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Enhancing the Museum Experience of an Augmented Reality (AR) Art Exhibition Through Digital Exhibit Labels and Gamification

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ABSTRACT

Due to emerging and disruptive technologies, museums are searching for ways to enhance their visitors' experience. This paper investigates aspects of an Augmented Reality (AR) art exhibition for their potential effects on a visitor's museum experience and engagement. Through a mixed-experimental design we tested the effects of two factors, namely the exhibit label's Channel (print vs. digital) and the presence of Gamification (none vs. quiz game). Forty-seven participants were randomly assigned to one of two groups, each with two treatments: (1) Print – No Gamification and With Gamification (n = 24), (2) Digital – No Gamification and With Gamification (n = 23). Results revealed that displaying exhibit labels for AR artworks in digital rather than print form resulted in a significantly higher level of Cognitive Absorption among participants. This, in turn, had a positive impact on visitors' aesthetics, education, entertainment and escapism (4Es), and ultimately both engagement and behavioural intentions.

Keywords

Augmented Reality, art museum, visitor experience, gamification, cognitive absorption, engagement.

INTRODUCTION

Today's art museums are facing difficult times and operational challenges. The variety of leisure activities and cultural experiences is constantly expanding, which affects the interest in museums among contemporary visitors. In addition, with emerging and disruptive technologies, museums need to reinvent themselves and find new ways to attract and engage visitors. This may be achieved by adapting new technologies to make the visitor experience more memorable and personal (Cranmer *et al.*, 2021). One such technology is Augmented Reality (AR). The number of AR users globally is expected to increase significantly to 1.73 billion [28]. As technology has advanced in recent years, artists have increasingly turned to AR to express themselves and create immersive, multi-sensory experiences. This innovative technology allows them to enhance their artworks or existing classic artworks, and to create an engaging visitor experience (Camilleri, 2020).

While museums and art galleries have been using AR art more and more in recent times, little is known about which aspects of an AR art exhibition affect visitors' experiences, engagement, and/or behaviours. This research aims to fill this gap in the current literature by analyzing these impacts in an art museum context from two distinct perspectives. *First*, it seeks to determine the best practice for displaying exhibit art labels of AR artworks (print vs. digital). In museology, exhibit labels are seen as a powerful tool of communication to convey information to visitors: they act as the main channel between museum meaning and the visitors' comprehension (Faron, 2003). *Second*, this study explores whether there is a difference in experiences when an AR art museum visit includes gamification in the form of a quiz game. Previous studies focussed on the design and development of a quiz game for cultural heritage (Prange *et al.*, 2017) or the educational benefits of implementing quiz games in museums (Noreikis *et al.*, 2019). However, there appears to be a lack of research on the impact of quiz games on visitors' engagement with the exhibition and subsequent behavioural intentions in the context of an art exhibition.

Based on the above-mentioned aims, this study will be guided by the following two research questions while drawing on existing literature and theories:

> **RQ1.** What are the impacts of displaying exhibit labels of an AR artwork in digital versus print form on the visitor's experience, engagement, and behavioural intentions (to recommend and to revisit) in the context of a museum?
>
> **RQ2.** What are the impacts of involving gamification in the form of a quiz game in an AR art exhibition on the visitor's experience, engagement and behavioural intentions (to recommend and to revisit) in the context of a museum?

The structure of this article is as follows. First, we will provide an overview of extant literature, from which we develop and present our hypotheses along with the proposed research model to be empirically tested in this study. Following that, we present the study's methodology as well as the results. We then discuss our study's findings and the associated theoretical, applied, and methodological

implications. Finally, we consider the limitations of this study and propose future directions.

LITERATURE REVIEW & HYPOTHESIS DEVELOPMENT

This section presents four theoretical and conceptual perspectives on museum visitor experience before concluding with a proposed research model (see Figure 1) that reflects the hypotheses proposed below.

The Multimedia Learning Theory (MLT) is a collection of principles on how to deliver words and visuals together for the best learning outcomes. This theory essentially states that learning with words and pictures is more effective than learning only with words (Mayer & Moreno, 2003). One of its main principles, *Spatial Contiguity Principle*, posits that images and their textual captions be placed close together. This allows learners to focus their cognitive effort on building connections rather than spatially aligning the meaning of text and images (Mayer, 2009).

Cognitive Absorption (CA) is a multi-dimensional construct that is conceptually related to flow (Csikszentmihalyi, 1990). It is a mental state that describes how involved individuals are when interacting with technology, software, or a virtual world (Occa & Morgan, 2022). Agarwal & Karahanna (2000) define CA as a concept with five dimensions: (1) Curiosity, (2) Control, (3) Temporal Dissociation, (4) Focussed immersion, and (5) Heightened Enjoyment. Based on the *Spatial Contiguity Principle* presented above, we hypothesize that displaying exhibit labels in digital form alongside AR enhanced artwork on the same mobile interface will be more conducive to the information being processed by visitors. We anticipate that visitors who read the exhibit label through the same channel (in our case, the mobile app) rather than the print label on the easels will be less distracted and have a lower cognitive load, resulting in a higher state of CA when viewing the AR artworks. Hence:

> **H1:** The exhibition artwork label's Channel will have an impact on CA such that digital labels will be associated with higher CA than print labels.

Gamification, is the use of game design elements in non-game contexts to increase motivation to complete specific tasks (Seaborn & Fels, 2015). It is commonly used in educational settings to increase learning motivation. The game elements include, among others, badge, leaderboard, level, time constraint, clear goals, challenge, and curiosity (Deterding *et al.*, 2011).

Previous research showed that the primary goal of educational gamification is to increase CA, engagement, and learning outcomes (Nah *et al.* 2013). According to Nah *et al.* (2013), the choice of system design elements such as leaderboards, points or challenges / questions will have an impact on CA and the overall gaming experience. Controlling for the quality of implementation of the system design elements selected in a gamified context, it is reasonable to expect that gamification, in aggregate, will positively impact Cognitive Absorption (CA) and, in turn, the visitors' engagement. Hence, we propose:

> **H2:** Gamification will have a positive effect on CA.

Pine & Gilmore (1998) developed the Experience Economy theory (also known as the 4Es) at the end of the 1990s, and it has been used numerous times by scholars in various fields and studies since then (Barhorst *et al*., 2021). This theory's authors argue that a memorable experience should include elements from four different realms: *entertainment, education, esthetics,* and *escapism*. According to them, the richest experiences incorporate elements from all dimensions, resulting in the ideal overall experience (Pine & Gilmore, 1998). Previous Information Systems (IS) research on AR and VR (Virtual Reality) in cultural tourism found that CA is one of the key factors that affects visitors' experiences (Han *et al.*, 2019). Thus, we hypothesize that:

> ***H3:*** *CA will have a positive impact on the 4Es.*
>
> **H3a:** CA will have a positive impact on esthetics.
> **H3b:** CA will have a positive impact on education.
> **H3c:** CA will have a positive impact on entertainment.
> **H3d:** CA will have a positive impact on escapism.

In the museum context, Othman *et al.* (2011) developed the Museum Experience Scale (MES) to assess the effect of technology and exhibitions on visitors. This scale, which is composed of four different factors, one of which is engagement with the exhibition, has been used in several studies in the museum context (Gong *et al.*, 2022).

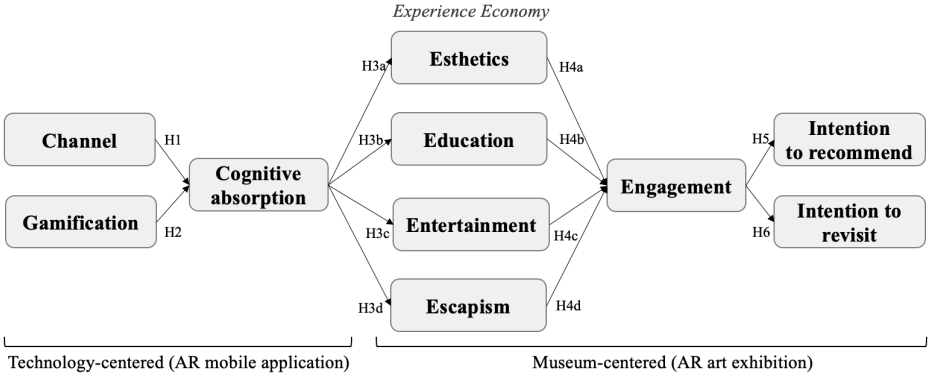

Figure 1. Proposed Research Model

Given this explicit link between experience and engagement, and referring to the previously mentioned Experience Economy, it is reasonable to expect that the latter's four core dimensions will increase visitors' engagement. This posited link is in line with Tom Dieck *et al.*'s research (2018) on AR in a tourism setting. Their results revealed a positive correlation between the 4Es model and visitor engagement (mediated by satisfaction and memory). Hence, we hypothesize that:

H4: *The 4Es will have a positive impact on engagement.*

H4a: Esthetics will positively impact engagement.
H4b: Education will positively impact engagement.
H4c: Entertainment will positively impact engagement.
H4d: Escapism will positively impact engagement.

Customer loyalty is a primary goal in all businesses to ensure their long-term viability. In tourism research, the likelihood of returning and recommending are the two most commonly used measures of loyalty (Chen & Chen, 2010). A recent study on museum experiences found that visitors who are engaged are more likely to return and recommend their experience to others (Loureiro & Ferreira, 2018). Another study on the effects of VR and AR in a museum setting analyzed how the 4Es model affected the visitors' experience and ultimately their revisit intention (Jung *et al.*, 2016). That research showed that with the exception of aesthetics, the remaining 4E dimensions had a significant effect on visitor experience, which in turn had an effect on behavioural intentions. By extension, we propose that:

H5: Engagement with the AR exhibition will positively impact the intention to recommend it.

H6: Engagement with the AR exhibition will have a positive impact on intention to return.

The above hypotheses are reflected in a proposed research model (see Figure 1). As can be inferred from it, upstream factors are technology-centered (i.e., use of a mobile AR app and a quiz game), while downstream factors are museum-centered (i.e., related to the technology-afforded museum experience and its outcomes).

METHOD

Experimental Design

A mixed experimental design with two factors was used to empirically validate the proposed research model presented above. Our two experimental manipulations were: (1) Channel, which displayed the exhibit labels either in *print* form beneath the artwork on the easel or in *digital* form via the mobile app, and (2) Gamification, which was in the form of a *quiz game* vs. no gamification being used. We used a between-subject design for the manipulation of the Channel, and a within-subject design for the manipulation of Gamification. Forty-seven participants were recruited and randomly assigned to one of the two condition pairs: (a) Print – No Gamification and With Gamification (n = 24), (b) Digital – No Gamification and With Gamification (n = 23).

Experimental Stimulus and Setup

The stimulus for this study was the AR art exhibition "Austria and Canada: A Unique Bond". The artists of this exhibition did not only create the physical artwork, but also a digital layer for the same artwork. The participants had to use the mobile app "Artivive", a visualization tool, to see the AR effect applied on each of the artworks.

As one of the two manipulations used a within-subject design, the pop-up art museum created for this study was separated in two sections (see Figure 2): the left section (no gamification) and the right section (with gamification). Both sections featured the same type of artwork to have two similar and well-balanced museum sections: (1) Nature, (2) Architecture, (3) People, (4) Abstract, (5) Forms and objects. Seven out of ten artworks were enhanced with sound and/or music.

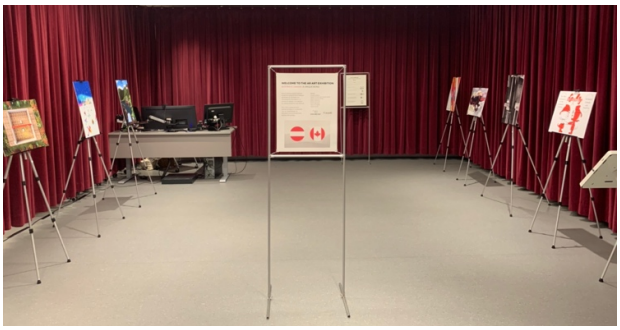

Figure 2. Pop-Up Art Museum Divided in Two Sections

Throughout the experiment, participants read exhibit labels in either digital or print form. The exhibit labels had an average text length of 224.40 characters (range: 123-300) and 36.70 words (range: 20-51). The digital exhibit labels were already integrated into the Artivive app by the artists.

For the gamification condition, we created a quiz game on the website quiz-maker.com with five questions and three response options each. Participants could earn one point for each correct answer and could see a progress bar and a leaderboard at the end of the quiz game. Moreover, the quiz game was interactive: after each correct or wrong answer, the participants could see an explanation text. Participants completed the quiz game on a tablet after viewing the five artworks in the right section of the museum.

Sample

The target population for this research was individuals, ranging from young adults to seniors, who were interested in visiting a museum art exhibition in AR. Among the 47 recruited participants, 18 identified as men and 29 as women. All participants were between the age of 20 and 65 with an average age of 34.96 years for both men and women (*SD* = 13.25). This research was approved by the authors' institution's Research Ethics Board (Certificate #2023-5055). All participants signed a consent form for participating in this study and were compensated with CAD $20 at the end of the experiment.

Procedure

Prior to the 90-minute in-person experiment, eligible participants were randomly assigned to one of the two conditions. After the participants signed a consent form, the tools for collecting physiological data were attached to their non-dominant hand (two EDA sensors) and to their chest (three ECG sensors). Before beginning the tasks, participants had to complete a pre-questionnaire on a tablet and an on-boarding task to become acquainted with the Artivive app on a smartphone (iPhone 11).

The sequence of the two tasks was counterbalanced: 23 participants began with Task 1 and 24 began with Task 2. In Task 1, participants were asked to appreciate the artwork without using their smartphone. Then, they had to scan the artwork with the Artivive app and view it through their smartphone (see Figure 3). Depending on their assigned condition, participants had to read the print label of each artwork displayed on the easel or the digital label via the Artivive app. As most of the artworks were enhanced with sound and/or music, participants wore in-ear headphones.

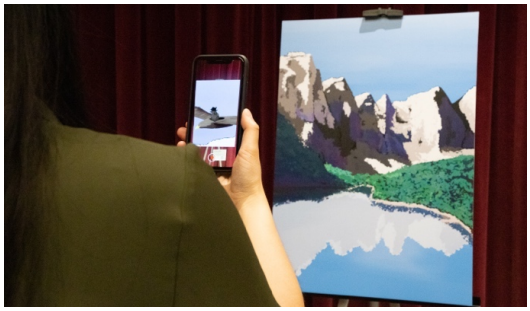

Figure 3. Viewing an AR Artwork Via the Artivive App

For Task 2, participants had to repeat the preceding steps from Task 1, but this time they also had to play a quiz game on the tablet. Moreover, participants were told that they were competing against other museum visitors that have also viewed this AR art exhibition. At the end of the quiz, they saw a leaderboard with their ranks and score.

During both tasks, participants could record 10-second videos of the AR artworks on the smartphone (an Artivive app feature) if they wanted to keep a copy of their museum visit. Following each task, participants completed a post-task questionnaire. Finally, they answered a post-study questionnaire, discussed their experience in a brief semi-structured interview, and filled out a compensation form.

Measurements and Operationalization

The measurement items in this research study to analyze the various constructs were adapted from existing studies whenever possible. All of the 7-point Likert scales used in this research study ranged from 1 to 7, with 1 being "strongly disagree" and 7 being "strongly agree".

Cognitive Absorption data was gathered through a 7-point Likert scale with 18 items. This scale was adapted from the research by Guinaliu-Blasco *et al.* (2019), the latter adapted from Agarwal & Karahanna (2000).

Data on the *Experience Economy* were collected through a 7-point Likert scale with 14 items, which were adapted from Tom Dieck *et al.* (2018). They had used this scale in a study on AR at a Science Festival.

Engagement with the exhibition was measured through four ways.
First, by using a 7-point Likert scale with 5 items, which were adapted from one of the four Museum Experience Scale (MES) components (Othman *et al.*, 2011) that explicitly measured engagement.
Second, physiological data were collected with the Cobalt Bluebox device (Courtemanche *et al.*, 2022). This device monitored electrocardiography activity (ECG) and electrodermal activity (EDA), also known as galvanic skin response, in participants by examining changes in sweat gland activity. An increase in ECG and EDA levels while performing a task can be interpreted as an increased physiological arousal (Dawson *et al.*, 2017).
Third, the Affective Slider (AS), an equivalent to the Self-Assessment-Manikin (SAM) scale in terms of self-reported valence and arousal (Betella & Verschure, 2016), was used to measure both emotion dimensions. The AS was used along with the physiological approach to measure emotion thus allowing for triangulation, leading to more accurate assessment outcomes (Brissette-Gendron *et al.*, 2020).
Forth, in terms of behavioural engagement, two measures were used: (1) the number of 10-second videos of the AR artworks participants had saved to their smartphones, and (2) their task completion time.

Finally, *behavioural intentions* (i.e., recommendation and revisit), were measured using a 7-point Likert scale with 5 items each, both adapted from Bonn *et al.* (2007).

Data Collection and Analysis

A baseline was established, and each participant's average EDA and ECG values were recorded while they completed the pre-questionnaire on the tablet. The baseline mean was subtracted from each participant's recorded EDA and ECG value. Due to technical issues at the beginning of the study, the physiological data from eight participants were discarded, reducing the usable sample from 47 to 39.

SAS software, Version 9.4, was used for all statistical analyses (SAS Institute Inc., Cary, NC, USA). Cronbach's alpha scores indicated that each construct's internal consistency had a high level of reliability, with scores ranging from good to excellent (from 0.83 to 0.97). A linear regression with random intercept model was used to evaluate how our two independent variables (channel and gamification) had an impact on CA, the 4Es, engagement, and, ultimately, our dependent variables (intention to recommend and intention to revisit). For the two dependent variables, they did not pass a normality test. However, assumption of normality is based on a sufficiently large sample size. As a result, it is presumed that the dependent variables follow a normal distribution.

RESULTS

The results for each hypothesis test and our study's main findings are presented below. All statistical analyses were one-tailed tests with a significance level of 0.05, and all hypotheses were tested using a linear regression with random intercept model, unless otherwise specified.

Independent Variables (Channel and Gamification) and Cognitive Absorption (CA)

The results reveal that Channel (in the form of digital exhibit labels) had a significant impact on the construct CA (t = 1.77, p = 0.042). However, there is no evidence that our experimental manipulation of gamification had an influence on CA (t = -0.20, p = 0.581). Thus, results support H1 and reject H2. Descriptive statistics confirm that, regardless of the presence or absence of gamification, the mean scores for CA were higher for channel in the form of digital exhibit artwork labels (No Gamification: M = 5.826, SD = 0.686; Gamification: M = 5.771, SD = 0.658) than for print labels (No Gamification: M = 5.436, SD = 0.740; Gamification: M = 5.461, SD = 0.783).

Cognitive Absorption and Experience Economy (4Es)

Our findings show that CA had a significant positive effect on each of the core dimensions of the 4Es, namely esthetics (t = 5.76, p < .0001), education (t = 4.37, p < .0001), entertainment (t = 10.02, p < .0001) and escapism (t = 3.02, p = 0.041), validating H3a, H3b, H3c and H3d. As these four sub-hypotheses have all been validated with significant results, we can conclude that our main hypothesis H3 (t = 8.61, p < .0001) has been fully supported.

Further statistical tests reveal that the physiological data of High-Frequency power or HF (adjusted to baseline) recorded by ECG sensors had a significant effect on the core dimensions esthetics (t = -2.01, p = 0.054) and entertainment (t = -2.47, p = 0.012) at the significance level of 0.10. The higher the HF value, the lower the perceived level of esthetics provided by the art exhibition experience. Moreover, the results show that the Low-Frequency power/High-Frequency power ratio, or LF/HF ratio (adjusted to baseline) recorded by the ECG sensors, seemed to also have a significant positive effect on entertainment (t = -2.06, p = 0.049).

4Es and Engagement (with the Exhibition)

Our results indicate that the 4Es core dimensions of esthetics (t = 2.21, p = 0.016), education (t = 5.06, p < .0001), and entertainment (t = 7.07, p < .0001) had a significant positive effect on the construct engagement respectively, supporting H4a, H4b and H4d. However, support was not obtained for the effect of escapism on engagement (t = 0.26, p = 0.398), thus rejecting H4d.

To confirm our main hypothesis H4, we combined the four core dimensions of the 4Es as one variable by calculating their respective means (EST, EDU, ENT, ESC) with an acceptable Cronbach's alpha score of 0.74. The results of our statistical test suggest that the 4Es has a positive effect on the construct engagement (t = 9.1, p < .0001) supporting H4. Also, our outcomes show that the perceived arousal (ARO) and self-reported valence (VAL) have a statistically significant positive effect on engagement (ARO: t = 2.46, p = 0.018; VAL: t = 2.58, p = 0.013).

As for the physiological data gathered, the results suggest that the phasic activity (adjusted to baseline) recorded by the EDA sensors has a significant positive effect on the construct engagement (t = 2.19, p = 0.036). The LF/HF ratio (adjusted to baseline), recorded by the ECG sensors, appeared to have a significant negative effect on engagement (t = -2.34, p = 0.027).

Engagement and Behavioural Intentions

According to the results, the construct engagement (with the exhibition) had a significant impact on the behavioural intention to recommend (t = 13.86, p < .0001), validating H5. No significant differences were found between the number of saved videos of AR artworks by participants and their intention to recommend (t = 0.31, p = 0.756).

Finally, our results show that our construct engagement has a significant effect on the intention to recommend (t = 6.82, p < .0001), thus supporting H6. Furthermore, unlike the dependent variable of intention to recommend, results show that the number of saved videos (behavioural engagement) had a significant impact on the intention to return to the art museum (t = 2.93, p = 0.005).

DISCUSSION AND CONCLUSION

This research contributes to the literature by identifying which elements of an AR art exhibition have a positive impact on visitors' engagement and behavioural intentions in a museum context.

Our study involved two experimental manipulations: channel (digital vs. print exhibit labels) and gamification in the form of a quiz game. Results show that the channel used for the art exhibit label impacted Cognitive Absorption such that digital labels facilitated greater CA than print labels. These findings are in line with the *Spatial Contiguity Principle* and provide empirical validation that individuals can process the exhibit label of an AR artwork on the screen more effectively than reading it from the easel. However, contrary to expectations, no significant difference was observed in terms of the impact of gamification on the participants' CA. One of the reasons could be that the quiz game was too short in length or too lean in the system design elements leveraged to allow participants to be more cognitively absorbed. Results could have been different if a more challenging quiz game with a larger number of questions had been used, or if we had included other system design elements from Nah *et al.*'s (2013) Gamification Framework in the quiz game.

Moreover, study results revealed that CA had a positive impact on the 4Es. We can therefore conclude that the more cognitively absorbed the participants are in the context of

the AR art museum, the higher their perceived level of being esthetically contented, educated, entertained, and getting away from the daily grind. The correlation between CA and the Experience Economy is in line with Han *et al.* (2019) who identified that CA as one of the key factors affecting visitor experiences in cultural tourism.

In turn, results show that the construct 4Es had a positive impact on the engagement with the exhibition in an art museum setting. This finding is supported by Tom Dieck *et al.*'s study (2018) in the context of a science festival where the 4Es affected positively the visitors' engagement mediated by satisfaction and memory. When the 4Es were examined separately, esthetics, education, and entertainment had positive effects on engagement. However, no evidence was found for escapism.

Furthermore, our results indicated a positive relationship between perceived emotions and engagement: the higher the participants' valence and arousal, the higher their engagement. Our research also revealed that there was a correlation between engagement and the phasic activity (adjusted to baseline) recorded by the EDA sensors. As a result, we can conclude that the greater the physiological arousal of the participants, the greater their engagement with the AR art exhibition. These findings are consistent with Brissette-Gendron *et al.*'s (2020) previous study in the context of a digital game, in which an increased emotional arousal resulted in higher engagement.

Our results also showed that engagement had a positive impact on both behavioural intentions. That is, the more engaged the participants were, the more likely they were to recommend and return to the AR art exhibition experience. Finally, in terms of behavioural engagement, the more videos of the AR artworks participants saved, the more likely they were to revisit.

In conclusion, the current research adds to the body of knowledge by providing empirical evidence that displaying exhibit art labels in digital form of AR artworks has a higher level of CA on visitors than the print form in the context of an art museum. These results will be helpful for designers and museums who seek to improve the user experience (UX) of appreciating AR artworks and reading the exhibit labels. In addition, our study's results revealed that being cognitively absorbed has a positive impact on the visitors' experiences (namely on the dimensions of esthetics, education, entertainment, and escapism), and thus on both engagement and behavioural intentions (intention to revisit and intention to recommend). We believe that museums will benefit from our findings by incorporating them into their strategies, resulting in increased visitor loyalty.

LIMITATIONS AND FUTURE WORK

As with any study, some limitations should be addressed. One of the main limitations of our experiment was that it was conducted in a lecture hall at our university. Even though our research team put a lot of effort in transforming it in a real museum, it would be unrealistic to compare it with an authentic art museum setting. Future studies should consider conducting an experiment in a real museum setting or art galleries testing to see if their findings are consistent with those of this study.

Second, our experiment was designed to run with one person at a time. In a typical art museum setting, the visitor number is higher, and often several people view the same artwork at the same time. It would be interesting to conduct research on visiting an AR art exhibition with a friend, relative, or a group of people, and seeing if results differ.

The purpose of this study was to fill a gap in the literature regarding the museum experience of AR art. Our study also sought to explore which aspects of an AR art exhibition influence visitors' experiences, engagement, and behavioural intentions in relation to museums. Our research findings will be beneficial to museums, which are finding it increasingly difficult to attract and engage visitors due to emerging and disruptive technologies. It also provides empirical validation for designers on how to enhance the visitors' museum experience related to AR technology. We hope that our study opens up new avenues for research related to AR art that is increasingly used by artists and art museum these days. Finally, we hope that our findings will spur future empirical studies to conduct additional research on elements of an AR art exhibition that may improve the museum experience.

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