first stage aimed to assess user requirements while the second stage focused on the learning experience. In comparison to the first stage testing, the second testing focused on the functionality of the application and it has been extended to allow for a broader testing with multiple paintings to be incorporated. The application was designed for visitors to be in control of the learning experience by enabling the user to choose a painting of choice (from within a selected group of eight paintings – due to development constraints) and explore the information associated with the particular painting. From there, the user was in control of whether he wanted to follow recommendations for other paintings based on three categories, same medium, same artist or same theme. For the purpose of this test, those three categories were chosen for demonstration purposes, but the categories could be expanded to virtually anything information is available for. Apart from letting the user control the type of paintings that were explained, the application provided functionality for reading aloud additional information about the painting and artist through the built in bone conducting speaker. In addition, visitors could share the presented information regarding the viewed painting with a social network of their choice; navigate to the next selected painting through the provision of a location card

as well as image recognition to match the painting being viewed at initially with the correct information cards. Google Glass does not allow the creation of a full AR experience due to the design of the device being in front of only one eye, however it allows that content is overlaid on objects in the format of small cards. In order to evaluate visitors' learning outcomes, a qualitative interview approach was employed. Twenty-two participants were recruited via Manchester Art Gallery's Twitter, Facebook and webpage and were each allocated a time slot on the 16<sup>th</sup> and 17<sup>th</sup> of June. The profile of participants can be found in Table 1.

Table 1. Participants' Profile

	Gender	Age	Education	Innovativeness
P1	Male	20-29	Undergraduate	Moderate
P2	Male	30-39	Postgraduate	Moderate
P3	Male	40-49	Postgraduate	High
P4	Male	50-59	High School	High
P5	Male	30-39	High School	High
P6	Female	30-39	Professional Degree	High
P7	Female	20-29	Undergraduate	Moderate
P8	Female	30-39	Postgraduate	High
P9	Female	30-39	Postgraduate	Moderate
P10	Male	30-39	Postgraduate	Low
P11	Male	30-39	Undergraduate	Moderate
P12	Female	30-39	Undergraduate	Moderate
P13	Female	30-39	Undergraduate	High
P14	Female	20-29	Postgraduate	Moderate
P15	Male	20-29	Undergraduate	Moderate
P16	Male	20-29	Postgraduate	High
P17	Female	20-29	Undergraduate	Moderate
P18	Male	20-29	Undergraduate	High
P19	Male	30-39	Undergraduate	High
P20	Male	50-59	Postgraduate	Moderate
P21	Female	20-29	Undergraduate	Moderate
P22	Male	20-29	High School	Low

Before starting the experiment, functionalities such as voice command, swiping, taking pictures and sharing functions were explained and demonstrated by the researcher and projected to a smartphone screen for the participant to follow. Afterwards, participants were asked to try Google Glass to get familiar with the device for about ten minutes. After this, participants experienced the Museum Zoom application for 30 minutes focusing on three paintings within the art gallery before taking part in a 15-25 minutes interview. The test was limited to three paintings due to time constraints. The interviews were semi-structured and based on previous research (<http://www.inspiringlearningforall.gov.uk>) and asked questions from the five GLO (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, behaviour, progression) categories. Questions included "What have you

learned in the art gallery using Google Glass today?” (knowledge and understanding) or “What value do you see in experiencing paintings using Google Glass?” (attitudes and value). Two to four questions were asked in each category. In addition, two warm-up and wrap-up questions were asked. The obtained data were analysed using thematic analysis to identify key themes in each category of the GLO framework. Boyatzis (1998) supported the use of thematic analysis to form themes prior to the analysis while sub-themes are able to emerge during the process of analysing the data. The present study identified themes according to the GLO thus, thematic analysis was perceived to be most suitable.

## **4 Findings**

### **4.1 Knowledge and Understanding**

The interviews revealed that the majority of participants were able to improve their knowledge and understanding of the art because of Google Glass and the Museum Zoom application which provided participants with additional information on the painting, artist as well as similar paintings. P1 acknowledged “just using the Google Glass it makes the journey a lot easier and more seamless rather than just wondering around every single room” and P18 confirmed “it was a lot easier to digest the information”. P7 strengthened that particularly the audio made it easier to remember information. Furthermore, P2 pointed out that he had a better understanding as he was able to reference back to what he looked at previously. The importance of engagement for the creation of knowledge and understanding is another theme that emerged throughout the interviews (P3, P4). For instance, P3 felt more responsive because of the thematic approach of viewing art. In general, participants felt the idea to look at art based on similar themes to be a novel and refreshing approach. This was confirmed by P4 who felt more engaged with the art because of using Google Glass. Overall, during the interview process when being asked for specific details of the viewed paintings, a large number of participants had specific knowledge about artist, name of the painting, further information as well as the connection with another painting (P1, P3, P5, P6, P7, P10, P11, P14, P15, P20). In fact, P7 stated “I normally would not remember these kind of specifics. I think that Google Glass probably... made me more aware of these connections”. The same was confirmed by P13 “I was actually looking closer at the paintings and looking at them in more detail”. Although not so detailed, other participants were able to remember the paintings, order of paintings and that there were certain connection between the paintings (P4, P8, P16, P17, P19, P21). P4 pointed out “I was more focused on working the device...by the last painting I was probably more engaged with the art. I remember the specific with the Trafalgar square lions”. The problem with the novelty factor was also raised by P4 and P8 who stated that they could not remember anything specific about the paintings as they were struggling with the functions of the device and application. Finally, P9 argued “I was not in the mood of learning I was just looking at the technology and maybe the opportunities it can have” and a similar statement was also made by P22.

### **4.2 Skills**

In terms of new skills, participants had problems to identify how exactly Google Glass changed their behaviour. Two participants (P6, P15) identified ‘appreciation’ as

a new skill they have learned by using Google Glass in the art gallery. P6 and P15 supported that the application provided more information so they were able to appreciate the painting more. P1 stated “I would not say that it changes how I learn but it makes it easier and a bit more interactive” and P7 even referred to it as “intimate experience”. The idea of a more personalised and intimate experience was also picked up by P18 who concluded that this personalisation adds value to the art gallery visit and learning experience. Nevertheless, P2 commented “I found it a bit disengaged, well not disengaged but perhaps it doesn’t provide the potential of engagement”. On the contrary, P5 acknowledged, “I would normally look at the images and walk away but now I am asking myself different questions”. The enhanced paying of attention is another theme that was picked up by a number of participants (P4, P13, P16, P18). P13 furthermore added “it made me look at the art in a different way and look at the way it is constructed and the subjects in it rather than the painting as a whole” and also P14 confirmed that she paid more attention to using Google Glass. In addition, P4 strengthened that he can get as much information as possible without being overloaded. P16 pointed out a skill he has learnt during the test by thinking about “which themes [he] might be interested”. P18 stated “I think if I didn’t have the Google Glasses, I would have looked at the picture and left but I got a more rounded understanding of the picture and the context”. Therefore, overall, it can be seen from the responses that participants got a more personalised and engaged experiences which enhanced their skill to learn about the paintings. In fact, only P3 and P4 simply stated that they believed to have learned no new skill during the test.

### **4.3 Attitudes and Values**

In terms of general attitude towards and the value of Google Glass as an enhancer of learning within the art gallery, the participants supported themes regarding advantage, usefulness and benefit of Google Glass (P1, P2, P3, P6, P8, P12, P13, P17). P1, for instance, assessed that looking at painting with the information provided by Museum Zoom stimulated his mind and P2 and P3 confirmed that they were much more engaged with the painting. In addition, P5 found it more interesting to look at the paintings with Google Glass as it brought the paintings and information to life. According to P14 the “value for me is ... that [Google Glass] is able to direct your journey through the gallery much more specifically and I think there is a lot to be said for being able to create your own experience rather than what an audio guide tells you what to do step by step”. Therewith, P14 strengthened the importance to control your own art gallery visit journey. In addition, P6 and P8 confirmed that they have an overall positive attitude and see the potential value of using Google Glass as it enables to learn more. Three participants (P12, P13 and P17) elaborated on the theme of ‘adding value’ as the value of an interactive and educational experience through Google Glass was identified by P12 and P13. Also P17 confirmed “it made you kind of appreciate [the paintings] more and look at them more rather than just going around and glance at each”. Finally, P13 stated “I kind of appreciated the paintings more and it makes me ... want to come back here and have a look”.

### **4.4 Enjoyment, Inspiration and Creativity**

Within the theme of enjoyment, inspiration and creativity, ‘seamless experience’ was identified as a sub-theme throughout a number of interviews (P1, P2, P15, P20).



Interestingly, one might believe that enjoyment is key when it comes to the usage of Google Glass however, participants were more surprised and inspired by the seamless access of information (P20). P1 for instance acknowledged that the biggest inspiration and enjoyment of using Google Glass within the art gallery is that this “seamless experience” hinders her from getting bored, which is normally his case in art galleries. Further, P2 pointed out that “I was inspired by the fact that you can actually look at art in an interestingly technological informed way”. P15 stated that “I was most inspired by the connections between the paintings... and the way the pictures were brought together [as] it brought different parts of the gallery together”. The only disappointments were related to the sub-themes of limited amount of content (P1, P5, P7, P8, P14, P16, P21) as well as Google Glass hardware and software limitations. P16 pointed out that “the functions work but it needs more content... I would like to look at art from the same period and art that is created with certain materials... how someone has used material and how someone else has used the material in a completely different way”. In terms of hardware limitations, participants were disturbed by the low volume of the sound (P9), small size of prism, and difficulty of adjustment of the prism (P4). In addition, P6 was rather annoyed that “the technology was not as slick as expected” and also P11 and P12 confirmed that they were annoyed by the speed of using it. P10 identified the sub-theme of isolation as a negative aspect of using Google Glass within the art gallery. P10 clearly stated that he felt isolated and was “disappointed by maybe just how intrusive they can be and basically the distance that created and [he] was lost wearing them ... [and] didn’t like being cocooned by it”. In addition, P13 stated that she was disappointed because of the fact that she could not use it very well as she is short-sighted and had to take the glass off.

#### **4.5 Activity Behaviour and Progression**

The final set of questions asked participants whether they changed their behaviour or are likely to change their behaviour within art galleries as a result of using Google Glass. Overall, a large number of participant confirmed that the activity of using Google Glass will change their future behaviour (P2, P5, P12, P13, P16). P16 confirmed that “It just makes me very perceptive to new ways of viewing art”. P2 added that it forces visitors to engage more and that “in the future I will focus more on things and try to find ways to personalise my experience”. Also P5 stated “I will ask myself more questions at what I am looking at” and P12 and P13 assessed that it will fundamentally change the way they view art in public spaces. According to P13 “it will change the way I will be looking at the painting. I think I will look at the way paintings are constructed and look at the way subjects have been depicted more” and P12 pointed out that “ it makes me think more about what else is around and how pictures are linked together”. Nevertheless, P9, P14, P15 and P19 revealed that using Google Glass has not changed their behaviour during the test or their future intentions, for now. P15 strengthened that when Google Glass will be publically available and fully functioning it will change these kinds of experiences. In addition, P8 pointed out that Google Glass is an ideal tool to create an art gallery experience for international tourists due to the opportunities to easily adapt languages through Google. Furthermore, P20 stated to have been “more reflective” while using Google Glass and that “it deepens the experience... that information could all be looked up later, but you would not, so you know it actually deepens your experience and use of

time as it is instant". Interestingly, P6 had a relatively negative attitude towards the usage of Google Glass as she "felt more intrusive to the enjoyment of others" due to talking to the device. Amosford (2007) identified measuring informal learning is difficult as visitors have different purposes for visiting art galleries and not necessarily intend a learning experience which was supported by P6 who mentioned "I just like looking at art" and also P11 confirmed "I just go to look at some art ...I mean it is good to learn". P9 and P22 were two participants who clearly stated that they did not come with the intention to look at art in detail but to try out Google Glass hence, it was difficult to evaluate their overall learning experience.

## **5 Discussion and Conclusion**

This study aimed to identify whether Google Glass can enhance the knowledge and understanding, skills, attitude and values, enjoyment, inspiration and creativity as well as activity, behaviour and progression of visitors at Manchester Art Gallery. Previously, the GLO was applied to the learning experience of children and adults within museums, galleries and libraries (Amosford, 2007; Hooper-Greenhill et al., 2003) however, there is a notable gap in the literature with regards to the potential of wearable computing as an enabler of learning within galleries and museums (Leue et al., 2014). Therefore, this study contributes to the gap in the literature by investigating art gallery visitors' learning outcomes from using a new and innovative technology – Google Glass. Monaco and Moussouri (2009, p. 318) identified that learning entails that visitors see "something in a different light, making new links" and that was exactly what Google Glass helped to achieve within the test at Manchester Art Gallery. A large number of participants confirmed that they normally look at art individually without making any connections; however the availability of Google Glass helped to see new links and to look deeper. This is considered one of the prominent learning outcomes of using Google Glass within the art gallery. In addition, as far back as 2002, Sparacino identified the potential of wearable technologies to enhance and personalise the museum experience. Some participants confirmed that the biggest advantage of using Google Glass, as opposed to no technology or audio guides, is the ability to be in control of your own journey (Leue et al., 2014). Participants do not have to go on pre-curated tour but are enabled to follow paintings based on the interest in specific themes (i.e. time period, artist or in the case of the tested Museum Zoom application the theme of anatomically correct painted animals). Although latest audio guides follow a similar approach of allowing visitors to freely select a desired route based on personal preference (Huang et al., 2011), participants within the present study perceived Google Glass to be a more personal and convenient device due to the hand-free approach. In addition, Google Glass can be an important tool for tourism as it allows international tourists to experience destinations in their own language. In terms of learning opportunities, the present study suggested that all the information could be gathered after the art gallery visit or by researching using smartphones. However, the majority of visitors would not do that and therefore Google Glass was considered as an optimal tool to get instant information and that encourages visitors to see connections and dig deeper and thus, enhance the learning experience and outcomes. Previous scholars included interaction as key element of adult and life-long learning (Falk and Dierking, 2000,

Schauble et al., 1997). There has been a big part of interactivity within the Museum Zoom application, allowing the visitor to influence the journey, talk to the device, share content and take pictures and it was found that one of the biggest values of the experience was actively engaging in the art gallery experience. This concurs with research by Brophy and Butters (2007) who found that interactivity, engagement and ease of use are crucial elements of learning. Overall, Google Glass can therefore be considered a good device to facilitate the learning experience as its functionalities allow the provision of interactive content; while being relatively small, lightweight and unobtrusive (Kahn, 2013). However, it also has to be noted that two participants felt Google Glass to be intrusive making them feel isolated from their environment and thus, had a negative effect on their experience. Monaco and Moussouri (2009) suggested that learning outcomes may entail changes in knowledge or skills however, may also be more subtle. Talking to participants it was found that using Google Glass and looking at paintings in a different way enhanced the appreciation of art which supports Monaco and Moussouri's (2009) findings that learning includes more than solely the increase of knowledge. Using new and innovative devices seems to change the viewpoint which may change future visit activity and behaviour.

### **5.1 Theoretical and Practical Implications**

Theoretically, this study applied the GLO framework to a new and unexamined field of Google Glass wearable as an enhancement of the learning experience within an art gallery. This study is an extension of the GLO framework in the wearable learning in the art gallery context. Previous research looked at the mobile learning context within museums and art galleries (Lonsdale et al., 2005), however due to the novelty factor of Google Glass, research focusing on these cutting-edge devices is scarce. Therefore, this research can be seen as a foundation for future research in wearable learning in museums and art galleries. It provides academia with the understanding of how innovative technologies are perceived by art gallery visitors. Practically, this study has shown the enormous opportunities wearable devices offer for the cultural heritage sector to enhance user experience and learning outcomes. The study identified the positive overall attitude to use Google Glass as an enhancer of the art gallery learning and visiting experience. Therefore, it could be considered as a starting point for art galleries to consider implementing wearable technologies. Despite the problems viewing the content due to being short sighted, this is no real limitation for Google Glass as such, as they are working on prescription lenses for the devices. Nevertheless, this needs to be considered by museum and art galleries that plan to provide Google Glass to their customers. In addition, the positive aspect of Google Glass is, similar to audio guides, that not all visitors have to use it. Thus, visitors who benefit from an enhanced learning experience and are curious to try it out can do so without interrupting fellow visitors' experiences. Therefore, art galleries are encouraged to offer its visitors this unique experience in order to enhance life-long learning, attract new markets and provide more personalized and interactive experiences.

## 5.2 Limitations and Future Research

There are a number of limitations within the present study. Due to the sampling technique, recruiting participants via social media and the website, there is not equal distribution among age groups, with the group below twenty and above sixty years of age not even being represented. In addition, 59 percent of participants were male. Nevertheless, Wood and Hoeffler (2013) suggested that the stereotyping of genders with regards to innovative technologies (men are more tech savvy than women) is accurate. Considering the voluntary participation and the selection of participant through social media; the majority of males within the sample accurately reflects patterns from other studies. Nevertheless, this affects the possibility to project findings to a wider target market and future research should incorporate a wider spectrum of participants. Furthermore, the test was performed in a controlled environment where participants were told which paintings to look at and where to go next. This might have influenced the learning experience. However, due to the limitations in content provided in the Museum Zoom application, participants only had the options of experiencing certain paintings. Another limitation is that participants could have been segmented into technology adoption classes based on their perceived degree of innovativeness as the general attitude and behaviour with respect to technology could have an impact on the outcome of the Google Glass experience. This could be addressed by future research. In addition, future research should include control groups in order to better understand the potential of Google Glass and wearables to enhance the learning outcomes. Not having identified learning outcomes from a group that used a different technology (e.g. audio guide) makes it difficult to measure how and why the learning was enhanced. Therefore, the present study can only provide subjective findings regarding learning outcomes. On the other hand, a testing of the application in a lab setting might provide valuable insight into dwelling times and actual usage behaviour. In addition, Google Glass provides further opportunities for urban cultural heritage destinations and future research could test Google Glass applications outdoor environment. Furthermore, the present study used local art gallery visitors as sample, however as discussed Google Glass could be an ideal technology to enhance tourism experience and also tourists' learning experience and thus, future research should investigate the potential of Google Glass to enhance the experience in tourism destinations.

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