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Designing for Engagement: Uncovering the Impact of Participatory AR Activities on Visitor Engagement and Learning in Art Museums

par
Chantel Chandler

Constantinos K. Coursaris
HEC Montréal
Directeur de recherche

Pierre-Majorique Léger
HEC Montréal
Codirecteur de recherche

Sciences de la gestion
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Abstract

This thesis aims to explore how augmented reality (AR) and participatory activities can be applied in an art museum context to enhance the shared visitor experience. In recent years, art museums have embraced the benefits of AR technology and the novel experiences that it could afford to visitors of all ages. Research suggests that exhibitions incorporating AR have led to successful outcomes, such as increased visitor engagement and enhanced learning experience. However, these AR-based exhibitions are typically designed for individual experiences rather than shared ones. Studies on museum visit motivation reveal that visiting a museum can be considered a social activity in which people are accompanied by friends or family, often exchanging their thoughts and ideas during or after a visit. Therefore, there is a gap in the literature regarding the ways in which AR technology can be implemented to enhance the shared visitor experience.

An experiment was conducted to explore how participatory activities using AR could be incorporated in a photography exhibition. Pairs of participants were recruited using the university study panel, resulting in 18 pairs, or 36 participants total. Two activities were created using design principles and elements of gamification and gameful design: a reward-oriented "gamified design" activity (i.e., Scavenger Hunt), and an expression-oriented "gameful design" activity (i.e., Storytelling Game). Using a between-subjects experimental design, 12 participants were assigned to three conditions: a control group and two treatment conditions ("gamified design" and "gameful design"). The participatory activities were evaluated for their impact on participants' perceived levels of engagement and learning post-activity. Additionally, the theoretical framework of the Self-Determination Theory (SDT) was incorporated to investigate the role of intrinsic motivation in influencing engagement and learning. Physiological data was also collected to assess engagement via electrodermal activity (EDA) and heart rate (ECG). Results suggest that intrinsic motivation is a significant predictor for engagement, but not for learning. Further, the "gamified design" activity led to significantly higher levels of perceived engagement and learning. Implications emerging from this research for both theory and practice are discussed.

Keywords : Augmented Reality (AR), art museum, photography, participatory activities, gamification, gameful design, intrinsic motivation, self-determination theory (SDT), learning, engagement

Research methods : experiment, behavioral observations, physiological data, questionnaire, interview, inductive thematic coding

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List of Abbreviations and Acronyms

AR – Augmented Reality

VR – Virtual Reality

MR – Mixed Reality

IS – Information Systems

SDT – Self-Determination Theory

MDA – Mechanics-Dynamics-Aesthetics

ELS – Educational Leisure Setting

Preface

This thesis, which was prepared in the form of articles, was submitted and approved by the Master of Science program Academic Affairs office.

The empirical study conducted as part of this master's thesis received approval by the HEC Montreal Research Ethics Board (CER) in June 2022 under the project number 2023-5055.

The article in Chapter 2 was written and submitted to the *ACM CHI Conference on Human Factors in Computing Systems*. This article, which had undergone two rounds of reviews, was ultimately not accepted. The article in Chapter 3 was written in preparation for submission to the publication *Curator: The Museum Journal*.

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Acknowledgements

It is an understatement to say that I have learned many things over the course of this program and completion of this thesis. Along this journey, I have been fortunate to have learned and received support from my supervisors, professors, peers, and many more.

I would first like to express my gratitude to my supervisors Constantinos Coursaris and Pierre-Majorique Léger who supported me throughout this process. They provided their wisdom and guidance as I developed my research topic and allowed me to study an area that I was passionate about while posing critical questions to ensure that my research would have a solid foundation. Thank you for your patience and encouragement!

I would also like to thank members of the Tech3Lab staff that helped me along the way, and most especially during the data collection process. Salima, David, Xavier - thank you!

I would like to express my appreciation for the NSERC grant (R2579) for funding my research and enabling me to contribute new findings and insights to fellow researchers who wish to explore the future avenues of AR in the art museum space. Art museums are not exclusively places for art; they are also a place for people. If my research can help influence the design of future AR exhibitions and improve the experience for art museum visitors in some way – however big or small – I would consider that to be a great success.

I would like to thank Patrick Vierthaler for granting me permission to incorporate his photography in my thesis project. It brought me great joy to see the beautiful scenes and depictions of Kyoto during my data collection and throughout this thesis process. I was fondly reminded of my time living in Japan and the places I visited in Kyoto, and it inspired me to "*ganbare*" and overcome the challenges I faced along the way.

A special thank you to Lan-Chi for her collaboration and being a part of this journey.

Finally, I would like to thank my partner Francis for his never-ending support and encouragement. Thank you for always believing in me and reminding me to do the same.

Introduction

Context

According to a recent market research report, the population of Augmented Reality (AR) users in the United States is predicted to increase from 28.6% to 30.5% by next year, which accounts for about 104.3 million people (eMarketer, 2022). AR technology has become more popular in large part due to social media applications, such as Facebook, Snapchat, and Instagram, which allow users to activate AR face filters to enhance their videos and photos. As of this year, it is estimated that about 17.8% of users, or about 60.5 million people, consume AR content through social media applications (eMarketer, 2022). However, due to the increasing availability of AR technology on the modern-day smartphone, it has also been adopted in other contexts, including games, shopping, navigation, education, and art. One area of particular interest is that of museums.

In recent years, museums have adopted digital technology, notably AR and VR, and incorporated them as part of their exhibitions. AR provides an opportunity for visitors to interact with the content of an exhibition in a more dynamic and active manner, such as through multimedia content that enhances or enriches their visit experience. This differs from the traditional experience of passively consuming information or viewing artistic or cultural artifacts on display. Studies suggest that offering AR technology as part of the museum visit experience can provide a more engaging learning experience (Attila and Edit, 2012; He et al., 2018), particularly for younger audiences who may not otherwise visit museums (Henderson and Atencio, 2007; Matuk, 2016.). Additionally, some AR applications allow visitors to share aspects of their visit experience with others through social media, such as videos or photos taken with cultural artifacts or artwork. This can satisfy the need for visitors to connect with their friends and family, as well as function as a manner of advertising for the exhibition or museum (Attila and Edit, 2012). Thus, despite the potential cost for developing and implementing AR-based exhibitions, museums have embraced the benefits of AR to enhance the visitor experience and engagement.

However, as AR-based exhibitions are becoming more commonplace in museums, there is the possibility that the perceived novelty of such experiences will diminish over time. Indeed, it is essential that AR-based exhibitions be designed appropriately and adapted to the content featured so as not to be perceived as mere market strategy gimmickry. In the case of art museums, AR can be incorporated as either an integral part of the exhibition itself, or as a supplemental and optional participatory activity. Moreover, it could function as a storytelling tool to help with presenting the narrative of the exhibition (Barry et al., 2012), or as a manner of interacting with the artwork in a more engaging or deeper level. One such avenue that has been explored by museums is that of AR-based game applications, which are designed using aspects of gamification to provide a more engaging learning experience (Khan et al., 2020; Camps-Ortueta et al., 2021). Gamification is the use of game design elements in non-gaming contexts (Deterding et al. 2011). For instance, competing with fellow visitors in challenges to earn points and rewards. Although such AR applications using a "gamified design" approach can be found in the context of cultural heritage or tourism, instances specifically adapted to art museums have not been explored as of yet.

Further, considering that art museums are known to be creative spaces which inspire visitors to imagine and emotionally connect with artwork, it is not certain that a "gamified design" approach would be suitable for this context. Nicholson (2012, 2015) discusses a potential alternative to this approach called "meaningful gamification," which also makes use of game design elements, but with the purpose of encouraging creativity, expression, and reflection. Nicholson argues that the use of "gameful" and "playful" aspects can be intrinsically motivating and result in long-term engagement, whereas the "gamified design" approach is more extrinsically motivated through external factors such as rewards, which are limited to short-term engagement.

According to Nicholson, the adoption of a "gameful design" approach could complement the art museum space in the form of participatory activities that emphasize factors such as Reflection, Exposition, Choice, Information, Play, and Engagement, also referred to as RECIPE (2015). Despite the perceived appropriateness of the "gameful design" approach in the context of art museums, there is no empirical research thus far that has applied

Nicholson's proposed framework in practice. Therefore, there exists a need for studies which evaluate the impact of different types of AR-based participatory activities in art museums, and more specifically, to compare the impact between participatory activities featuring a "gamified design" versus a "gameful design." This could help in determining which design approach is more engaging and appropriate for use in art museums, as well as to explore how AR technology could be leveraged and provide potential design implications for its implementation.

Another area of potential concern is the fact that most AR-based exhibitions are designed for individual rather than shared visit experiences. Studies suggest that many people consider visiting a museum to be a social activity that they enjoy with their friends or family (Falk 2016; Phelan et al., 2018). Further, previous research on museum visit experiences indicates that accompaniment status influences the visit experience, such that solo visitors may experience more cognitive engagement whereas accompanied visitors may experience heightened emotional, behavioral, and cognitive engagement, in addition to social enjoyment (Debenedetti 2003; Falk 2016; Phelan et al., 2018). However, there is a lack of empirical research investigating the ways in which AR can be incorporated in participatory activities for shared visit experiences.

Research Objective and Questions

This research aims to achieve two main objectives. The primary objective is to determine whether the design of participatory activities can positively enhance an AR-mediated art museum visit experience. More specifically, this research will evaluate the difference between a participatory activity characterized by a "gamified design" versus one characterized by a "gameful design." Further, the role of perceived gamefulness and intrinsic motivation will be investigated as potential predictors of visitor engagement and learning, which are hypothesized to positively influence visitor intention to visit and recommend AR-based art exhibitions.

The secondary objective is to explore ways in which AR technology can be incorporated in the design of participatory activities and to gain insight into potential best practices for art museums to consider. These insights will be derived from the feedback provided by participants during the post-test interview.

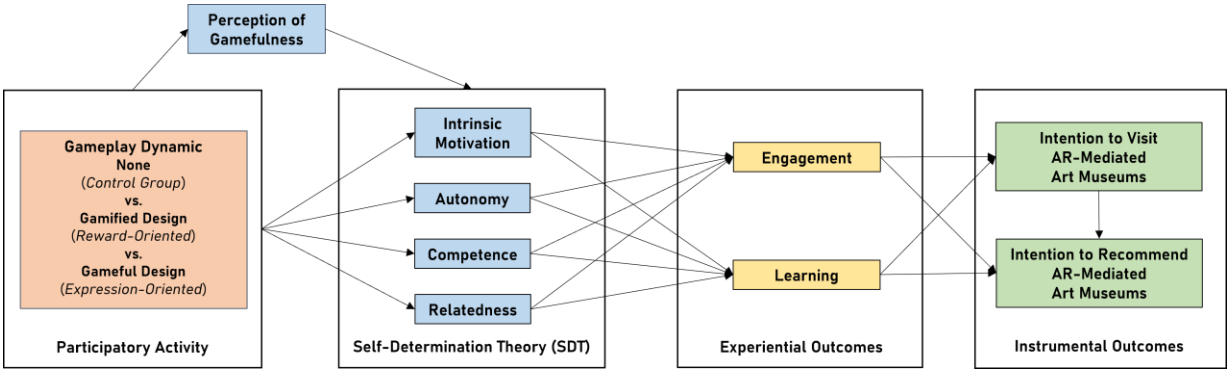
This research aims to address the following research questions:

RQ1. What are the relative effects of gamified versus gameful design on intrinsic motivation and perceptions of autonomy, competence, and relatedness? How do these constructs from the Self-Determination Theory contribute to experiential outcomes, such as engagement and learning, during an AR-mediated art museum visit?

RQ2. How does perception of gamefulness mediate the relationship between the type of participatory activity and the constructs of the Self-Determination Theory? Are these constructs differentially mediated depending on the type of participatory activity?

RQ3. What is the relationship between experiential outcomes, such as engagement and learning, and instrumental outcomes, such as higher intention to revisit and higher intention to recommend an AR-mediated art museum? Which type of participatory activity is associated with more positive instrumental outcomes?

Figure 1. Proposed Research Model



Potential Research Contributions

This research aims to provide both theoretical contributions and managerial implications.

Theoretical Contribution

There are four potential theoretical contributions resulting from this research. First, this study will incorporate key constructs derived from the Self-Determination Theory, namely intrinsic motivation and psychological need satisfaction for autonomy, competence, and relatedness (Ryan and Deci, 2000). This theoretical framework, which has been extensively adopted in previous research in a variety of other contexts, has not been yet utilized in the context of the art museum visit experience. Thus, the findings from this research could help further validate the use of the Self-Determination Theory and its proposed constructs in future research within this domain.

Second, this study will investigate the role of perceived gamefulness as a potential mediating factor that enhances intrinsic motivation (Högberg et al., 2019). Although this relationship has been demonstrated previously in a study related to gamification (Wesseloh et al., 2021), it has not been yet established within this specific context using AR-based participatory activities. Thus, the findings from this study may provide additional evidence for the relevance of perceived gamefulness when exploring topics pertaining to intrinsic motivation and different game design approaches, such as "gamified design" and "gameful design."

Third, the research model designed for this study incorporates Liu, Santhanam, and Webster's (2017) framework for the Design and Research of Gamified Information Systems in conjunction with the Self-Determination Theory. This framework provides guidance for the design and research of gamified information systems with the aim of eliciting meaningful engagement in the form of experiential and instrumental outcomes. Considering that intrinsic motivation plays a critical role in influencing experiential outcomes, such as engagement and learning, and consequently instrumental outcomes, such as increased intention to recommend, it seems reasonable that the two theories could be combined to further illustrate this causal relationship between intrinsic motivation and experiential and instrumental outcomes. Although this framework is appropriately

designed and developed to guide research relating to the use of gamified information systems, empirical studies that have experimented with the use of AR-based gaming applications in museums have not adopted this framework. Thus, this study's findings can explore the potential value of incorporating this framework in future research examining AR-based games, as well as provide implications for bridging it with the Self-Determination Theory.

Lastly, this study will apply Nicholson's (2012, 2015) RECIPE framework when designing the AR-based participatory activity representing the "gameful design" approach. Considering that this framework has yet to be applied in any studies as of now, this is an exploratory area of the research that, depending on the results, could shed insight into the validity and relevancy of adopting this framework in the design of future AR-based participatory activities. It could also provide support for Nicholson's claim that participatory activities could help enhance the art museum visit experience.

Managerial Implications

In addition to providing theoretical contributions, this study also aims to provide more practical implications for art museum curators and exhibitors by offering suggestions for potential best practices when designing AR exhibitions and participatory activities. By exploring two different design approaches, this study could provide insight into which types of activities would be the most compatible and appropriate for an art museum context. Further, the participatory activities developed for this study will be designed for the shared visit experience, of which there is a gap in the literature.

Contributions

The following table outlines my contributions for each step of this research project represented as a percentage value. Additional details in which I have collaborated with other parties is also included where appropriate.

Table 1. Student's Thesis Contributions

Step	Contribution
Research Question	Identifying gaps in existing literature and defining a research question and problem – **100%**
Literature Review	Reviewing relevant literature consisting of theoretical papers and empirical studies – **100%** Writing the literature review – **100%**
Conceptualization	Defining appropriate constructs for experiment – **100%** Proposing a research model – **100%**
Experimental Design	Defining experimental stimuli – **70%** • Photography: I collaborated with photographer Patrick Vierthaler who provided permission to use (8) pictures in the study. In addition, he created and provided a title and description for each picture. I prepared and printed the photos and their descriptions for the study. • AR-Based Descriptions: I created (16) additional descriptions to be displayed as an AR layer, (2) within each picture. Creating questionnaires and interview guide – **100%** Creating the experimental protocol – **100%**
Ethics	Preparing and submitting application to CER along with necessary modification forms – **100%** • I worked in conjunction with another student in the French cohort (Lan-Chi Maria Tran) whose study topic was similar to mine in context (use of AR in an art museum) and methods (experiment, questionnaire, interview, audio-video recordings). Therefore, we submitted a combined application to reflect the needs of each of our studies. However, I completed all of the necessary forms in English and she completed all of the forms in French.
Recruitment	Preparing the recruitment form – **100%** • I created the recruitment form using Panel Fox. Recruiting participants for the study – **100%** • The study was shared via email to the HEC Panel. I also advertised the study using the HEC Montreal Facebook group. Managing recruitment and scheduling - **100%** • I managed recruitment using Panel Fox and scheduled pairs of participants for study sessions. I also sent confirmation e-mails to pairs of scheduled participants to provide additional details on the study location.
Pre-Tests and Data Collection	Conducting pre-tests – **100%** Conducting sessions for data collection – **100%**

Data Extraction and Transformation	Extracting and cleaning of data* – **100%** • Tech 3 Lab technician Salim Tazi provided instructions on how to transform and post-process physiological data from the Tech 3 Lab BlueBox devices using Cobalt Photobooth and Observator. *This includes data from questionnaires, video and audio recordings, and physiological EDA and ECG data
Data Analysis	Conducting statistical analyses using SPSS – **90%** • Tech3Lab statistician Carl St-Pierre provided assistance with performing structural equation modeling (SEM) using the EQS software and analyzing the results. Conducting qualitative analyses – **100%** • I used Optimal Workshop to analyze data from the interviews, which allowed me to import and tag quotes, analyze the patterns and trends, and develop insights.
Writing	Writing the articles and thesis – **100%**

Note: These percentages do not account for the guidance and support received from my supervisors.

Thesis Structure

This thesis is structured in the form of articles. The current chapter is an introduction to this thesis, including a context to frame the research problems and the proposed research questions that will be investigated through the empirical study conducted. Chapter 1 will present a literature review summarizing the current state of the research, defining the relevant key concepts and constructs posed by the aforementioned research questions, and identifying the gaps in the literature that will be investigated through the study conducted as part of this thesis.

Chapter 2 will present an empirical article that was written and submitted to *ACM CHI Conference on Human Factors in Computing Systems*. This article had undergone two rounds of reviews, and although it was ultimately rejected and not published, the reviewers' detailed and constructive feedback was helpful in revising the article and improving the quality of the final version, which will be presented in this thesis. It will provide details regarding the experimental study that has been conducted with the aim of evaluating the impact of two different participatory activities – namely a gamified design versus a gameful design, on engagement and learning in the context of an AR-mediated

art museum visit. The proposed hypotheses, methodology, and results will be provided, followed by a discussion on the implications and limitations of the research.

Chapter 3 will present a managerial article that provides recommendations on designing AR-based exhibitions and participatory activities for art museums based on interviews conducted with participants following the experimental study. The article will also include insights on visitors' motivations for visiting art museums and what they are most interested in seeing in future art exhibitions. Lastly, a conclusion will be presented and will provide a summary of the previous chapters of this thesis, namely the key findings from the study, theoretical and managerial contributions, and recommendations for future research.

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Chapter 1
Literature Review

Introduction to Literature Review

This literature review chapter will present an overview of the current state of research on the topics of augmented reality (AR), gamification, and their combined implementation in the context of art museums. The purpose of this literature review is to explore how AR and gamification have been used in art museum visit experiences to generate insights and identify opportunities for future research. There will be a total of four sections, including a concluding summary of the literature review.

The first section will provide an introduction to AR, including how it is defined and designed, followed by a review of its applications in a museum context and the challenges and concerns of developing AR for this specific context. The second section will present an introduction to gamification and "gameful design," also referred to as "meaningful gamification," including how the terms have been defined and conceptualized in the literature and how they are distinct from one another. Additionally, this section will present theoretical frameworks that have been widely used in the field of games research as it pertains to gamification, such as the Self-Determination Theory (SDT; Ryan and Deci, 2000), HEXAD (Marczewski, 2015), and Mechanics-Dynamics-Aesthetics (MDA; Hunicke et al., 2004), followed by a review of applications of gamification in museums. The third section will focus on the combined incorporation of AR and gamification in a museum context and present details on the different types of applications that have been developed. Finally, the fourth section will conclude this chapter with a summary of the literature review findings, as well as identify gaps in the literature and suggest potential areas for future research and inquiry.

This literature review adopted a search strategy consisting of four steps: 1) identifying scientific databases to search in, 2) selecting keywords to search with, 3) reviewing and assessing the search results based on inclusion and exclusion criteria, and 4) analyzing and synthesizing the results. The following databases were consulted for this literature

review: Google Scholar, Science Direct, ACM Digital Library, Scopus, ERIC, Frontiers, Elsevier, Springer Link, and Web of Science. Additionally, the table below presents the search terms that were used (see *Table 1*).

A set of inclusion and exclusion criteria were used to filter the results and narrow the scope of the review. The criteria that were used are specified below (see *Table 2*). Once the search results were filtered, the quality of the shortlisted articles were analyzed using a set of rules to determine the quality of each article, namely the number of citations (more than 20 total), the sample size (more than 10 participants), and the implications of the results to the fields of HCI and IS. Additionally, articles that were published more recently within the last 10 years were particularly valuable as they provided a more recent perspective on applications of AR technology and gamification in museums. The articles that satisfied these requirements were then synthesized and included in this review.

Table 1. Literature Review Search Terms

Search Term		**Search Term**
"Augmented Reality"	**AND**	"Museum"
		"Art Museum"
		"Hedonic Experience"
		"Hedonic"
		"Gamification"
		"Gamified"
		"Intrinsic Motivation"
"AR"		"Self-Determination Theory"
		"SDT"
		"Engagement"
		"Educational"
		"Learning"
		"Learning Affordances"
		"Learning Effectiveness"
		"Learning Motivation"

Table 2. Literature Review Criteria

Inclusion Criteria	Exclusion Criteria
1) Year of publication within the last two decades (2002-2022)*	1) Articles without empirical evidence (e.g., theoretical and conceptual articles, essays, tool demonstrations, technical reports, etc.)*
2) English language of publication	2) Book chapters
3) Articles published in a peer reviewed workshop, conference, or journal	

*Exceptions to both these criteria were made for literature focused on the early development and applications of AR, as well as theoretical frameworks that were relevant to the discussion on AR and gamification, such as the self-determination theory (SDT) and meaningful gamification.

1.1 Augmented Reality (AR)

1.1.1 Introduction to Augmented Reality

Augmented Reality (AR) is commonly used nowadays, although many users may not be aware of how it is implemented in applications and how it is distinct from Virtual Reality (VR) technology. According to Milgram and Kishino (1994), AR and VR exist along a virtual-reality continuum (see *Figure 1*). While VR is positioned on the "virtual" end of the continuum in which users are fully immersed in a virtual environment and able to interact with virtual objects, AR differs in that users are able to interact with virtual objects while remaining in the physical environment. Thus, "AR is able to bridge the gap between real and virtual objects" (Manuri and Sanna, 2016).

AR use follows three different paradigms, or modalities: see-through devices, hand-held devices, and monitor-based systems. In the case of see-through devices, the user can view AR layers overlaid through a medium, such as AR glasses which are specifically designed for AR. In this way, users can see-through the lenses of the glasses without the need to interact with any additional devices or interfaces, while also being able to perceive their physical surroundings. In the case of hand-held devices, the user can view AR layers overlaid through mobile devices such as smartphones or tablets. This is also referred to as mobile AR, or MAR. Like see-through devices, people can perceive their physical surroundings, although indirectly as it is through the camera lens of the mobile device and

not transparent as in the case of using AR glasses. In the case of monitor-based systems, the user can view AR layers displayed on a screen larger than a typical smartphone or tablet. Of the three paradigms or modalities, mobile AR is the most used and recognized. Due to the growing population of smartphone users, AR applications are becoming more available and accessible (Manuri and Sanna, 2016).

Regarding the architecture behind AR, there are two main approaches or types: marker-based and marker-less. The former requires the user to scan a recognized pattern, such as a QR code, to display the AR. The latter relies on environmental information and calculates the relative position of the object aligned with the camera positioning to display the AR. Early definitions of AR highlight the ability to combine both real and virtual objects and allow users to interact with them in real time. The virtual objects that AR affords are referred to as assets. These assets consist of various multimedia types, including text labels, videos, audio, and 3D models. Further, assets can be combined, such that a user can interact with several different AR layers for a single AR-mediated 3D object. For instance, if a user scans a real object with an AR application, they could be prompted into a multisensory experience consisting of viewing an animated 3D model displayed alongside a text label and accompanied by an audio guide narrating the information written on the label. Another example could be a painting, which once a user scans it, displays a video of the painting in motion with the brushstrokes and featuring instrumental music as another layer (Manuri and Sanna, 2016).

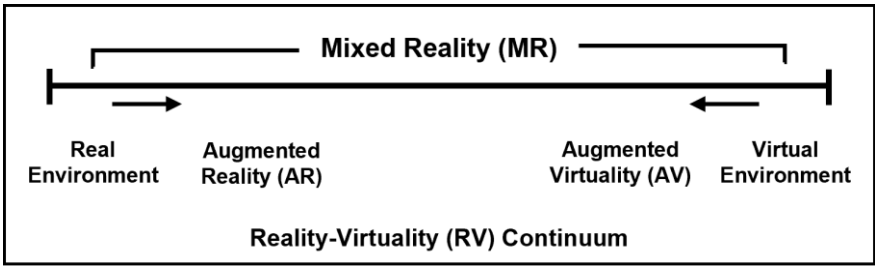

Figure 1. Reality-Virtuality (RV) Continuum (adapted from Milgram, P. and Kishino, F. (1994))

1.1.2 Applications of AR

AR technology has come a long way since Sutherland (1968) developed the first AR prototype using a Head Mounted Device (HMD). Applications of AR vary and exist in several industries, including medicine, maintenance and repair, entertainment, tourism, cultural heritage, education, and military (Manuri and Sanna, 2016). AR has contributed to the field of medicine as doctors can prepare and perform surgeries while using the technological affordances of AR to visualize areas of the human body that are either hidden or inaccessible. Technicians are also able to benefit from AR technology when reviewing the steps to perform a complex maintenance or repair task involving a high level of cognitive effort and demands precision and accuracy. Within the realm of entertainment, people have been able to enjoy AR-based games and live broadcasted sports events enhanced through AR. In the context of tourism and cultural heritage, AR has been used to provide travelers and museum visitors with additional information in the form of text labels, audio guides, and videos. AR use has been particularly valuable in education by providing engaging ways for students to interact with course materials. Teachers have experimented with adopting hybrid teaching approaches, which incorporate digital technology, including AR, into their classrooms.

1.1.3 Applications of AR in a Museum Context

Research suggests that there are benefits to implementing AR in museums, whether they be within the realm of cultural heritage or art (Attila and Edit, 2012). The use of AR featuring multimedia layers can provide visitors with supplemental information on cultural or art exhibits, recreate cultural artifacts, or allow for user interactivity, thus promoting an enriched and engaging learning experience. Moreover, AR applications can afford users with the opportunity to share their experiences through social networks, which not only satisfies the need to interact within a community of those with similar interests but can also serve as a method of advertising for the exhibition and encouraging future visitors. Therefore, although there is a cost to implement AR applications into museums, this can be outweighed by the publicity and number of visitors who attend their exhibitions.

AR not only improves the user experience for visitors, but it also benefits museum curators and exhibitors. The limitations of traditional cultural exhibitions and museums can be remedied through the adoption of AR technology, such as the time and cost to update or change printed labels and the restricted amount of space available to allocate additional information. Therefore, in the context of museums, the contributions of AR are two-fold.

1.1.4 Challenges and Concerns of Developing AR for Museums

Despite previous research with evidence illustrating the benefits of incorporating AR in museums and exhibitions, there are still concerns and challenges to consider. Among these are the potential for encouraging gimmickry to increase visitor attendance (Matuk 2016), detraction from the intended museum experience (Mann 2012) and difficulty with onboarding visitors who are unfamiliar with AR (Madsen et al., 2012). There are also practical concerns related to potential logistical and technical issues of AR use within indoor exhibition settings, such as the inability to implement AR applications that rely on user tracking through GPS signals (Carmigniani and Furht, 2011; Craig 2013), over-crowded exhibitions preventing visitors from standing within the necessary distance to effectively use AR accompanied by a noisy environment which hinders the ability to hear audio-based AR (Ballantyne and Uzzell, 2011), and the necessity of internet access which presents an additional cost either on the part of the museum or the visitor (Thian 2012). However, studies investigating these concerns suggest that although some technical aspects should be addressed and considered prior to AR adoption, other aspects, such as gimmickry and detraction are unfounded (Marques and Costello, 2018).

Although the presence of novel and unique digital technologies in museums may be perceived as market strategy gimmickry, the implementation of AR can enhance the visitor experience when designed effectively as a storytelling tool that aids the user in becoming immersed with the narrative of the exhibition (Barry et al., 2012). In this way, the use of AR becomes a relevant and meaningful part of the intended experience of the

exhibition instead of merely a supplemental virtual offering or a digital detraction from the exhibition artifacts that exist within the physical space (Latham 2015).

1.2 Gamification

1.2.1 Introduction to Gamification

Gamification is defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011). Game design elements are considered as the "set of building blocks or features shared by games" (Deterding et al., 2011). Based on the current literature, there are five levels or categories of game design elements which range from specific and concrete, to more abstract and nuanced. The first level consists of *game interface design patterns*, which are concrete elements added to a game that serve as a design solution. For instance, incorporating a system with badges, leaderboards, or levels in the user interface of a game is an example of a concrete design solution (Deterding et al., 2011).

The second level consists of *game design patterns and mechanics*, which impact the player's game experience or gameplay. These include features such as a time limit, turn-based gameplay, or introducing scarcity or limited resources (Deterding et al., 2011).

The third level consists of *game design principles and heuristics*, which serve as guidelines for evaluating design problems and approaching a solution. Some sample guidelines include establishing clear goals or objectives for the game, encouraging long-term gameplay, and accommodating for various gameplay styles or needs (Deterding et al., 2011).

The fourth level consists of *conceptual game models* that provide a framework for designing the game experience. The Mechanics-Dynamics-Aesthetics framework, commonly referred to as the MDA framework, is one such model that has been widely used within the field of game studies and serves as a tool for game designers in the industry (Hunicke et al., 2004). According to this model, the mechanics are the components of the game that work in conjunction with the behavioral input of players to

form the gameplay dynamics. The player's emotional response as they interact with the game mechanics and dynamics represents the aesthetics of the game.

There are several possible aesthetics that can be incorporated in a game's design, such as sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission. Each aesthetic is characterized by a different theme, and thus, can elicit different emotional responses from the player depending on their gameplay preferences and interests. For instance, a player who is curious and imaginative may prefer playing a game which incorporates a fantasy aesthetic, whereas a player who enjoys puzzles or undertaking obstacles may prefer playing a game which incorporates a challenge aesthetic (Hunicke et al., 2004). It is also possible to incorporate multiple aesthetics in a single game, encouraging a more varied and engaging game experience. For instance, fantasy, narrative, and discovery are complementary aesthetics that are often designed in role-playing games, or RPGs.

The fifth level consists of *game design methods*, which refer to the practices and processes used by game designers. These include activities such as playtesting and conducting user research (Deterding et al., 2011).

1.2.2 Gamification versus Gameful Design

Studies on gamification primarily exist within the fields of Human-Computer Interaction (HCI) and game studies, although they also exist outside of these fields due to the growing interest in applying gamification to other contexts, such as in education, health, and work. As a result, researchers claim that the use of the term "gamification" has been overused or applied inappropriately, when in fact, terms such as "gamefulness" or "gameful design" should be adopted instead (Deterding et al., 2011).

"Gamefulness" refers to the experiential quality of the activity or interaction, whereas "gameful design" refers to the intentional design for eliciting gamefulness through game design elements. This is distinct from the definition of gamification which similarly suggests the application of game design elements but within a non-game context and without the specific intention of eliciting an experience of "gamefulness" for the user.

This distinguishes the two from other forms of games, such as serious games which are designed with the purpose of training or educating the user (Deterding et al., 2011).

1.2.3 "Meaningful Gamification" through Gameful Design

Nicholson (2012, 2015) further develops this concept of "gameful design" by introducing what is called "meaningful gamification." "Meaningful gamification" is defined as "the use of gameful and playful layers to help a user find personal connections that motivate engagement with a specific context for a long-term change." In contrast, gamification focused on external factors, such as rewards, is more extrinsically motivating and hinders intrinsic motivation, resulting in users having a temporary engagement with the gamification system and short-term benefits. Intrinsic motivation is an essential factor associated with promoting positive and long-term change (Deci and Ryan, 2000). Therefore, meaningful gamification, which encourages deeper and extensive engagement without external rewards, is ideal when the desired outcome is to intrinsically motivate users to adopt a long-term change in behavior.

According to Nicholson (2015), there are six factors that should be considered in the design of gamification systems: Reflection, Exposition, Choice, Information, Play, and Engagement (RECIPE). *Reflection* refers to the notion of providing users with an opportunity to expand upon their learning experience and by building connections between the gamification system and their own lives. The aim of reflection is to encourage users to proactively integrate their experience into their personal lives in a meaningful way. Although users can reflect individuals, there are more benefits in listening to the perspectives of their peers. This allows them to be exposed to other possibilities with which they can build more connections and visualize "the bigger picture."

Nicholson (2015) outlines three potential areas for gamification systems to focus on for reflection, which can be done sequentially as a series of steps. The first step is description, in which the user describes the activity they engaged in using the system. The second step is analysis, in which the user imagines how the activity can be connected to their personal

life. The third and final step is application, in which the user is encouraged to act upon what they have learned and discovered about themselves.

Exposition refers to the notion of developing a narrative in the gamification system and presenting it to the user through game design elements. The aim of exposition is to offer an additional way for users to connect the gamification system to the real world. This can be achieved by developing a narrative that mimics, or is analogous to, the real world. However, allowing users the opportunity to create their own stories within the gamification system is ideal as it encourages freedom, autonomy, and personalization of their experience. This is related to the next aspect of RECIPE, which is Choice (Nicholson 2015).

Choice refers to the notion of allowing users flexibility and control in their engagement with the gamification system. This benefits the user's learning experience and the perception of playfulness, which are both essential in meaningful gamification. When users can choose the conditions of how they interact, they can learn in a way that best suits their needs and abilities. Additionally, it is possible to present users with several choices to choose from, or even allow them to opt out of choosing to engage with the system entirely (Nicholson 2015).

Information refers to the notion of the gamification system providing users with information that is necessary and relevant in connecting the system to the real world. The information should explain the backstory behind the narrative and convey its value such that users can understand and apply to their own lives. This can be achieved by making optimal use of the user interface, creating non-playable characters (NPCs) to serve as guides to help navigate through the system, or by integrating the information into the narrative or exposition (Nicholson 2015).

Play refers to the notion of the gamification system providing a space for users to explore and engage with voluntarily. Additionally, allowing users the freedom to play with their own set of rules and boundaries is important as enforcing pre-defined objectives and a structure to abide by will diminish perceptions of playfulness. In this way, Play is aligned with the previously mentioned aspect of Choice in meaningful gamification. When incorporating play in the design of a gamification system, it is ideal to allow users the

flexibility to engage with the system based on the rules and boundaries that are agreed upon by the users. This includes the idea of play being an optional activity (Callois 2001). The perception and experience of playfulness amongst users replaces the need for external rewards as the interactions and activities are intrinsically motivating and rewarding themselves (Nicholson 2015).

Engagement refers to the notion of providing opportunities for users to engage with fellow users and the gamification system itself. The former is related to social or player engagement. The latter is related to the concept of flow. Social engagement can be facilitated through game mechanisms, such as creating a space within the system for users to connect and communicate, like guilds, forums, and chat services. Game designers can also consider ways to incorporate game dynamics such as competition or cooperation within the system. Some common examples are leaderboards or challenges requiring teamwork. However, the impact of such game dynamics will differentially impact users' motivational level, and thus social engagement, as some users may thrive from competitive-based systems while others may prefer the relationship building that group effort and teamwork provides (Nicholson 2015).

Regarding user engagement with the gamification system, game designers can enhance users' gameplay experience by balancing the difficulty of the system to create an optimal state of flow. When a system adapts to users' skill level and adjusts the difficulty level such that the two are in alignment, this creates the opportunity for users to be fully engaged with the system and reach a state of flow. Contrastingly, when a system's difficulty level is too low or too high, this can cause users to experience either boredom or anxiety (Csikszentmihalyi 1997).

Social engagement and user engagement with the system can be integrated together to maximize the benefits of each, but the issue lies in determining the appropriate time to allow users to engage with one another. Users who feel competent using the system will be better able to interact with others as they are more confident in their skills, whereas users who are still struggling with mastering the system are likely to feel less comfortable interacting with others. Therefore, game designers need to consider ways to support users

in their competency and then allow opportunities to connect with others once a certain competency level has been reached (Nicholson 2015).

1.2.4 Meaningful Engagement for Gamified Information Systems

Liu, Santhanam, and Webster (2017) developed a framework for the Design and Research of Gamified Information Systems that focuses on how to create meaningful engagement. According to the authors, meaningful engagement consists of both experiential outcomes and instrumental outcomes. Experiential outcomes represent the ideal and intended experience of users after using a system. Some examples which are common in the Information Systems (IS) literature are enjoyment, satisfaction, and engagement, but more complex concepts such as flow, cognitive effort, attention, learning, and arousal could also be considered as experiential outcomes. On the other hand, instrumental outcomes are typically more objective, such as desired actions or behaviors taken by users after using a system. For instance, re-engagement with a system or reaching a certain level of proficiency or mastery with a system can be considered as instrumental outcomes.

According to Liu *et al.* (2017), meaningful engagement is influenced by a combination of three factors: the gamified system, the user-system interactions, and the gamification design principles applied. The gamified system consists of the gamification design elements, which include gamification objects and mechanics, and the target system, whether it be the user, the task, or the type of technology used. Gamification objects are essentially design game elements and are considered as the building blocks of the gamified system. They include multimedia like images, videos, and audio, as well as scripts and characters that can help shape stories and narratives. Gamification mechanics are the set of rules or conditions that influence users' interactions with the gamification objects, including aspects such as leaderboards, guilds, leveling or progression systems, and channels by which users can interact with one another.

The interaction between the target system – the user, the task, or the technology – with gamification design elements forms what are referred to as user-system interactions. There are three different types of user-system interactions: user-to-system, system-to-

user, and user-to-user. The first can be viewed as input as the user interacts with the gamified system, whereas the second can be viewed as output such that the gamified system communicates messages to the user. The third represents the social interactions amongst users of the gamified system, which can be facilitated through the support of game design elements within the gamified system, or even outside of the gamified system if such a community exists (Liu et al., 2017).

Gamification design principles help to inform the design of the gamified system, the conditions for the user-system interactions, and the desired experiential and instrumental outcomes that culminate in meaningful engagement. Such principles are developed based on theoretical frameworks found in the literature across different disciplines, including information systems, economics, marketing, and psychology. Some of the theories include Bandura's Social Cognitive Theory (1991), Csikszentmihalyi's Flow Theory (1975, 1992), Ryan and Deci's Self-Determination Theory (SDT; 2000), and Fulk et al.'s Social Influence Model of Technology Use (1990).

1.2.5 Theoretical Frameworks Used in Games Research

Self-Determination Theory

Ryan and Deci's Self-Determination Theory (2000) centers on the construct of intrinsic motivation, which is defined as "interest or enjoyment while performing a given activity." Their theory proposes that intrinsic motivation plays a role in influencing long-term behavioral changes, and that people become intrinsically motivated when their psychological needs for competence, autonomy, and relatedness have been satisfied. Despite the psychological nature, SDT has been widely used in various contexts, but notably in examining levels of engagement and learning in education (Niemiec and Ryan, 2009) and game-based learning approaches (Liu et al., 2017). This is particularly relevant in the context of art museums as they are often considered to be educational leisure settings (ELS) that encourage and foster learning experiences.

Previous empirical studies within the field of games research have investigated the relationship between specific game design elements and intrinsic motivation to determine

which types were more highly associated with fulfilling certain psychological needs. Mekler, Brühlmann, Tuch, and Opwis (2017) conducted an online experiment to examine the impact of points, leaderboards, and levels on participants' feelings of competence, levels of intrinsic motivation, and performance on an image annotation task. The results indicate that there was no significant impact on perceived competence nor levels of intrinsic motivation, although performance quantity was significantly higher with the presence of gamification elements. The authors concluded that game design elements, such as points, leaderboards, and levels, are likely perceived as external rewards, and therefore, they would not intrinsically motivate participants.

Sailer, Hence, Mayr, and Mandl (2017) also conducted a study to examine this relationship between specific game design elements and psychological need satisfaction through an online simulation environment, which consisted of badges, leaderboards, performance graphs, avatars, stories, and teammates. The results indicate that badges, leaderboards, and performance graphs were positively associated with the psychological need for competence, whereas the presence of avatars, meaningful stories, and teammates were positively associated with the psychological need for relatedness. Their findings suggest that there exists an association between specific types of game design elements and psychological needs, and that the presence of gamification alone is not a significant predictor of satisfying these needs or resulting in intrinsic motivation.

HEXAD

With the application of gamification in different contexts and industries, there is a growing need for such gamified information systems to be personalized and adapt to the needs of the user. Based on the Self-Determination Theory (SDT), Marczewski (2015) developed the HEXAD framework which proposed a taxonomy of six different gamification user types motivated by either intrinsic or extrinsic factors. These user types consist of the following: philanthropists, socializers, free spirits, achievers, players, and disrupters. While some user types may share a similar motivational factor, the degree to which they are motivated varies, and they are each characterized by a different focus or objective.

The development of the intrinsically motivated HEXAD user types was directly influenced by the three types of intrinsic motivation proposed by SDT. Free Spirits, Achievers, and Socializers are motivated by a need for autonomy, competence, and relatedness respectively. Another user type called Philanthropists are also intrinsically motivated, but by purpose. The remaining two user types – Players and Disruptors – are motivated by external rewards and causing change and are thus considered to be extrinsically motivated.

Moreover, there are suggested design elements for each user type (Tondello et al., 2016). For instance, Free Spirits are motivated by freedom and expression, so design elements that support creativity, customization, and exploration are recommended. Meanwhile, Achievers are motivated by challenges and gaining progress, so design elements that provide a sense of progression, such as a leveling system, a quest log, or opportunities to develop new skills, are ideal. Socializers enjoy interacting with others and would benefit from design elements that allow them to connect with other users, such as guilds or an online community. While Philanthropists also enjoy interacting with others, they are motivated to help others by sharing their resources or wisdom, so design elements that allow trading or gifting to other players, or even offer users an optional role as a mentor to support fellow players, would be more appealing.

Since Players are extrinsically motivated by rewards, design elements such as leaderboards, points, or achievements would be the best fit. On the other hand, Disruptors would benefit from design elements that allow them to make changes in the game, such as systems for voting or developing tools that could be incorporated into the game. Such changes could lead to positive results, such as developing tools or voting on features with the aim of improving the game experience for other players, but there is a potential for Disruptors to behave in ways that negatively impact a game, such as those who find methods of "cheating the system" or selling in-game currency, which can hinder the game experience for others.

Mechanics-Dynamics-Aesthetics (MDA) Framework

Hunicke, LeBlanc, and Zubek's Mechanics-Dynamics-Aesthetics framework (2004), also known as the MDA framework, is another example of a theoretical framework that has been widely used within the field of games research. It proposes a conceptual model for analyzing games through examining three main components: mechanics, dynamics, and aesthetics. Consequently, this framework also functions as a design tool for game developers and designers to consider when creating games. Mechanics refer to the "rules" of a game, dynamics refer to the "system" of a game, and aesthetics refer to the "fun" of a game. All three aspects are interconnected and require an interplay between the player and the game. For instance, when players interact with the mechanics of a game, they are providing behavioral input that will receive a form of feedback or output from the game. As the player receives this feedback, they will experience an emotional response. This is often interpreted as "fun," but will largely depend on the intended response, or "aesthetic," that the game designer is aiming to elicit. There are several possible aesthetics, such as discovery, challenge, expression, fantasy, and fellowship. Some game genres are more commonly associated with certain intended aesthetics. For instance, role-playing games, also referred to as RPGs, often evoke feelings of fantasy, narrative, discovery, whereas an online team-based battle royale game may evoke feelings of challenge and fellowship. Considering that game design is a creative process, there is the potential for many different combinations of aesthetics.

1.2.6 Applications of Gamification in a Museum Context

Madsen (2020) conducted a literature review on gamification in museums and found a total of 1,381 publications between 2007 and 2017. Of these, a total of 64 publications were selected for full-text analysis and review as these publications had a title and abstract which mentioned details pertaining to gamification and the museum context. The next round of full-text reviews focused on the relevance of the publications to the scope of the author's literature review, which reduced the number to 26 publications. Upon closer examination, it was determined that only 8 of these were considered as relevant to the context of gamification in museums, and thus, the author concluded that although some

studies may mention gamification or allude to their application to museums, there does not seem to be a clear consensus on what qualifies as gamification. However, the author was able to identify key research areas, namely theoretical gamification with an emphasis on academic discussion as opposed to practical implications, studies examining intrinsic and extrinsic motivation, studies experimenting with add-on games to supplement an existing museum experience, and studies experimenting with different game-based learning approaches. Overall, the use of gamification in museums seems to be a trend that will likely continue in the years to come.

In Nicholson's (2015) discussion of "meaningful gamification," he proposes that museums can enhance visitor engagement and learning through the offering of supplemental participatory activities. Further, he recommends that these activities be designed with "play-based elements" that encourage aspects of exploration, reflection, and improvisation, as opposed to the external reward system commonly used in "BLAP" gamification approaches. In this case, "BLAP" refers to the use of badges, levels and leaderboards, achievements, and points. However, studies on gamification in museums have yet to incorporate Nicholson's framework for "meaningful gamification" or "RECIPE," and thus, there is no evidence to support that this approach to gamification would result in positive outcomes such as increased engagement and learning.

1.3 AR and Gamification

1.3.1 Applications of AR and Gamification in a Museum Context

Khan, Melro, Amaro, and Oliveira (2020) conducted a systematic review on the use of gamification for cultural heritage dissemination and found a total of 72 studies that were published between 2015 and 2020. The authors final selection consisted of 45 studies, but of these, 21 studies leveraged AR and VR technology. Although these findings are specific to cultural heritage, this demonstrates the growing interest in incorporating gamification, including AR-based games, for the purpose of enhancing learning experiences in educational leisure settings.

Camps-Ortueta, Deltell-Escolar, and Blasco-López (2021) also conducted a literature review on studies examining gamification in a museum context, but with a focus on AR and VR video game applications developed with the intention to increase visitor motivation and learning. They analyzed 21 articles published between 2015 and 2018 and found that the game genres varied, such as treasure hunts, cooperative games, simulations, and puzzles. Of these, treasure hunts and scavenger hunts were found to be the most popular method of leveraging AR technology in combination with gamification. Further, these games were used in different contexts, including cultural heritage museums (Mesáro et al., 2016; Seppälä et al., 2016; Varinlioglu and Halici, 2019) and public exhibitions (Noreikis et al., 2019), but with the shared purpose of enhancing the learning experience.

1.4 Summary of the Literature Review

The aim of this literature review was to provide an overview of the current state of research pertaining to AR, gamification, and their respective application in art museums. There is evidence to suggest there is a plethora of research examining the incorporation of AR technology and aspects of gamification in various contexts, and this popularity extends to museums. However, through this literature review, research gaps were found that would be best addressed in future research. First and foremost, there is a lack of empirical studies demonstrating the application of AR and gamification in the specific context of art museums. Indeed, many of the current studies researching AR and gamification were found to be related to the contexts of cultural heritage, tourism, or public exhibitions. Although these contexts may share some similarities with art museums, such as creating opportunities for visitors to explore and learn, it is not clear whether the findings could be extended and applied amongst these different contexts and venues. For instance, cultural heritage museums are characterized by the presentation of informational content that is often educational and cognitively stimulating. Alternatively, art museums are characterized by the presentation of creative content that communicates the intentions and ideas of the artist to the viewer, potentially eliciting an emotional reaction or feeling of connection with the artist. Although it is possible for art museum visitors to have educational and learning experiences, there is a fundamental difference in

the visit purpose and visitor outcomes in these two examples alone. Thus, it seems that it would be inappropriate to apply the findings and design implications from a study focused on using AR and gamification in a culture museum to the context of art museums.

Second, there is a lack of research illustrating how AR technology can be leveraged with gamification in an art museum context. Although there is literature on the use case of AR in art museums, combinations of AR and gamification are typically found in cultural heritage and tourism. Given the growing popularity of AR technology in museum exhibitions and the implementation of gamification in participatory activities at museums, it would be useful to consider how the two can be bridged effectively. Currently, there are empirical studies experimenting with prototypes of AR-based games in cultural heritage settings, but none exist thus far for the art museum context. Additionally, there is no set of best practices or design implications for developing AR-based games, which would be valuable for art and cultural museum curators alike when considering how to incorporate AR and gamification in their offerings. Thus, there is a need for more research which explores the design and development of AR in art museum exhibitions, including AR-based participatory activities such as games.

Lastly, this literature review also demonstrated a lack of empirical research to validate some of the theoretical frameworks discussed, namely Nicholson's (2015) framework for "meaningful gamification" and Liu, Santhanam, and Webster's (2017) framework for the Design and Research of Gamified Information Systems. While both frameworks were developed with a specific focus on the field of games research, neither have been evaluated or applied empirically. And thus, although both frameworks could be considered relevant to the study and design of AR-based participatory activities, it is not possible to determine their perceived value without any empirical support. This is another gap that could be addressed with future research by incorporating these theoretical frameworks as part of a research model and evaluate their potential to provide additional explanatory value. Alternatively, and perhaps more reasonably, these frameworks could also function as a guide for the development and design of participatory activities or gamified information systems.

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Chapter 2
Empirical Article*

Playful and Meaningful Engagement: Applying Gameful Design to an Augmented Reality-Mediated Art Exhibition

Chantel Chandler, Constantinos K. Coursaris, Pierre-Majorique Léger, Sylvain Sénécal

HEC Montréal, Montréal, Canada

Abstract

In recent years, museums have embraced the benefits of Augmented Reality (AR) technology and the novel experiences that it could afford to visitors of all ages. Art and culture museums alike have incorporated AR in exhibitions with research demonstrating successful outcomes, including increased visitor engagement and enhanced learning. However, AR-based activities typically found in exhibitions are designed for individuals rather than shared experiences. This study explores how AR and gameful design may be used to facilitate interactive activities in the context of a photography exhibition. Using a between-subjects design with 36 participants, two interactive activities were evaluated for their relative impact on engagement and learning: a reward-oriented "gamified design" activity (i.e., Scavenger Hunt), and an expression-oriented "gameful design" activity (i.e., Storytelling Game). Results suggest that the "gamified design" activity led to significantly higher levels of perceived engagement and learning. Implications on visitor intention to revisit and recommend AR-mediated art exhibitions are also discussed.

Keywords: Augmented Reality (AR), art museum, photography, gamification, gameful design, intrinsic motivation, self-determination theory (SDT), learning, engagement

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2.1 Introduction

Due to the growing population of smartphone users, Augmented Reality (AR) applications are becoming increasingly available and accessible. Research suggests that there are benefits to implementing AR in museums, whether they be within the realm of cultural heritage or art [4]. The use of AR featuring multimedia layers can provide visitors with supplemental information on cultural or art exhibits, recreate cultural artifacts, or allow for user interactivity, thus promoting an enriched and engaging learning experience for the visitor. Moreover, AR applications can afford users with the opportunity to share their experiences through social media, which not only satisfies users' need to interact within a community of those with similar interests but can also serve as a method of advertising for the exhibition and encourage future visits [4]. Therefore, although there is a cost to implement AR applications into museums, this can be outweighed by the increased publicity and number of visitors who attend such AR-enhanced exhibitions.

However, despite previous research illustrating the benefits of incorporating AR in museums and exhibitions [4], there are still concerns and challenges facing decision makers. Among these are the potential for encouraging gimmickry to increase visitor attendance [38], detracting from the intended museum experience [35], and adding difficulty in onboarding visitors who are unfamiliar with AR [34]. There are also practical concerns related to potential logistical and technical issues of AR use within indoor exhibition settings, such as the inability to implement AR applications that rely on user tracking through GPS signals [9, 13], over-crowded exhibitions preventing visitors from standing within the necessary distance to effectively use AR accompanied by a noisy environment which hinders the ability to hear audio-based AR [6], and the necessity of internet access which presents an additional cost either on the part of the museum or the visitor [59]. However, studies investigating these concerns suggest that although some technical aspects should be addressed and considered prior to AR adoption, other aspects, such as gimmickry and detraction are unfounded [37].

Although the presence of novel and unique digital technologies in museums may be perceived as market strategy gimmickry, the implementation of AR can enhance the visitor experience when designed effectively as a storytelling tool that aids the user in

becoming immersed with the narrative of the exhibition [7]. In this way, the use of AR becomes a relevant and meaningful part of the intended experience of the exhibition instead of merely a supplemental virtual offering or a digital distraction from the exhibition artifacts that exist within the physical space [31]. This is evidenced by the increased interest in incorporating aspects of gamification to develop AR-based game applications to enhance museum visitor engagement, learning, and overall experience [28, 8]. However, there is a lack of empirical studies that apply such applications to the specific context of art museums or exhibitions, as many are designed for cultural heritage or tourism.

The inappropriate design and incorporation of AR-based game applications in art museums is another potential area of concern [35]. For instance, phone applications or activities which adopt a "gamified design" approach, which typically involve completing challenges to earn points and competing with fellow visitors, may not be equally appealing to all types of visitors. Therefore, careful consideration of the exhibition theme and its content is needed when deciding how to best implement AR technology and games in art museums, as increasing engagement and learning experiences does not have a "one-size-fits-all" solution. Art museums are considered to be creative spaces where visitors can witness the creativity of different artists, attempt to interpret what an artist was trying to express with a particular piece, and have an emotional connection with the artwork [18]. An alternative approach to "gamified design" that may be more appropriate within this context is that of "gameful design." This approach applies game design elements with the intention of eliciting feelings of "gamefulness" or play, such as designing games which encourage reflection, expression, and creativity [43, 44]. However, despite the appropriateness of adopting a "gameful design" approach, much of the empirical research as-to-date has focused on more "gamified design" applications in art museums, such as through AR-based games [8, 28].

Further, such AR-based game applications are mostly designed for individual experiences and do not accommodate for shared visitor experiences. Prior research on museum visit experiences has investigated the impact of accompaniment status on motivation, learning, and engagement. Results suggest that although solo visitors are more likely to experience

higher cognitive engagement, the presence of a companion can positively influence visitors' emotional, behavioral, and cognitive experience [15, 18, 51]. Indeed, many people prefer to visit museums with their friends or family. Studies exploring museum visitor motivations have also found that social learning and social enjoyment are among some of the reasons people pursue museum visit experiences [18, 51]. However, there is currently a lack of research examining shared experiences within the specific context of AR-mediated art exhibitions. Museums would benefit from the insights of empirical studies evaluating methods of incorporating social interaction in a way that improves visitor engagement and enhances the shared visitor experience.

The present study aims to explore the impact of two participatory activities using different game design approaches on visitor engagement and learning within the context of an AR-mediated art exhibition. These participatory activities, which we will subsequently refer to as "game-based learning activities," will incorporate game design elements to help foster a learning experience. The game-based learning activities will be designed using two different approaches: one with a "gamified design" approach, the other with a "gameful design" approach. The authors will evaluate which approach is the most effective in increasing engagement and learning, as well as visitors' intention to visit AR-mediated art museums and recommend them to others. Additionally, by applying the theoretical framework proposed by the Self-Determination Theory [54], this study investigates the role of intrinsic motivation on visitor engagement and learning, and more specifically, how psychological need satisfaction for autonomy, competence, and relatedness can be differentially achieved through a game-based learning activity featuring a "gameful design" versus a "gamified design." Lastly, this study seeks to provide managerial implications by demonstrating how the incorporation of game-based learning activities adapted to AR-mediated art exhibitions may improve visitors' intention to revisit and recommend such exhibitions to others.

In sum, this study seeks to answer the following research questions:

RQ1. What are the relative effects of gamified versus gameful design on engagement, learning, and overall experience during an AR-mediated art museum visit?

RQ2. How does perception of gamefulness mediate the relationship between the type of game-based learning activity and intrinsic motivation?

RQ3. Which type of game-based learning activity is associated with higher intention to revisit and recommend an AR-mediated art museum?

The paper is structured as follows. We first provide a brief literature review on AR and gamification, their application in art museums, followed by key and relevant concepts from Self-Determination Theory (SDT) [54], the framework for Designing Gamified Information Systems for Meaningful Engagement [33], and the Mechanics-Dynamics-Aesthetics (MDA) framework [24] to provide context for our study, research model, and the design of our experimental conditions. Next, we present the theoretical foundations that position our research by demonstrating the key findings from previous studies that have examined similar constructs. We then provide the methods by which we designed our study, present the results, and discuss the key findings. We conclude with the theoretical contributions and managerial implications of the study, acknowledge the limitations, and provide suggestions for future research.

2.2 Background

In the subsequent paragraphs, we provide a brief overview of AR, gamification, SDT, and the MDA framework, followed by an introduction to the game-based learning activities that were designed and tested in this study. First, we describe AR technology and introduce gamification along with related concepts such as gamefulness, gameful design, and meaningful gamification. Next, we cite relevant studies which demonstrate how AR and gamification have been applied specifically in a museum context. Then, we summarize the key aspects of Self-Determination Theory and the MDA framework as they relate to the discussion of gamification and our study. Lastly, we briefly present the design of the game-based learning activities that were used in this study to compare the two design approaches, which we refer to as “gamified design” and “gameful design.”

2.2.1 Augmented Reality

Despite how AR use has become more commonplace in our everyday lives, particularly through social media platforms such as Instagram, Facebook, and TikTok, users may not be aware of how it is implemented in specific application contexts and how it is distinct from Virtual Reality (VR) technology. According to Milgram and Kishino [42], AR and VR exist along a virtual-reality continuum (see *Figure 1*). AR differs from VR in that users can interact with virtual objects while remaining in the physical environment. Thus, "AR is able to bridge the gap between real and virtual objects" [36]. The virtual objects that AR affords, which are referred to as assets, consist of various multimedia types, including text labels, videos, audio, and 3D models. Further, assets can be combined, such that a user can interact with several different AR layers for a single AR-mediated 3D object [36].

AR applications developed for art museum visits typically take the form of mobile multimedia guides that provide additional information for visitors to better appreciate the artwork featured in exhibitions [10, 14, 26]. Such implementations of AR have been shown to positively impact visitor experiences as they provide a novel opportunity to interact with artifacts in more engaging and meaningful ways, beyond the visual perception of the works within the physical space. Mobile AR using spatial recognition cues and geo-location technology can also support visitors with museum navigation and orientation.

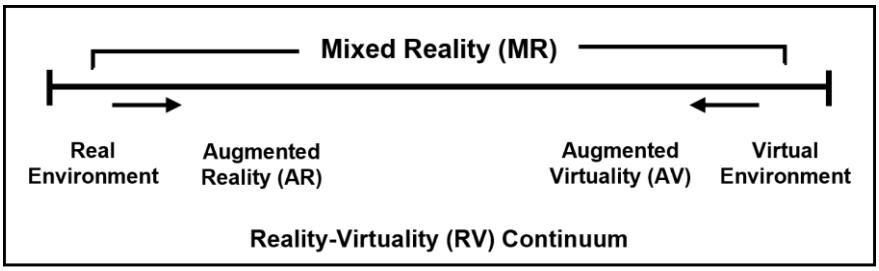

Figure 1: Reality-Virtuality (RV) Continuum (adapted from Milgram, P. and Kishino, F. (1994)).

2.2.2 Gamification

Gamification is defined as "the use of game design elements in non-game contexts" [16]. Game design elements are considered as the "set of building blocks or features shared by games" [16]. Based on the current literature, there are five levels or categories of game design elements which range from specific and concrete, to more abstract and nuanced. These five categories of game design elements are: 1) *game interface design patterns*, such as badges, leaderboards, or levels, 2) *game design patterns and mechanics*, which include features such as a time limit, turn-based gameplay, or limited resources, 3) *game design principles and heuristics*, which can be goals or objectives of the game that serve as guidelines for evaluating design problems, 4) *conceptual game models*, which provide a framework for designing the game experience, such as the Mechanics-Dynamics-Aesthetics (MDA) framework [24], and 5) *game design methods*, which refer to the practices and processes used by game designers, such as playtesting and user research.

2.2.2.1 Gamified Design versus Gameful Design

"Gamified design" simply refers to a design approach that applies gamification, which is to say, the application of game design elements in non-game contexts [16]. This approach often includes game interface design patterns such as points, levels, and badges. Studies on gamification primarily exist within the fields of Human-Computer Interaction (HCI) and game studies [16, 3, 39, 60], although they also exist outside of these fields due to the growing interest in applying gamification to other contexts, such as in education, health, and work. While some applications take the form of the "gamified design" approach, incorporating leaderboards and competition-based gameplay, other applications cannot be neatly characterized as gamification. Due to the plethora of attempts to incorporate gamification in various contexts and industries, researchers claim that the use of the term "gamification" has been overused or applied inappropriately, when in fact, terms such as "gamefulness" or "gameful design" should be adopted instead [16].

"Gamefulness" refers to the experiential quality of an activity or interaction, whereas "gameful design" refers to the intentional design for eliciting gamefulness through game

design elements [17]. This is distinct from the definition of gamification which similarly suggests the application of game design elements but within a non-game context and without the specific intention of eliciting an experience of "gamefulness" for the user. This also distinguishes "gamefulness" and "gameful design" from "gamified design" and other forms of games, such as serious games, which are designed with the purpose of training or educating the user [16].

Nicholson [44] further develops this concept of "gameful design" by introducing what is called "meaningful gamification." "Meaningful gamification" is defined as "the use of gameful and playful layers to help a user find personal connections that motivate engagement with a specific context for a long-term change." This contrasts with gamification that is focused on external factors, such as rewards, as that is more extrinsically motivating and hinders intrinsic motivation, resulting in users having a temporary engagement with the gamification system and only short-term benefits. Intrinsic motivation is an essential factor associated with promoting positive and long-term change [54]. Therefore, meaningful gamification, which encourages deeper and extensive engagement without external rewards, is ideal when the desired outcome is to intrinsically motivate users to adopt a long-term change in behavior.

According to Nicholson [44], there are six factors that should be considered in the design of gamification systems: Reflection, Exposition, Choice, Information, Play, and Engagement, resulting in the six-letter acronym, "RECIPE." *Reflection* refers to the notion of providing users with an opportunity to expand upon their learning experience and build meaningful connections between the gamification system and their personal lives. *Exposition* is presenting the narrative to users through different game design elements that allow users to create their own stories within the system while encouraging freedom, autonomy, and personalization. *Choice* refers to the notion of allowing users flexibility and control in their engagement with the gamification system. *Information* is providing users with details that are necessary and relevant in connecting the system to the real world. *Play* refers to providing a space for users to explore and engage with the system voluntarily with their own set of rules and boundaries, as opposed to enforcing pre-defined objectives. Lastly, *Engagement* is providing users with opportunities to

interact with fellow users, either through communication spaces like guilds and forums, or through competition or cooperation [44].

2.2.3 AR-Based Gamification in Museums

Research studies have explored the combined use of AR technology and gamification within the museum context. Khan, Melro, Amaro, and Oliveira [28] conducted a systematic review of gamification used for cultural heritage dissemination and found 72 studies published between 2015-2020. Of those, at least 21 of them applied gamification with VR or AR. Camps-Ortueta et al. [8] also reviewed studies from 2015-2018 of gamification applied to museums using AR and VR in the form of video game applications. They found that the majority of the games were developed to enhance learning, although the games varied in genre, such as treasure hunts, cooperative games, simulations, and puzzles. Indeed, AR-based treasure hunts and scavenger hunts appear to be a popular method of combining AR technology and gamification as many empirical studies can be found focused on the development and testing of prototypes designed for museums. Scavenger/treasure hunt AR games have been designed for a variety of contexts, such as enhancing the learning experience from cultural heritage museums [41, 57, 61] or to increase enjoyment and learning at public exhibitions [46].

Interestingly, there are also studies exploring the use of AR for interactive storytelling. Researchers have experimented with different methods of implementing AR in this regard, with some giving users the ability to choose alternate paths for a pre-designed story told through tangible AR-marker cubes [25], while others measured users' narrative skills and creativity as they created stories while using AR-based cards as reference or guidance [68]. Another study focused on a prototype of an AR-based content creation app which combined elements of social media and storytelling so that users can connect with one another as they annotated points-of-interest (POIs) through the use of multimedia AR layers, such as text, images, audio, videos, and 3D objects [63].

2.2.4 Self-Determination Theory

When deciding how to best implement AR-based gamification in museums, the Self-Determination Theory (SDT) proposed by Deci and Ryan [54] provides a useful framework on how to incorporate fun or enjoyment through its concept of intrinsic motivation. Intrinsic motivation can be defined as "participants' interest or enjoyment while performing a given activity" [53]. According to SDT, intrinsic motivation is the key to encouraging long-term individual change in behavior. Consequently, SDT has been used to explain the role of intrinsic motivation on engagement and learning in education [45] as well as in research investigating the use of gamification in game-based learning approaches [33].

Museums are considered as educational leisure settings (ELS), providing visitors an opportunity to experience positive learning outcomes. Research has explored how gamification can be incorporated into the museum visit experience to enhance learning, engagement, and enjoyment [28, 34]. However, there is a need for more empirical studies investigating the impact of specific game design elements on intrinsic motivation and psychological need satisfaction [40, 55].

According to SDT, people become intrinsically motivated when their psychological needs for competence, autonomy, and relatedness with others have been satisfied [54]. In Nicholson's RECIPE for "meaningful gamification" [43], he suggests that museums can enhance visitor engagement and learning by providing supplementary, participatory activities designed with "play-based elements" that encourage exploration, reflection, and improvisation, as opposed to the external reward system commonly used in "BLAP" gamification, which refers to the use of badges, levels and leaderboards, achievements, and points [43]. However, this conflicts with previous research which suggests that game mechanics such as points and leaderboards do not negatively impact intrinsic motivation, but rather serve as progress indicators when used in non-game contexts [39].

2.2.5 Designing Gamified Information Systems for Meaningful Engagement

While SDT is a theoretical framework which can be used to examine the effects of AR-based gamification at the individual experience level by measuring perceptions of intrinsic motivation and psychological need satisfaction, there also exists a framework that could be used to examine the design of AR-based gamification at the information systems level. Liu, Santhanam, and Webster [33] developed a framework for the design and research of gamified information systems that focuses on how to create meaningful engagement. According to the authors, meaningful engagement consists of both experiential outcomes and instrumental outcomes. Experiential outcomes represent the ideal and intended experience of users after using a system. Some examples common within the field of Information Systems (IS) are enjoyment, satisfaction, and engagement, but more complex concepts such as flow, cognitive effort, attention, learning, and arousal could also be considered as experiential outcomes. On the other hand, instrumental outcomes are typically more objective, such as desired actions or behaviors taken by users after using a system. For instance, re-engagement with a gamified information system or reaching a certain level of proficiency or mastery with a system can be considered as instrumental outcomes.

2.2.6 Mechanics-Dynamics-Aesthetics Framework

Although Liu, Santhanam, and Webster's [33] framework for designing gamified information systems for meaningful engagement provides a valuable lens to examine the outcomes of gamification more systematically and at the macro level through experiential and instrumental outcomes, it does not provide specific guidance for the conceptual design of gamification at the micro level. The Mechanics-Dynamics-Aesthetics framework [24], commonly referred to as the MDA framework, has been widely used within the field of game studies and serves as both a conceptual model for researchers to analyze games as well as a design tool for game developers and designers in the industry to follow. As the name suggests, the three components to the framework are mechanics, dynamics, and aesthetics. Mechanics are the components of the game design that serve as the rules of the

game. Dynamics are the interplay of game design mechanics and players' behavioral input and can be considered as the system of the game. Aesthetics are players' emotional responses as they interact with the game mechanics and dynamics, creating what is considered the "fun" of playing the game.

2.2.7 Participatory Activities: Applying Gamified Design vs. Gameful Design

For our experimental study, we designed two game-based learning participatory activities using different design approaches: a "gamified design" and a "gameful design." The MDA framework was used as a reference tool during the design process, particularly for establishing more concretely which mechanics to include to create the desired dynamics and aesthetic [24]. A comparison of both activities based on the MDA framework is presented in *Table 1*.

The Gamified Design activity represents the aspects that are commonly associated with gamification, such as points, leaderboard, levels, and competition with peers. For this study, the activity was designed as a competitive AR-mediated scavenger hunt quiz game in which each player would earn points for correctly answering a question, earning more points for quicker responses. The quiz game also featured a leaderboard and notified the players of winning streaks, which further enhanced the competitive dynamic of the game. Thus, based on the MDA framework, the Gamified Design activity was designed with a challenge aesthetic by establishing a dynamic of competition using game mechanics such as points and leaderboards.

The Gameful Design activity was carefully designed with consideration of the six factors recommended by Nicholson [44] as outlined in his RECIPE for "meaningful gamification" (see *Table 2*). For this study, the activity was designed as a storytelling game in which each player would create a story based on the artwork featured in the exhibition and take turns guessing the artwork the story was based upon. The idea for the game was inspired by the storytelling game "Find the artwork behind the story!" proposed by Vayanou, Ioannidis, Loumos, and Kargas [62], which was applied to visitors of art galleries and played in groups. The Gameful Design activity could also be described using

the MDA framework, such that it was designed with a narrative and expression aesthetic by establishing a dynamic of interaction between the players using game mechanics such as choice and creation.

Table 1: Comparison of the two activities based on Hunicke et al.'s MDA framework [24]

Participatory Museum Activity	Game Mechanics ("Rules")	Game Dynamics ("System")	Game Aesthetics ("Fun")
Gamified Design (Scavenger Hunt)	Points/Leaderboard	Competition	Challenge
Gameful Design (Storytelling Game)	Choice/Creation	Interaction	Narrative/Expression

Table 2: Nicholson's RECIPE [44] incorporated in the Gameful Design activity

RECIPE Factors	In the Gameful Design activity, players can…
Reflection	…reflect on the artwork using their own personal experiences…
Exposition	…while creating a written narrative using a digital interface...
Choice	…with flexibility in choosing the artwork to write about…
Information	…supported by information provided through AR text labels for each artwork…
Play	…with few rules and pre-defined objectives introduced in the gameplay…
Engagement	…and an opportunity to engage with their partner by sharing their story.

2.3 Theoretical Foundation

2.3.1 Game Design Dynamics and Psychological Need Satisfaction

When designing a game, it is useful to consider how the incorporation of certain game design elements will impact an individual's experience when playing, and whether or not this is in alignment with the intended experience of the game. Previous research has investigated the extent to which certain game design mechanics and dynamics could fulfill psychological needs. Sailer, Hence, Mayr, and Mandl [55] investigated the impact of specific game design elements on fulfilling the three psychological needs presented in SDT, namely autonomy, competence, and relatedness. For their experimental study, 419 participants played a game and completed a questionnaire with items measuring their psychological need satisfaction. The results demonstrated that game design elements such as points, badges, and leaderboards positively impacted need satisfaction for competence

as they provided the individual with sustained or cumulative feedback. In addition, game design elements such as avatars, meaningful stories, and the presence of teammates positively impacted need satisfaction for relatedness as there is an underlying sense of relevance and membership in a community with shared goals. The researchers also considered how the presence of customization of avatars could impact the need for autonomy, although the results did not demonstrate any significant association between the two.

Research by Suh, Wagner, and Liu [58] also examined the role of specific game dynamics, such as rewards, competition, self-expression, and altruism, on the fulfillment of certain psychological needs. The results demonstrated a positive correlation between rewards and competition on the need for competence, between self-expression and the need for autonomy, and between altruism and the need for relatedness. Interestingly, the results also indicate a positive relationship between competition and relatedness, but this can be explained due to the social presence of others. While competition has the potential to negatively impact intrinsic motivation, it can also elicit positive outcomes depending on the design and context of the competitive task or activity.

Overall, these findings suggest that the impact of gamification on fulfilling psychological need satisfaction is related to the use of specific game design elements, as opposed to the experience of the game itself. Further, it is hypothesized that reward-oriented game design elements in the Gamified Design condition, such as points and leaderboards, would satisfy the need for competence, whereas expression-oriented game design elements in the Gameful Design condition, such as narrative storytelling with a partner, would satisfy the need for relatedness. The ability to choose is also emphasized in the Gameful Design condition and is expected to satisfy the need for autonomy.

According to SDT, intrinsic motivation is more likely to occur when all three psychological needs are satisfied. Since the Gameful Design condition is expected to satisfy at least two of the three psychological needs, it is anticipated that those in the Gameful Design condition will experience higher levels of intrinsic motivation compared to those in the Gamified Design condition.

The following hypotheses have been formulated to investigate the relationship between the type of participatory activity and psychological need satisfaction:

H1a. The Gameful Design condition will result in higher perceived *Intrinsic Motivation* compared to the Gamified Design condition.

H1b. The Gameful Design condition will result in higher perceived *Autonomy* compared to the Gamified Design condition.

H1c. The Gameful Design condition will result in lower perceived *Competence* compared to the Gamified Design condition.

H1d. The Gameful Design condition will result in higher perceived *Relatedness* compared to the Gamified Design condition.

2.3.2 Perception of Gamefulness

Previous research suggests that perception of gamefulness may serve as an explanatory factor and predictor of intrinsic motivation. A recent study by Wesseloh et al. [66] examined the impact of gamification on perception of gamefulness and intrinsic motivation. The results indicate that perception of gamefulness had a mediating effect on the relationship between gamification and intrinsic motivation. The researchers also examined the effect of perception of gamefulness on psychological need satisfaction and found support for the mediating effect on the need of autonomy and partial support on the need for relatedness. Given that the Gameful Design condition is expected to satisfy these two needs, it is expected that participants will report higher perceived gamefulness compared to those in the Gamified Design condition. Hence, we propose that:

H2. The Gameful Design condition will result in higher *Perception of Gamefulness* compared to the Gamified Design condition.

H3. *Perception of Gamefulness* is positively associated with *Intrinsic Motivation*.

2.3.3 Intrinsic Motivation and Psychological Need Satisfaction on Engagement and Learning

Previous research has confirmed that intrinsic motivation maintains a positive impact on engagement and learning outcomes, particularly in the context of education [12, 20]. Additionally, gamification has been found to enhance user engagement through the mediation of intrinsic motivation [58], as well as elicit positive effects on cognitive, behavioral, and motivational learning outcomes [56]. Recent meta-analyses have also confirmed the effectiveness of gamification in improving students' learning performance [5, 29, 69].

It should be noted that although engagement and learning may be considered as separate experiential outcomes, they are also interconnected, such that engagement can enhance and benefit the learning experience. To this effect, Oudeyer, Gottlieb, and Lopes [48] hypothesize that there is a closed feedback loop in place, in which intrinsically motivated individuals who are driven by curiosity, proactively continue their engagement in the learning task or activity in the pursuit of learning more. Incorporating elements such as personalization, choice, and contextualization of the learning process can also elicit positive effects on the learner as they support the fulfillment of psychological needs that are essential for intrinsic motivation [12].

The influential role of intrinsic motivation on enhancing visitor engagement and learning can also be extended to the museum context, as museums function as informal learning spaces or educational leisure settings [49]. Visitors of museums, whether they be cultural heritage sites or art galleries, are often motivated by the need to learn and discover new things. However, visitor motivations may vary across contexts and populations. Whereas some individuals may be driven by the need to learn and have new experiences, others may seek contemplative relaxation, and others may prefer opportunities for social interaction amongst fellow visitors. Therefore, combining a mix of educational and entertaining content – which is commonly referred to as edutainment – is beneficial when designing museum visit experiences that accommodate different visitor motivations.

In recent years, museums have leaned into the benefits of AR technology and gamification while experimenting with the development of AR-based games and learning applications to supplement their service offerings [38, 41, 57, 61]. By incorporating aspects of play and interaction into exhibitions, younger museum visitors become more intrinsically motivated, and thus more engaged and motivated to learn [22]. Thus, the following plausible relationships are proposed:

H4a. *Intrinsic Motivation* is positively associated with *Perceived Engagement*.

H4b. *Autonomy* is positively associated with *Perceived Engagement*.

H4c. *Competence* is positively associated with *Perceived Engagement*.

H4d. *Relatedness* is positively associated with *Perceived Engagement*.

H5a. *Intrinsic Motivation* is positively associated with *Perceived Learning*.

H5b. *Autonomy* is positively associated with *Perceived Learning*.

H5c. *Competence* is positively associated with *Perceived Learning*.

H5d. *Relatedness* is positively associated with *Perceived Learning*.

2.3.4 Engagement and Learning on Intention to Visit and Intention to Recommend

According to the Theory of Planned Behavior (TPB) [1, 2], behavioral intention is influenced by three factors: an individual's attitude towards the behavior, their perceived sense of behavioral control, and their subjective norms. Previous research in tourism has confirmed that positive, satisfactory experiences can impact behavioral intentions, including intentions to revisit a location or recommend it to others through word-of-mouth (WOM) [11, 19].

Additionally, a recent study [21] examined the impact of AR use in a museum context on future purchase intention and results indicated that visitors were more likely to pay a

higher cost for the visit experience when their evaluated their experiential value to be high using AR that presented dynamic verbal cues through text layers and high virtual presence through 3D object filters. These findings provide evidence of the relative impact of experiential outcomes during a museum visit, such as satisfaction, engagement, and learning, on post-visit attitudes and behaviors, such as intentions to revisit exhibitions or recommend them to others. Hence, the following hypotheses are proposed:

H6a. *Perceived Engagement* is positively associated with *Intention to Visit AR-Mediated Art Museums.*

H6b. *Perceived Learning* is positively associated with *Intention to Visit AR-Mediated Art Museums*.

H7a. *Perceived Engagement* is positively associated with *Intention to Recommend AR-Mediated Art Museums.*

H7b. *Perceived Learning* is positively associated with *Intention to Recommend AR-Mediated Art Museums.*

H8. *Intention to Visit AR-Mediated Art Museums* is positively associated with *Intention to Recommend AR-Mediated Art Museums*.

2.3.5 Proposed Research Model

The research model developed for this study is based on the Self-Determination Theory [54] and includes key constructs from the theory, such as intrinsic motivation, autonomy, competence, and relatedness. The model is also influenced by the Framework for Design of Gamified Information Systems [33] and presents engagement and learning as experiential outcomes and intention to visit and recommend AR-mediated art museums as instrumental outcomes (see *Figure 2*).

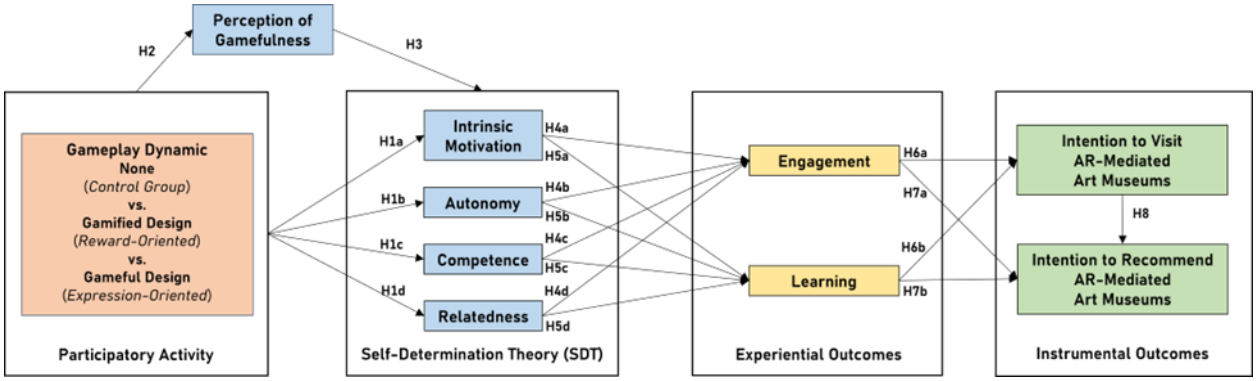

Figure 2: Proposed research model

2.4 Methods

2.4.1 Experimental Design

This experiment utilized a single-factor between-subjects design to evaluate the effect of the two game-based learning activities in the context of an AR-mediated photography exhibition. This resulted in the following three conditions: the control group, the Gamified Design condition, and the Gameful Design condition. Pairs of participants were randomly assigned to each condition. Participants in all three conditions were tasked with viewing the artwork in the exhibition using an AR app. Those in the experimental conditions participated in an additional game-based learning activity with their partner, which required them to use the AR app again to view the artwork, as well as individual tablets to complete the activity. This allowed us to explore how AR technology could be incorporated in the design of a participatory activity, as opposed to using a self-contained gamified AR application. This study was approved by the Research Ethics Board of our institution (2023-5055).

2.4.2 Participants

Participants were recruited using the university study panel, as well as a combination of convenience and snowball sampling. Participants completed a pre-screening questionnaire to verify their eligibility to participate in the study. Participants were

considered eligible for the study if they were at least 18 years old with written and spoken fluency in English. Participants were also asked to provide the contact information for either a friend, partner, or family member with whom they would like to invite to join them in participating in the study. This additional participant completed a pre-screening questionnaire to determine their eligibility to participate beforehand. Once both participants' eligibility was verified, a scheduling email was sent, and they selected a study session as a pair.

The pre-screening questionnaire included questions assessing participants' prior experience with using AR, visiting museums, and using AR in museums. This information was collected again in the pre-task questionnaire for descriptive analysis; however, it was not used as part of the sampling method nor to match participants into certain experimental conditions. Pairs of participants were randomly assigned to each condition (Control Group, Gamified Design, and Gameful Design), such that participants' characteristics were not matched to any specific condition.

To determine whether there was a potential relative impact of prior experience characteristics, chi-square tests were conducted. The results indicate that there was no significant difference between the three conditions. Further, the sample for each condition comprised of a similar range of prior experience with using AR, visiting museums, and using AR in museums.

There was a total of 36 participants in the study (19 female, 16 male, 1 non-specified). The mean age was 30.97 years (SD = 12.04) with a range of 20 - 65 years. There were 12 participants assigned to each condition, resulting in 6 pairs per condition (Control Group: 6 female, 6 male; Gamified Design: 6 female, 6 male; Gameful Design: 7 female, 4 male, 1 non-specified). Regarding the pair types, there were 8 friend pairs, 9 romantic partner pairs, and only 1 family pair. Each participant received a $20.00 (CAD) Interac transfer payment as compensation for their participation.

2.4.3 Experimental Stimuli

2.4.3.1 Photography Art Exhibition

An art exhibition was set up using one of the classrooms on the university campus (see *Figure 3*). The theme of the exhibition was "Four Seasons of Kyoto" featuring photography of landscapes and artifacts throughout Kyoto, Japan. All the photos were photographed by Patrick Vierthaler, a photographer and contemporary history researcher based in Kyoto [64]. There was a total of 8 artworks with two representing each of the four seasons.[1] However, it should be noted that the photography artworks were not originally created with AR layers, and as such, are not considered to be AR artworks themselves.

Figure 3: Preview of the photography exhibition featuring four artworks and two interactive tablets for the game-based activity.

2.4.3.2 Augmented Reality Application: Halo AR

To design the AR-mediated photography exhibition, the researchers used the commercially available mobile application Halo AR [LightUp, San Mateo, CA, USA; 32] to create AR layers and embed them onto each artwork. This application allows the user to create different types of AR layers, such as text, image, audio, or video. These AR

[1] The photographer provided permission for the researchers to display the artworks for the purpose of the study and assisted with creating titles and descriptions for each photo to be presented in the exhibition.

layers can then be superimposed onto real-world objects using marker-based, image recognition technology. For instance, the user can take a picture of the target object that they wish to superimpose AR layers onto, choose the type and placement of the AR layers, and then save this data into the application. Then, the user can scan the target object using the scan feature to trigger the display of the AR layers. This marker-based method is like that of QR codes, in which the user scans the QR code to trigger and access the AR content.

For the present study, the researchers created AR layers featuring text labels designed as speech bubbles. These AR text labels were positioned near artifacts within the artworks with the purpose of providing additional information and context to supplement the title and description (see *Figure 4 and 5*). For instance, the user would scan an artwork using the *Halo AR* application and be able to view AR text labels embedded in the artwork describing some of the objects present, such as a lantern or statue. These text labels also introduced Japanese words to describe the objects, along with their English translations. Two AR text labels were created for each artwork, resulting in a total of 16 AR text labels.

Figure 4: Preview of how a user can scan the artwork using the Halo AR application.

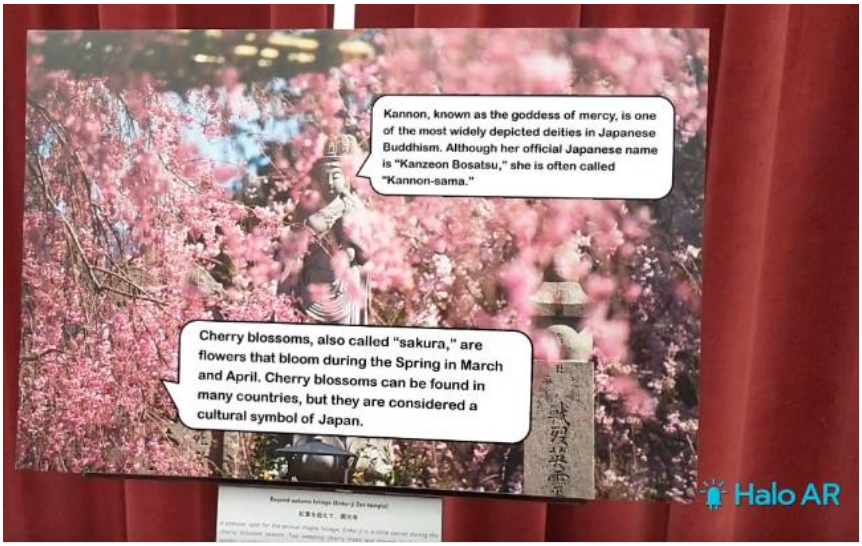

Figure 5: Preview of the AR text labels scanned in real-time using the Halo AR application.

Captions for AR text labels: (Top) "Kannon, known as the goddess of mercy, is one of the most widely depicted deities in Japanese Buddhism. Although her official Japanese name is 'Kanzeon Bosatsu,' she is often called 'Kannon-sama.' (Bottom) "Cherry blossoms, also called 'sakura,' are flowers that bloom during the Spring in March and April. Cherry blossoms can be found in many countries, but they are considered a cultural symbol of Japan."

2.4.4 Data Collection

A mixed methods approach was used and both quantitative and qualitative data was collected. Quantitative data was collected through questionnaires facilitated on Qualtrics [Qualtrics, Provo, UT, USA]. Qualitative data was collected primarily from interviews at the end of the experiment, but additionally from participants' comments during the experiment while viewing the artwork in the exhibit and completing the tasks.

2.4.4.1 Measurements

Several instruments were used to measure the constructs in this study. A comprehensive list of the constructs and measurement items are provided in the Appendix.

Perception of Gamefulness (POG) was measured using items from the "Playfulness" dimension of the *Gameful Experience Questionnaire* (GAMEFULQUEST) created by Högberg et al. [23]. Although the original questionnaire uses 10 items, the researchers selected only 5 of the items based on the highest factor loadings to reduce the number of items on the questionnaire and minimize participant fatigue. Thus, there was a total of 5 items scored on a 7-point Likert-scale.

Intrinsic Motivation (IM) was measured using items from the "Interest/Enjoyment" dimension of the *Intrinsic Motivation Inventory* (IMI) created by Ryan [53]. There was a total of 7 items scored on a 5-point Likert-scale. In addition, psychological need satisfaction for ***Autonomy***, ***Competence***, and ***Relatedness*** was measured using items from both the *Intrinsic Motivation Inventory* and the *Ubisoft Perceived Experience Questionnaire* (UPEQ) [66]. There was a total of 6 items scored on a 7-point Likert-scale with 2 items for each dimension.

Perceived Engagement was measured using items from the *Audience Engagement in Multimedia Presentations* scale created by Webster et al. [64, 65]. There was a total of 7 items scored on a 7-point Likert-scale.

Perceived Learning was measured using items originating from the "Education" dimension of the *Experience Economy Scale* created by Pine and Gilmore [52], but later adapted by Oh et al. [47]. The adapted version of the items was used for the present study. There was a total of 4 items scored on a 7-point Likert-scale.

Intention to Visit was measured using items adapted from Pallud and Straub [50]. There was a total of 2 items scored on a 7-point Likert-scale. These items were used during both the pre-task and post-task questionnaires to observe any potential change in participants' intention to visit an art museum before and after the study, as well as their intention to visit an AR-mediated art museum in the future.

Intention to Recommend was measured using items adapted from Kim and Son [30]. There was a total of 3 items scored on a 7-point Likert-scale.

2.4.4.2 Construct Reliability

Tests for construct reliability for the measurement scales were conducted using data from the sample with the majority resulting in Cronbach's alpha values higher than 0.8 (*Intrinsic Motivation*, *Perceived Engagement*, *Perceived Learning*). The exception to this is the Perception of Gamefulness (POG) scale with a value of 0.697, which is close to the recommended value of 0.7. Overall, the reliability of the measurements adopted for this study can be considered acceptable.

2.4.5 Procedure

2.4.5.1 Task 1: Viewing the AR-Mediated Photography Exhibition

Prior to viewing the artwork in the exhibition, participants received instructions on how to use the Halo AR app and completed a short practice session to ensure that they were able to successfully use the app without any issues. Afterwards, they were provided with information regarding the theme of the exhibition and the photographer. Participants were advised to take their time exploring the exhibition as they normally would if they were visiting an exhibition. For instance, they could choose to view the artwork together or separately, with or without conversation. Allowing participants flexibility in how they viewed the artwork, namely either with or without their partner, afforded some external validity for the study, which was necessary given that the art exhibition was located on campus and not at an actual art gallery or museum. After viewing the artwork using the Halo AR app, participants were asked to complete a post-task questionnaire to report their perceived level of intrinsic motivation.

2.4.5.2 Task 2-A: Gamified Design Condition (Scavenger Hunt)

Participants in the Gamified Design condition were asked to participate in a competitive scavenger hunt activity which consisted of solving riddles by locating clues in the artwork using the Halo AR app. The game session was facilitated using the web-based platform Kahoot [27]. A TV monitor located in the lab room (i.e., the art exhibition room) was used to display the Kahoot game session. In addition, two electronic tablets were set up in the

room and assigned to each participant so they could log into the game session and answer the riddles.

Participants were shown a riddle on the TV screen and presented with four multiple-choice options (see *Figure 6*). To solve the riddle, participants used the Halo AR app to scan the artwork and search for text-based clues for the correct answer. Participants were allowed four minutes to solve each riddle. Once they figured out the answer, they used the tablet to tap on the appropriate option (see *Figure 7*). After each riddle, the leaderboard was displayed on the TV screen so participants could compare their performance with their partner. There was a total of 8 riddles, one for each of the artworks in the exhibit. The order of the riddles and multiple-choice options were randomized in Kahoot. After finishing the activity, participants completed a post-task questionnaire to measure their perceived gamefulness, intrinsic motivation, autonomy, competence, and relatedness.

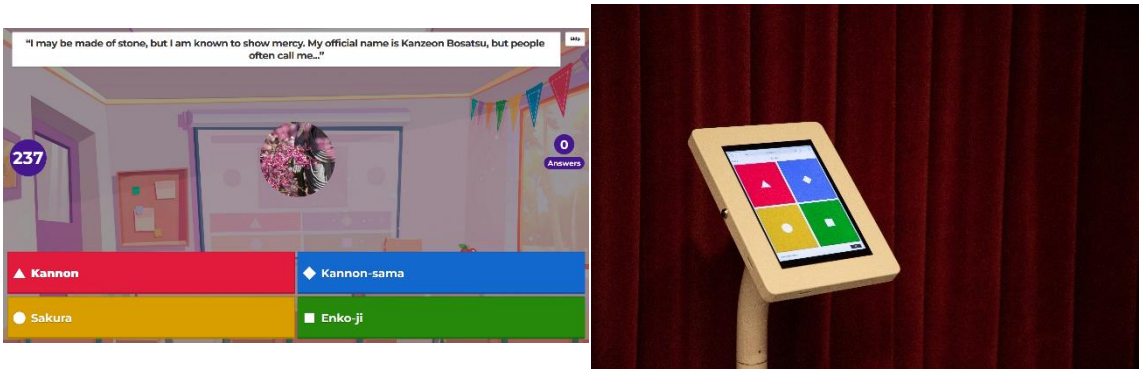

Figure 6 and 7: (Left) Screenshot of a riddle from the scavenger hunt activity using Kahoot. (Right) Preview of a tablet participants used to input their answers.

In Figure 6, the text for the riddle reads: "I may be made of stone, but I am known to show mercy. My official name is Kanzeon Bosatsu, but people often call me…"

2.4.5.3 Task 2-B: Gameful Design Condition (Storytelling Game)

Participants in the Gameful Design condition were asked to participate in a storytelling game which consisted of writing stories based on the artwork and sharing them with their partner. The game session was facilitated through the web-based platform Wooclap [67]. Similar to the Gamified Design condition, a TV monitor located in the lab room (i.e., the art exhibition room) was used to display the Wooclap game session, and two electronic tablets were set up in the room and assigned to each participant so they could log into the game session and type in their stories.

Participants were instructed to choose an artwork from the exhibit and write a story (see *Figure 8*). They were advised that they could choose how long or short the story could be. For instance, they could write a phrase, a sentence, a paragraph, a poem, etc. They were encouraged to write a story longer than one word. They were also instructed to use the Halo AR app to choose at least one word from the artwork's AR text layer and to include it in their story to serve as a clue.

Participants were allowed 5 minutes to choose an artwork from the exhibit and type their story. Once both participants' stories were submitted in Wooclap, they were displayed on the TV screen, and participants took turns storytelling and guessing which artwork the stories were based on (see *Figure 9*). They were allowed to check the artwork again using the Halo AR app for clues. There were no points rewarded for correctly guessing the artwork. To prevent participants from seeing which artwork their partner chose, they were instructed to choose an artwork from opposite sides of the room. There was a total of 2 rounds to allow participants an opportunity to choose an artwork from both sides of the exhibition. After finishing the activity, participants completed a post-task questionnaire to measure their perceived gamefulness, intrinsic motivation, autonomy, competence, and relatedness.

Figure 8: Screenshot of a prompt from the storytelling activity using Wooclap.

The text reads: “Story #1: Choose an artwork and write your story! (Go to opposite sides of the room).”

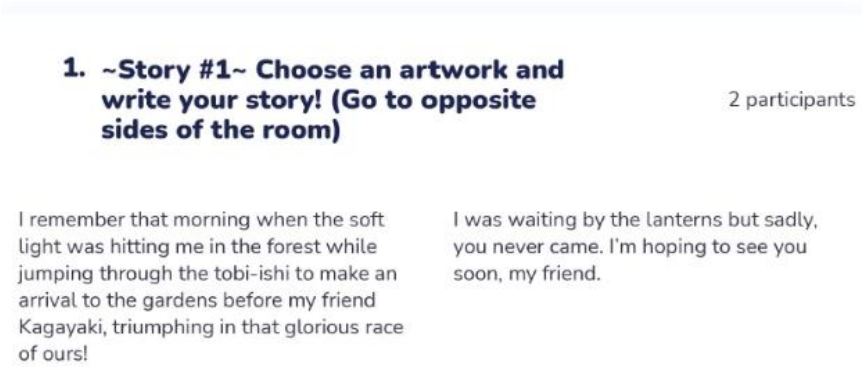

Figure 9: Sample stories created by P17 and P18.

The text on the left reads: “I remember that morning when the soft light was hitting me in the forest while jumping through the tobi-ishi to make an arrival to the gardens before my friend Kagayaki, triumphing in that glorious race of ours!” The text on the right reads: “I was waiting by the lanterns but sadly, you never came. I’m hoping to see you soon, my friend.”

2.4.5.4 Post-Test Questionnaire and Interview

After finishing the tasks, participants completed the post-test questionnaire to measure their perceived engagement, perceived learning experience, intention to revisit an AR-mediated art museum, and intention to recommend an AR-mediated art museum. Participants’ demographic data was also collected at the end of the questionnaire, namely

their age, gender, and education level. At the end of the experiment, semi-structured interviews were conducted with each pair of participants. Participants were encouraged to freely share their feedback and opinions on potential areas of improvement regarding the use of AR and incorporation of game-based learning activities in the context of an art museum or exhibition. *Figure 10* provides an outline of the experimental procedure and study tasks.

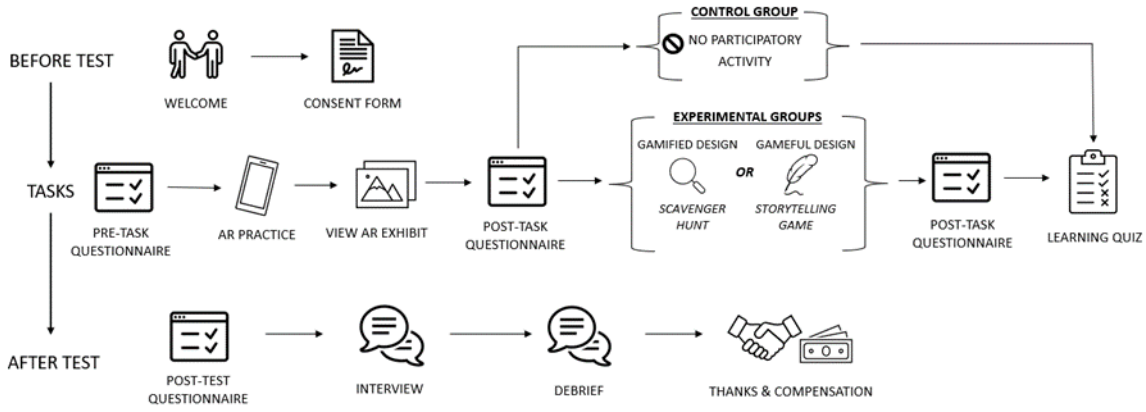

Figure 10: Outline of experimental procedure presenting the tasks that participants completed.

2.4.6 Analysis

Quantitative data was analyzed using IBM SPSS Statistics software version 28.0.1.1 [IBM, Armonk, NY, USA]. Descriptive statistics and frequencies were calculated for the demographic variables of age, gender, education, as well as previous experience using AR, visiting art museums, and using AR in an art museum.

The following statistical tests were conducted as part of our analysis:

- Independent samples t-tests were conducted to compare the mean differences of *Intrinsic Motivation*, *Psychological Need Satisfaction*, and *Perceived Gamefulness* between the two experimental conditions (H1a, H1b, H1c, H1d, H2).

- A simple linear regression was conducted to assess the impact of *Perception of Gamefulness* on *Intrinsic Motivation* (H3),

- Multiple linear regressions were conducted to assess the impact of *Intrinsic Motivation* and *Psychological Need Satisfaction* on *Perceived Engagement* (H4a, H4b, H4c, H4d) and *Perceived Learning* (H5a, H5b, H5c, H5d), separately.

- Additional multiple linear regressions were conducted to assess the impact of *Perceived Engagement* and *Perceived Learning* on *Intention to Visit* (H6a, H6b) and *Intention to Recommend* (H7a, H7b), separately.

- An additional simple linear regression was conducted to assess the impact of *Intention to Visit* on *Intention to Recommend* (H8).

A post-hoc analysis was also conducted, namely a multivariate analysis of variance (MANOVA) to compare the mean differences of *Perceived Engagement*, *Perceived Learning*, *Intention to Visit*, and *Intention to Recommend* between all three conditions. A post-hoc Bonferroni test was applied for error correction when determining the significance of the pairwise comparisons. Additionally, as mentioned previously in the Methods (see section *4.4.2 Construct Reliability*), an internal consistency reliability analysis was conducted on the scales used to measure *Intrinsic Motivation*, *Perception of Gamefulness*, *Perceived Learning* and *Perceived Engagement*.

For all the analyses, we used an alpha of $p = 0.05$ as the threshold of significance to confirm if the null hypothesis could be rejected. We also reported the effect sizes and confidence intervals to determine the importance and magnitude of the findings more comprehensively.

2.5 Results

2.5.1 Descriptive Statistics

Most participants reported previous experience with using AR (n = 29, 80.6%) whereas the remaining participants reported “Never” using AR before. Of those with previous AR

experience, there was a mean frequency of 4.19 (*SD* = 2.91). However, looking more closely at the data revealed that the frequency of AR use was split, with roughly a third using AR "Once a year" to "Once every 2 to 3 months" (n = 10, 27.8%) and half reporting a higher frequency ranging from "Once a month" to "Several times a week" (n = 18, 50%).

The overwhelming majority of participants reported previous experience with visiting art museums (n = 35, 97.2%), with a mean frequency of 4.47 (*SD* = 2.10). Most participants reported visiting an art museum within the last 6 months (n = 19, 52.7%) with only a few reporting their last visit to be more than 3 years ago (n = 4, 11.1%).

According to many participants, the present study was their first opportunity to use AR technology in the context of an art exhibition. About a third of participants reported using AR in an art museum during a previous visit (n = 10, 27.8%), with the majority only experiencing it once before (n = 6, 16.7%). Consequently, the mean frequency of previously using AR in an art museum was low (*M* = 0.42, *SD* = 0.77).

2.5.2 Intrinsic Motivation and Psychological Need Satisfaction: Gamified Design versus Gameful Design

Participants in the Gamified Design condition reported higher levels of *Intrinsic Motivation* (*M* = 4.36, *SD* = 0.64) compared to those in the Gameful Design condition (*M* = 4.17, *SD* = 0.54). Although the mean difference was not found to be statistically significant, there was a medium effect found ($t(22) = 0.78$, $p = 0.221$, $d = 0.59$, 95% CI [-0.49, 1.12]). However, ultimately support was not found for hypothesis H1a, which anticipated that the Gameful Design condition would result in higher levels of *Intrinsic Motivation*.

In terms of psychological need satisfaction for *Autonomy*, *Competence*, and *Relatedness*, there was a mean difference observed between the two experimental conditions (see *Figure 11*). Participants in the Gamified Design condition reported higher perceived *Competence* (*M* = 3.63, *SD* = 1.03) compared to those in the Gameful Design condition (*M* = 3.50, *SD* = 0.90). Although this mean difference was not statistically significant, a

large effect size was found, $t(22) = 0.32$, $p = 0.377$, $d = 0.97$, 95% CI [-0.67, 0.93]. This result suggests that a potential relationship exists, but ultimately, support in the form of statistical significance was not found for hypothesis H1c, which anticipated that the Gamified Design condition would result in higher perceived *Competence*.

Meanwhile, there was an opposite trend observed in the case of *Autonomy* and *Relatedness.* Participants in the Gameful Design condition reported higher perceived *Autonomy* ($M = 4.25$, $SD = 0.62$) compared to those in the Gamified Design condition ($M = 3.67$, $SD = 1.39$), $t(22) = -1.33$, $p = 0.099$, $d = 1.07$, 95% CI [-1.35, 0.28]. In addition, participants in the Gameful Design condition reported higher perceived *Relatedness* ($M = 4.29$, $SD = 0.54$) compared to those in the Gamified Design condition ($M = 3.67$, $SD = 1.23$), $t(22) = -1.61$, $p = 0.061$, $d = 0.95$, 95% CI [-1.47, 0.17]. Both findings have a large effect size and would be considered statistically significant at the 10% level. However, based on our pre-determined threshold of significance at the 5% level, support was not found for hypotheses H1b and H1d, which anticipated that the Gameful Design condition would result in higher perceived *Autonomy* and *Relatedness*.

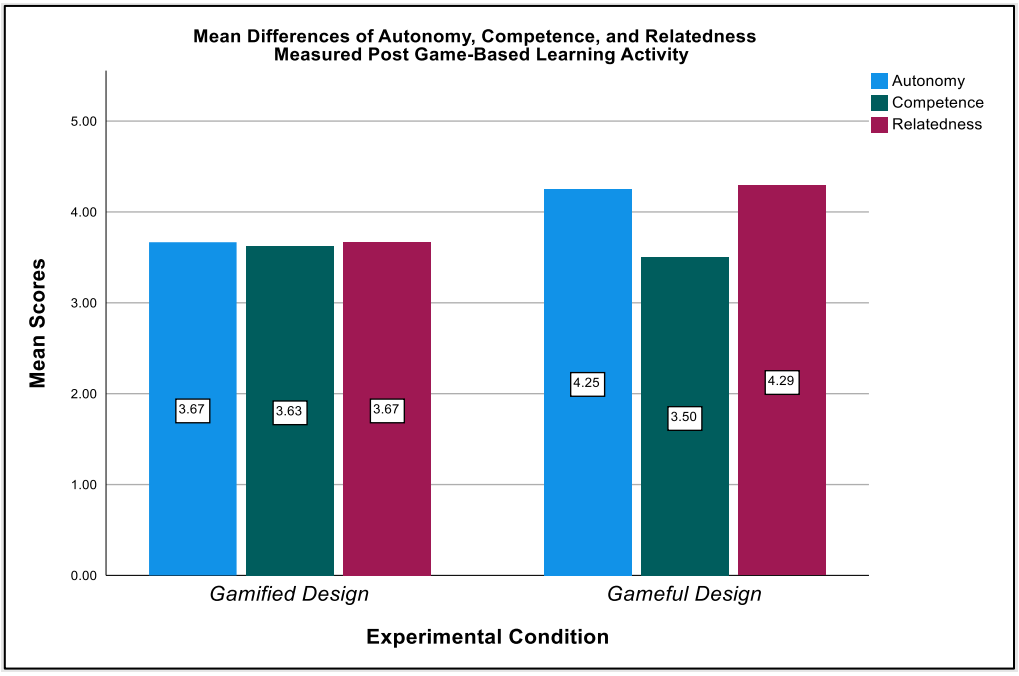

Figure 11: A bar chart visualizing the mean differences observed in measures of Autonomy, Competence, and Relatedness between the Gamified Design and Gameful Design experimental conditions.

2.5.3 Perception of Gamefulness

Participants in both experimental conditions reported similar levels for *Perception of Gamefulness*, with those in the Gameful Design condition reporting a slightly higher mean (M = 6.03, SD = 0.61) compared to those in the Gamified Design condition (M = 6.02, SD = 0.78), although this difference was not found to be statistically significant, $t(22) = -0.06$, $p = 0.477$, $d = 0.70$, 95% CI [-0.82, 0.78]. Thus, no support was found for hypothesis H2, which anticipated that the Gameful Design condition would result in higher *Perception of Gamefulness.*

Perception of Gamefulness and *Intrinsic Motivation* were found to be positively correlated with a significant regression, $R^2 = .54$, $F(1,22) = 28.01$, $p < .001$. Additionally, there was a significant positive correlation, $r(22) = .75$, $p < .001$. Thus, support was found for hypothesis H3 related to the relationship between *Perception of Gamefulness* and *Intrinsic Motivation*.

2.5.4 Intrinsic Motivation and Psychological Need Satisfaction on Perceived Engagement and Perceived Learning

The overall multiple linear regression model to assess the combined predictive value of *Intrinsic Motivation*, *Autonomy, Competence,* and *Relatedness* on *Perceived Engagement* was not found to be significant, $R^2 = .23$, $F(4,19) = 2.73$, $p = 0.060$. However, it should be noted that this finding would be considered statistically significant at the 10% level.

When examining the individual predictors in the model, *Intrinsic Motivation* was found to significantly predict *Perceived Engagement*, $\beta = 0.63$, $t(22) = 2.63$, $p = 0.016$. Additionally, there was a significant positive correlation, $r(22) = .49$, $p = 0.007$. Thus,

support was found for hypothesis H4a related to *Intrinsic Motivation* and *Perceived Engagement*.

Regarding the three dimensions of psychological need satisfaction, there were no significant predictors for *Perceived Engagement*. *Autonomy* demonstrated a lack of predictive value (β = -0.36, $t(22)$ = -1.01, p = 0.324) with no correlation, $r(22)$ = .02, p = 0.467). Similarly, *Relatedness* demonstrated a lack of predictive value (β = -0.10, $t(22)$ = -0.26, p = 0.801), with nearly a weak correlation, $r(22)$ = .09, p = 0.341). *Competence* also lacked predictive value (β = 0.21, $t(22)$ = 0.90, p = 0.381), although a moderate correlation was observed which would be considered statistically significant at the 10% level, $r(22)$ = .33, p = 0.060). However, ultimately, support was not found for hypotheses H4b, H4c, and H4d related to *Autonomy*, *Competence*, *Relatedness*, and *Perceived Engagement*.

In terms of *Perceived Learning*, the overall multiple linear regression model to assess the combined predictive value of *Intrinsic Motivation, Autonomy, Competence,* and *Relatedness* was also not found to be significant, R^2 = .02, $F(4,19)$ = 1.09, p = 0.390. *Intrinsic Motivation* was not found to be a significant predictor (β = 0.28, $t(22)$ = 1.03, p = 0.316), although a moderate correlation was observed, $r(22)$ = .30, p = 0.080). *Autonomy* also lacked predictive value (β = 0.15, $t(22)$ = 0.38, p = 0.708) with a weak correlation, $r(22)$ = .10, p = 0.323). Similarly, *Relatedness* lacked predictive value (β = -0.45, $t(22)$ = -1.06, p = 0.304) with no correlation, $r(22)$ = .05, p = 0.418). However, *Competence* lacked predictive value (β = 0.35, $t(22)$ = 1.29, p = 0.213), but with an observed moderate correlation that would be considered statistically significant at the 10% level, $r(22)$ = .31, p = 0.068). Therefore, although support could not be found for hypotheses H5a, H5b, H5c, and H5d related to *Intrinsic Motivation, Autonomy, Competence, Relatedness*, and *Perceived Learning*, the findings suggest that there is a potential relationship between *Intrinsic Motivation*, *Competence*, *Perceived Engagement* and *Perceived Learning*.

2.5.5 Perceived Engagement and Perceived Learning on Intention to Visit

The overall multiple linear regression model did not find *Perceived Engagement* and *Perceived Learning* to be significant predictors of *Intention to Visit*, $R^2 = .02$, $F(2,33) = 1.37$, $p = 0.269$. *Perceived Engagement* did not demonstrate predictive value ($\beta = 0.20$, $t(33) = 1.12$, $p = 0.272$), although a weak correlation was observed which would be considered statistically significant at the 10% level, $r(34) = .25$, $p = 0.070$). Similarly, *Perceived Learning* did not demonstrate predictive value ($\beta = 0.13$, $t(33) = 0.69$, $p = 0.493$) with a weak correlation, $r(34) = .20$, $p = 0.116$).

Thus, no support was found for hypotheses H6a and H6b related to the relationships between *Perceived Engagement*, *Perceived Learning*, and *Intention to Visit*.

2.5.6 Perceived Engagement and Perceived Learning on Intention to Recommend

The overall multiple linear regression model found *Perceived Engagement* and *Perceived Learning* to be significant predictors of *Intention to Recommend*, $R^2 = .37$, $F(2,33) = 11.45$, $p < .001$. When examining the individual predictors, the results demonstrate that *Perceived Engagement* significantly predicts *Intention to Recommend* ($\beta = 0.37$, $t(33) = 2.54$, $p = 0.016$) with a strong positive correlation, $r(34) = .52$, $p = 0.001$). Additionally, *Perceived Learning* is also a strong predictor of *Intention to Recommend* ($\beta = 0.40$, $t(33) = 2.76$, $p = 0.009$) with a strong positive correlation, $r(34) = .54$, $p < .001$). Thus, support was found for hypotheses H7a and H7b related to the relationships between *Perceived Engagement*, *Perceived Learning*, and *Intention to Recommend*.

2.5.7 Intention to Visit AR-Mediated Art Museums and Intention to Recommend

Intention to Visit was found to significantly predict *Intention to Recommend*, $R^2 = .41$, $F(1,34) = 24.91$, $p < .001$. Moreover, a significant positive correlation was found, $r(34) = .65$, $p < .001$). Thus, support was found for hypothesis H8 related to the relationship between *Intention to Visit* and *Intention to Recommend*.

The following table provides an overview of the research hypotheses proposed by the study and indicates if support was obtained as evidenced by the results (see *Table 3*). The final version of our research model is also provided (see *Figure 12*).

Table 3: Overview of hypotheses and support status based on results

Hypothesis	Support
H1a. The gameful design condition will result in higher perceived intrinsic motivation compared to the gamified design condition.	No
H1b. The gameful design condition will result in higher perceived autonomy compared to the gamified design condition.	No
H1c. The gameful design condition will result in lower perceived competence compared to the gamified design condition.	No
H1d. The gameful design condition will result in higher perceived relatedness compared to the gamified design condition.	No
H2. The gameful design condition will result in higher perceived gamefulness compared to the gamified design condition.	No
H3. Perceived gamefulness is positively associated with intrinsic motivation.	**Yes**
H4a. Intrinsic motivation is positively associated with perceived engagement.	**Yes**
H4b. Autonomy is positively associated with perceived engagement.	No
H4c. Competence is positively associated with perceived engagement.	No
H4d. Relatedness is positively associated with perceived engagement.	No
H5a. Intrinsic motivation is positively associated with perceived learning.	No
H5b. Autonomy is positively associated with perceived learning.	No
H5c. Competence is positively associated with perceived learning.	No
H5d. Relatedness is positively associated with perceived learning.	No
H6a. Perceived engagement is positively associated with intention to visit AR-mediated art museums.	No
H6b. Perceived learning is positively associated with intention to visit AR-mediated art museums.	No
H7a. Perceived engagement is positively associated with intention to recommend AR-mediated art museums.	**Yes**
H7b. Perceived learning is positively associated with intention to recommend AR-mediated art museums.	**Yes**
H8. Intention to visit AR-mediated art museums is positively associated with intention to recommend AR-mediated art museums.	**Yes**

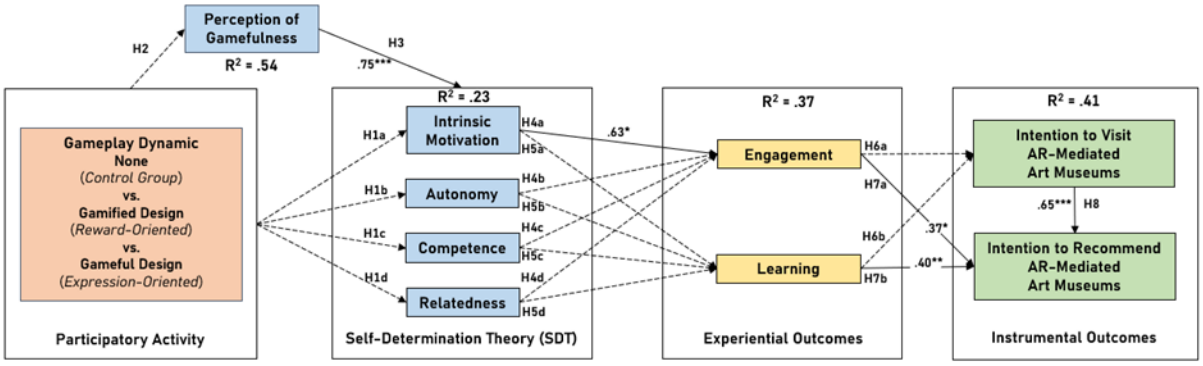

Figure 12: Final research model demonstrating predictive value of supported hypotheses (*p < 0.05, **p < 0.01, ***p < 0.001).

2.5.8 Post-Hoc Analyses

Post-hoc analyses were conducted to examine potential group differences for the outcome variables, namely *Perceived Engagement*, *Perceived Learning*, *Intention to Visit*, and *Intention to Recommend*. A post hoc Bonferroni test for pairwise comparisons was applied to determine if the mean differences between the three groups were significant. Although participants in the Gamified Design condition reported the highest scores on *Perceived Engagement* (M = 6.31, SD = 0.42) when compared with the other two conditions, the results suggest that the mean difference was not significant, $F(2,35) = 2.50$, $p = 0.098$, $\eta p^2 = .131$ (see *Table 4*).

Similarly, participants in the Gamified Design condition also reported the highest scores on *Perceived Learning* (M = 6.15, SD = 0.68) when compared with the other two conditions, but the results suggest that the mean difference was not significant, $F(2,35) = 1.39$, $p = 0.262$, $\eta p^2 = .078$.

Table 4: Mean differences between all three conditions on outcome variables

Outcome Variable	Condition	N	Mean	Standard Deviation
Perceived Engagement	Control Group	12	5.91	.489
	Gamified Design	12	6.31	.425
	Gameful Design	12	5.80	.796
	Total	36	6.00	.617
Perceived Learning	Control Group	12	5.75	.826
	Gamified Design	12	6.15	.678
	Gameful Design	12	5.63	.876
	Total	36	5.84	.807
Intention to Visit AR-Mediated Art Museums	Control Group	12	6.46	.689
	Gamified Design	12	6.46	.498
	Gameful Design	12	5.50	.769
	Total	36	6.14	.790
Intention to Recommend AR-Mediated Art Museums	Control Group	12	6.00	.651
	Gamified Design	12	6.61	.566
	Gameful Design	12	5.61	.874
	Total	36	6.07	.805

However, there was a significant mean difference observed for Intention to Visit, such that participants in the Gameful Design condition reported significantly lower scores (M = 5.50, SD = 0.77) when compared with the other two conditions, $F(2,35) = 8.39$, p = 0.001, ηp^2 = .337. A similar trend was observed for Intention to Recommend, with participants in the Gameful Design condition reporting significantly lower scores (M = 5.61, SD = 0.87) when compared with the other two conditions, $F(2,35) = 6.05$, p = 0.006, ηp^2 = .268. The difference in scores amongst the three conditions is presented in *Table 4*.

2.5.9 Qualitative Results

Qualitative data collected during the paired participant interviews was analyzed and reviewed to assess participants' experience with using the AR application to determine potential areas of improvement, as well as to gather participants' impressions of the participatory activities to evaluate if there is an interest in having similar activities available in art museums or photography exhibitions.

The majority of participants enjoyed the theme of the photography exhibition (n = 35) with many citing an admiration for Japanese culture and art (n = 18).

"I intend to go one day to Japan, so I like the pictures. They're really beautiful. And I felt like they're really different too, even if it comes from the same place, he could capture many different aspects of Japan. So, I really like it." (P18)

"I like Japanese art and I like mountains and temples and stuff, so it's very cool to learn about it." (P06)

Regarding participants' experience with using AR while viewing the artwork (Task 1), many participants appreciated how AR was used to provide them with additional information about the elements within the artwork (n = 26), although some expressed an interest in having more interactivity using AR (n = 7), such as having the artwork enhanced or modified (n = 5) or having additional multimedia layers like music or videos (n = 2).

"It was definitely nice to get that extra information and it was like a 'Hey, here's a little tidbit about what you're looking at' that you don't get from the description of the photo in general." (P04)

"Maybe you could superimpose something that would enhance the picture. […] Like for the cherry blossoms, you saw blossoms opening and closing and stuff, that would be really exciting for me..." (P32)

Regarding the participatory activities, there was a mix of positive and negative impressions for both. However, it should be noted that this was the first time that participants experienced such activities in the context of an art exhibition. Thus, their impressions of the activities are based on their experience in the study.

For the Gamified Design condition, about half of the participants (n = 7) found the scavenger hunt to be fun and enjoyable, with some mentioning that it allowed them to interact more with the artwork (n = 5). However, some potential concerns were the emphasis on competition (n = 2), the lack of free exploration (n = 2), and the feasibility of participating in such an activity when visiting a crowded museum (n = 1). Some suggestions included making the activity a team-based competition to encourage collaboration, solving a puzzle using the answers from the scavenger hunt, and

randomizing the order of the questions so that visitors are not crowded at one artwork at a given time. Overall, some participants could imagine such an activity in a bigger museum or in an interactive exhibit at a zoo, and thought it had potential to engage and educate kids.

"It was really fun. I was able to interact with the images more." (P03)

"It also basically holds onto my attention and also reminds me of some of the words because it's a very good absorbing activity as part of that exhibition experience, so I really liked it." (P33)

"…these kinds of activities are a little bit at odds in general with how I visit museums, especially art museums, because activities like this are almost - if you want to follow them, are almost necessarily prescriptive. Like you have to kind of follow a certain like sequence or, you know, if it's a museum, that kind of guide or museum quiz that kind of guides you through the exhibits." (P10)

For the Gameful Design condition, half of the participants (n = 6) found the storytelling game to be fun and enjoyable, with some appreciating how it allowed them to express their imagination and creativity (n = 5). One participant felt it allowed them to interact more with the artwork, and another thought it could be a good way to connect with others when visiting a museum with family or friends. However, there were some concerns that the activity would not be appealing for adults who prefer to exclusively appreciate the artwork (n = 2). Another participant mentioned the potential blurring of the line between playing a game and visiting an exhibit (n = 1), while another expressed discomfort with the idea of participating with strangers (n = 1). Additionally, one participant mentioned that the rule of including a word from the AR labels in the story felt like a constraint that limited their ability to express themselves freely. One suggestion was to showcase other visitors' stories along with the artwork. Overall, some participants felt that the activity could attract people who do not usually visit museums, that it could be an interactive experience, and that it could be particularly beneficial for kids.

"*I liked it because it made me think more about the art. Like I had to look into it more to come up with the story or poetry or something, which adds more layers to it, which is cool.*" (P06)

"I really liked the way that we interpreted what we had to do in different manners. As [P35] *was really into creating stories, and I was more like, I'm not good at creating stories and everything. So just creating more personal sentences that relate both to us and to the pieces. So, I think it's a great way to connect with the people around us."* (P36)

"…a lot of adults, they just like to go and appreciate the pieces overall. It might be just a bit more difficult to do that with grown adults, but it's fun. It might depend on their personality." (P29)

Overall, the findings suggest that there is potential value in implementing such participatory activities to art museums or in art exhibitions. Participants in both conditions found the activities to be enjoyable and particularly engaging for kids. The scavenger hunt in the Gamified Design condition provided an opportunity to interact more with the artwork, while the storytelling game in the Gameful Design condition provided an opportunity to express imagination and creativity. Considering that each activity has its respective advantages, they could be strategically designed, adapted, and implemented depending on the context.

2.6 Discussion

Overall, the present study provided insight into the role of intrinsic motivation in perceived engagement and learning, as well as revealed how game-based learning activities could differentially impact intrinsic motivation. Although some hypotheses could not be confirmed through this study, we were able to obtain confirmation for others and provide additional support for findings from previous research.

First, and perhaps most importantly, we found evidence to suggest that the Gamified Design condition resulted in an overall better user experience when compared with the

Gameful Design condition and control group. This is counter to what was expected as it was hypothesized that participants would report higher levels of engagement and learning when provided with an opportunity to connect more deeply with the artworks in the exhibit. Moreover, these findings are counter to Nicholson's theory of meaningful gamification, which suggests that participatory activities that encourage reflection, exposition, and play are more likely to enhance intrinsic motivation and engagement compared with activities focused on mastery and competence. However, this result was not found to be significant, so more research would be needed to confirm if participatory activities with a Gamified Design are associated with higher engagement and learning. It is possible that the design of the storytelling game used for the Gameful Design activity did not match the level of interactivity and interest as the scavenger hunt used for the Gamified Design activity.

Second, we found a significant and positive relationship between *Perception of Gamefulness* and *Intrinsic Motivation*. This coincides with previous research which suggests that there is a link between the two constructs as the former is related to feelings of curiosity, imagination, and exploration, while the latter is related to feelings of enjoyment and peaked interest. This finding confirms that *Perception of Gamefulness* has a mediating role on *Intrinsic Motivation* and provides further support for its use in future research as a potential predictor of *Intrinsic Motivation*.

Third, although we found non-significant mean differences in psychological need satisfaction for *Autonomy*, *Competence*, and *Relatedness* between the Gamified Design and Gameful Design conditions, the effect sizes ranged from medium to large, indicating a possible trend. The Gameful Design condition, which consisted of an expression-oriented activity that tasked participants with creating stories based on the artwork however they wished with an opportunity to interact and connect with their partner, was more associated with the psychological need satisfaction for both *Autonomy* and *Relatedness*. Meanwhile, the Gamified Design condition, which consisted of a reward-oriented activity that tasked the participant to successfully perform and complete objectives, was more associated with the psychological need satisfaction for *Competence*. These findings illustrate that participants were able to perceive the conceptual differences

between the two game-based learning activities and that key elements from each activity resulted in a different experience for both groups of participants.

Fourth, we found a significant and positive relationship between *Intrinsic Motivation* and *Perceived Engagement*, and a non-significant yet moderate positive correlation between *Intrinsic Motivation* and *Perceived Learning*. This finding is consistent with previous research demonstrating the impact of intrinsic motivation on engagement and learning. However, the significance of the results seems to suggest that the link between enjoyment and engagement is much stronger than that of enjoyment and learning, which may be due to how the participatory activities were designed in this study. For instance, we may have been able to elicit enjoyment and intrinsic motivation through the incorporation of engaging game design elements and dynamics in the scavenger hunt and storytelling game, such as competition, rewards, and creative expression. However, it is possible that the elements necessary to foster a sense of learning were not achieved through our study design and thus, were experienced to a lesser degree compared with engagement.

Lastly, we found that participants who reported higher *Perceived Engagement* and *Perceived Learning* were more likely to report a higher *Intention to Recommend AR-Mediated Art Museums*, with this finding maintaining significant and predictive value. This provides further evidence for the link between positive museum visit experiences and visitors' likelihood to recommend such experiences to others. However, higher *Perceived Engagement* and *Perceived Learning* was not associated with a higher *Intention to Visit AR-Mediated Art Museums* as hypothesized. This finding may suggest that despite experiencing enhanced engagement and learning from an AR-mediated exhibition, visitors may not necessarily wish to re-experience and re-visit the same exhibition but are nonetheless still likely to recommend it to others. This highlights the role of engagement and learning in motivating art museum visitors to recommend exhibitions to others. Additionally, there was a significant and positive relationship between *Intention to Visit AR-Mediated Art Museums* and *Intention to Recommend AR-Mediated Art Museums*. This could be due to the desire for visitors to share their positive experience with friends and family or seeing potential benefits of experiencing an art museum in a novel way using AR technology.

2.7 Conclusion

2.7.1 Theoretical Contributions

The theoretical contributions for this study are four-fold. First, the explanatory value of the Self-Determination Theory was validated through this study as evidenced by the differential impact of the game-based learning activities on intrinsic motivation and psychological need satisfaction. These findings reinforce the continued relevance of applying SDT to empirical research focused on gamification, as well as extends the theory into a new context, namely an AR-mediated photography art exhibition.

Second, this study incorporated and further validated the role of perception of gamefulness as a mediating variable for intrinsic motivation, as evidenced in previous research. This may indicate that future research focused on gamification through the SDT framework can incorporate perception of gamefulness as a predictor of intrinsic motivation.

Third, the research model developed for this study incorporated the Framework for Design of Gamified Information Systems alongside SDT, with findings that suggest intrinsic motivation plays a critical role in influencing experiential outcomes, such as engagement and learning, thus providing support for bridging both theories.

Lastly, this study applied the Mechanics-Dynamics-Aesthetics (MDA) framework [24] and Nicholson's [44] RECIPE for meaningful gamification in the design of the Gameful Design condition with results indicating there was an impact on perceived autonomy, competence, and relatedness as hypothesized. This is encouraging as it further validates the value of the MDA framework, but also shows that the RECIPE framework can potentially serve as a set of guiding principles for designing applications of gamification to positively enhance intrinsic motivation through fulfilling the need for autonomy and relatedness, as successfully achieved in this study. Further, the RECIPE framework may also be valuable as a conceptual lens for evaluating applications of gamification on their ability to incorporate "gameful" qualities, such as reflection, exposition, choice, information, play, and engagement, and thus, foster intrinsic motivation.

2.7.2 Practical Implications

This study demonstrates how AR technology could be used in the context of shared visitor experience in a photography art exhibition along with gameful design with mixed findings for practitioners. For museum curators and exhibitors, the results suggest that incorporating mobile AR that provides additional information about the artwork is beneficial for engaging museum visitors as it affords an interactive experience through a digital medium. However, while creating exhibitions that facilitate learning opportunities is important, the findings indicate that incorporating engaging elements is vital in encouraging visitors to visit and recommend AR-mediated art museums in the future.

Additionally, AR can be used to facilitate two-person game-based learning activities with successful outcomes for engagement and learning experience, as evidenced by the gamified design scavenger hunt activity in this study. However, considering the lower levels of perceived engagement and learning associated with the gameful design storytelling activity, it will be necessary to iteratively test the design of future activities that deviate from more conventional applications of gamification which feature points, leaderboards, and a competitive dynamic.

As for managers, it is recommended that art museums continue to explore the different ways that AR can be implemented, as a medium for viewing artwork or as a tool to achieve a goal or complete a task. Ideally, AR would be implemented during the design phases of the exhibitions as opposed to being added later in development. However, this study demonstrated the possibility of incorporating AR to supplement the shared visitor experience through participatory activities. The feasibility of conducting such activities will depend on the size of the museum and the nature of the exhibition, but nonetheless, it is worth considering as it has the potential benefit of increasing visitor engagement and providing a positive experience that can attract future visitors.

2.7.3 Limitations and Future Research

This study was limited in the following four key aspects. First and foremost, it should be acknowledged that this study lacked a robust sample size. Considering the number of hypothesized relationships between the constructs in the research model, it would have been ideal to have more than 36 participants to provide more confidence in the statistical significance of the results. Additionally, a larger sample size may have potentially provided evidence for hypothesized results that were not explained despite demonstrating medium-to-large effect sizes. Second, participants visited an art exhibition that was experimentally set up and located on a university campus, thus perhaps reducing the generalizability of the results. Third, there was only one pair of participants in the art exhibition at a given time, which may contrast with real-world experiences of visiting an art museum crowded with people. Therefore, it would be valuable for future studies to investigate how game-based learning activities can be facilitated with groups of participants, who may or may not know each other, in an actual art museum setting. And lastly, it is possible that the design of the two participatory activities did not sufficiently match in respect to their gameplay mechanics and level of interactivity, thus introducing some potential confounds that were not experimentally manipulated in the study. Therefore, it is recommended that future studies with the objective of comparing gamified and gameful design approaches establish more alignment between the two designs to control and examine influential factors more precisely. Future research should further investigate how AR technology can be incorporated in the design of game-based learning activities and how such activities can be applied to an art museum context.

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Appendix

A.1 Measurement Items

Construct	Definition	Source
Game-Based Learning Activity	Whether the game-based learning activity features a Gamified Design (Reward-Oriented) or Gameful Design (Expression-Oriented).	Dichev et al. [17]; Sailer et al. [55]
Perception of Gamefulness (POG)	The degree to which the game-based learning activity is perceived as a game. - Participants' self-reported perceived gamefulness will be measured by the "Playfulness" dimension of the Gameful Experience Questionnaire (GAMEFULQUEST) (using 5 out of 10 items based on highest factor loadings).	Högberg et al. [23]
Intrinsic Motivation	The degree to which participants are motivated to complete a task due to internal rewards or satisfaction. - Participants' self-reported intrinsic motivation will be measured by the "Interest/Enjoyment" dimension of the Intrinsic Motivation Inventory (IMI). - In addition, participants' intrinsic needs for Autonomy, Competence, and Relatedness will be measured by a combination of the Intrinsic Motivation Inventory (IMI) and the Ubisoft Perceived Experience Questionnaire (UPEQ).	Ryan [53]; Wesseloh et al. [66];
Perceived Engagement	The extent to which a system holds the users' attention, and they are attracted to it for intrinsic rewards. - Participants' self-reported perceived engagement will be measured by the Audience Engagement in Multimedia Presentations scale.	Webster et al. [64, 65]
Perceived Learning	The extent to which participants feel that they had a learning experience after visiting the art exhibit. - Participants' self-reported perceived learning will be measured by the "Education" dimension of the Experience Economy Scale.	Pine & Gilmore [52]; Oh et al. [47]
Intention to Visit	The degree to which participants would visit an (AR-mediated) art exhibition in the future. - Participants' self-reported intention to visit an (AR-mediated) art exhibition will be measured using items adapted from Pallud and Straub	Pallud & Straub [50]
Intention to Recommend	The degree to which participants would recommend AR-mediated art exhibitions to others via word-of-mouth. - Participants' self-reported intention to recommend an AR-mediated art exhibition will be measured using items adapted from Kim and Son.	Kim & Son [30]
Previous Experience with AR	Participants' previous experience with using AR technology.	N/A
Previous Experience Visiting Art Museums	Participants' previous experience with visiting art museums.	N/A
Age	Participants' age in years.	N/A
Gender	Participants' self-identified gender.	N/A
Education	Participants' highest level of educational attainment.	N/A

A.2 Measurement Items

A.2.1 Pre-Task Questionnaire

Variable	Items
Previous Experience with AR	1. Have you used Augmented Reality (AR) in the past? (Yes/No) Examples: Filters on Snapchat / Instagram / or similar, Pokemon Go app, IKEA Place app, Hololens by Microsoft, Google Glass, etc.
	2. How often do you use Augmented Reality (AR)?* - Several times a week - Once (1) a week - Once (1) every 15 days - Once (1) a month - Once (1) every 2 to 3 months - Once (1) every 6 months - Once (1) a year - Once (1) in my life *only asked if "Yes" is answered to Q1
Previous Experience Visiting Art Museums	3. Have you visited an art museum before? (Yes/No)
	4. When was the last time you visited an art museum?* - Within the last month - More than 1 month ago, but within the last 3 months - More than 3 months ago, but within the last 6 months - More than 6 months ago, but within the last 12 months - More than 1 year ago, but within the last 2 years - More than 2 years ago, but within the last 3 years - More than 3 years ago *only asked if "Yes" is answered to Q1
	5. Have you used Augmented Reality (AR) in an art museum before?* (Yes/No) *only asked if "Yes" is answered to Q1
	6. How many times have you used Augmented Reality (AR) in an art museum? - Never - 1 time - 2 or 3 times - 4 or 5 times - 6 or 7 times - 8 or 9 times - More than 10 times
Intention to Visit	Rate your level of agreement for the following statements on a 7-point scale, from "strongly disagree" to "strongly agree" 1. Given the opportunity, I intend to visit an art exhibition. 2. It is likely that I will actually visit an art exhibition in the future. 3. Given the opportunity, I intend to visit an AR-mediated art exhibition. 4. It is likely that I will actually visit an AR-mediated art exhibition in the future.

A.2.2 Post-Task Questionnaire

Variable	Items
Perception of Gamefulness (POG)	Rate your level of agreement for the following statements on a 7-point scale, from “strongly disagree” to “strongly agree” This activity… 1. Taps into my imagination. 2. Gives me the feeling that I explore things. 3. Feels like a mystery to reveal. 4. Gives me a feeling that I want to know what comes next. 5. Appeals to my curiosity.
Intrinsic Motivation	For each of the following statements, indicate how true it is for you on a 5-point scale, from “not at all true” to “entirely true” 1. I enjoyed doing this activity very much. 2. This activity was fun to do. 3. I thought this was a boring activity. (R) 4. This activity did not hold my attention at all. (R) 5. I would describe this activity as very interesting. 6. I thought this activity was quite enjoyable. 7. While I was doing this activity, I was thinking about how much I enjoyed it.
Autonomy	Same instruction as above: 1. I was free to decide how I wanted to do the activity. 2. I could approach the activity in my own way.
Competence	Same instruction as above: 1. I think I am pretty good at this activity. 2. I am satisfied with my performance at this activity.
Relatedness	Same instruction as above: 1. Doing this activity, I feel I can learn with other participants. 2. With this activity, I feel I can relate with other participants.

A.2.3 Post-Test Questionnaire

Variable	Items
Perceived Engagement	Rate your level of agreement for the following statements on a 7-point scale, from "strongly disagree" to "strongly agree" The AR art exhibition… 1. …kept me totally absorbed in browsing the artwork. 2. …held my attention. 3. …excited my curiosity. 4. …aroused my imagination. 5. …was fun. 6. …was intrinsically interesting. 7. …was engaging.
Perceived Learning	Same instruction as above: 1. This experience has made me more knowledgeable. 2. I learned a lot. 3. It stimulated my curiosity to learn new things. 4. It was a real learning experience.
Intention to Visit	Same instruction as above: 1. Given the opportunity, I intend to visit an art exhibition. 2. It is likely that I will actually visit an art exhibition in the future. 3. Given the opportunity, I intend to visit an AR-mediated art exhibition. 4. It is likely that I will actually visit an AR-mediated art exhibition in the future.
Intention to Recommend	Same instruction as above: 1. I will say positive things about AR-mediated art exhibitions to other people. 2. I will recommend AR-mediated art exhibitions to anyone who seeks my advice. 3. I will refer my acquaintances to AR-mediated art exhibitions.
Age	Please select your age in years. - Dropdown list with ages ranging from 18 to 65+
Gender	Please choose the category that best reflects your gender. - Female; Male; Non-Binary / Third Gender; Prefer not to say
Education	Please choose the category that best reflects the highest degree or level of education that you have completed. - Less than high school diploma - High school diploma or GED - Some college/university - Associates degree (e.g. AA, AS) - Bachelor's degree (e.g. BA, BBA, BS) - Master's degree (e.g. MA, MS, MEng) - Professional degree (e.g. MD, DDS, JD) - Doctorate degree (e.g. PhD, EdD)

Chapter 3
Managerial Article
In Preparation for: *Curator: The Museum Journal*

Design Recommendations for AR-Based Exhibitions and Participatory Activities in Art Museums

Chantel Chandler, Constantinos K. Coursaris, Pierre-Majorique Léger

HEC Montréal, Montréal, Canada

Summary

The number of museums incorporating AR technology in their exhibitions has increased in recent years as an effort to increase visitor engagement and appeal to younger audiences. However, there is little research on how to design and implement AR in the context of art museums, and much less is known on how to adapt AR to interactive, participatory activities. Our team conducted interviews with 18 pairs of participants to investigate what defines a well-designed AR exhibition and to evaluate if there is an interest or need for AR-based participatory activities in art museums. As part of the study, participants also had the opportunity to partake in one of two types of participatory activities (a creative storytelling activity and a competitive scavenger hunt activity) and provided feedback on their experience. Overall, the results suggest that there is an interest in AR-based exhibitions that are interactive, enhance the artwork displayed, and include AR layers featuring multimedia content, such as music, videos, and text captions. Further, there is potential appeal for participatory activities, but with thoughtful adaption to the context of the art exhibition and offered as an optional experience for the visitor. In this article, we provide best practices for art museums to consider when designing AR-based exhibitions and participatory activities.

3.1 Introduction

According to a recent eMarketer report, the number of people experiencing AR content is growing in the U.S. (2022). While there was a 2.9% increase from 2020 to 2021, there is predicted to be an increase from 2022 to 2025. The use of AR technology has become more common and widely available, especially through social media applications such as Facebook, Instagram, and Snapchat. With these applications, users can enjoy video chatting with their friends and family while adding different face filters, such as animals or silly characters. AR technology has also been used in the context of mobile gaming applications, such as *Pokémon GO*. This application allows users to catch Pokémon while taking a stroll around their neighborhood as Pokémon pop-up on their smartphones and seemingly in their actual environment.

AR use has extended outside of personal contexts as museums have gradually begun offering AR experiences as part of their exhibitions. In 2021, *The National Gallery* in London displayed public artworks through AR using QR codes and the *Museum national d'Histoire naturelle* in Paris displayed digital versions of extinct animals using Microsoft's *Hololens* (Coates 2021). Even back in 2017, the Art Gallery of Toronto, or AGO, provided visitors with a collection of reimagined classical artwork using an AR app (Coates 2021). Research has shown that exhibitions that incorporate AR technology can lead to positive outcomes, such as increased artwork appreciation and visitor engagement (Attila and Edit, 2012; Chang et al., 2014; Damala et al., 2008; Kaghat et al., 2020). Needless to say, the novelty, interactivity and enjoyment that users experience when using AR motivates visitors to revisit such exhibitions and recommend them to others. However, what constitutes a "well-designed" AR exhibition? What are some best practices that art museums can follow to ensure that their exhibition will be well-received by their visitors?

3.2 Designing AR Exhibitions for Art Museums

To explore how AR could be designed to satisfy the needs and interests of art museum visitors, we interviewed participants who expressed an interest in visiting art museums. Most participants had previous experience with AR (29 out of 36), with about half who used AR at least once a month and up to several times a week (18 out of 36). The majority of participants also had previous experience with visiting art museums (35 out of 36), with about half who visited an art museum within the last 6 months (19 out of 36). However, few participants had previous experience with using AR during an art museum visit (10 out of 36), and even fewer had used AR more than once during an art museum visit (4 out of 36).

During our interviews, they shared with us what they considered to be the benefits, or good use cases, of AR in art museums.

The following characteristics were identified as ideal or recommended:

1. Interactive
2. Responsive
3. Multimedia layers
4. Enhancement or modification of art
5. Additional contextual information

We will briefly describe each characteristic and provide suggestions on how to design AR with these characteristics.

1. Interactive

Designing AR with **interactivity** allows visitors to engage more with the exhibition content. The traditional style of art museum visits is characterized by a passive viewing experience, in which visitors look at the artwork displayed. Alternatively, digital exhibits that offer AR can provide a dynamic viewing experience, in which visitors can interact with select artworks using their mobile device. A single artwork may feature several points of interaction, in which the visitor can learn more about the work, thus enhancing their appreciation.

"The more interactive, in my opinion, the art pieces are, the better it is for me. I like that better, so I'm more inclined to go, rather than looking at images." (P03)

2. Responsive

Designing AR with **responsiveness** allows visitors to experience the AR content seamlessly without slow loading times. For instance, if AR content glitches while a visitor is accessing it, this would disrupt the immersive quality and negatively impact their experience. Achieving a high level of responsiveness is dependent upon the technology being used, such as the mobile device and the AR application, as well as internet connectivity, if required. This is an area that is still under development, however, as AR technology is further developed, ensuring responsiveness is anticipated to become much more attainable.

"*In my past experiences, some AR applications have been janky, to say the least.*" (P22)

3. Multimedia Layers

Designing AR with multimedia layers, such as music, videos, or visual effects, allows visitors to have a much more engaging and immersive experience. Artwork that is accompanied by music can enhance the intended emotional response or help to communicate the "feeling" behind a piece. Similarly, sound effects can be used to highlight portions of a piece, such as adding the sound of water flowing to an artwork featuring a river, or the sound of birds chirping to an artwork featuring a park. Artwork that includes videos or visual effects can also heighten the feeling of immersion as it provides more depth to a piece.

"*I like the idea of videos and sound. Sound adds a lot of information on the atmosphere or the mood of the place."* (P24)

4. Enhancement or Modification of Art

Designing AR with the ability to **enhance or modify the art** allows visitors to have a more immersive experience when compared to viewing a static artwork. For instance, upon scanning a painting with your smartphone, a character's facial expression changes, or perhaps objects move around in the background.

"*If you hover, it would be sometimes cool to maybe have the picture move a little. For example, the Sakura tree like weaving in the wind or something, or here, you see the sunset and the sun actually comes down."* (P09)

5. Additional Contextual Information

Designing AR to provide **additional contextual information** allows visitors to develop a greater appreciation for the artwork. For instance, providing a text description of the objects within an artwork through AR can enhance visitors' learning experience. Moreover, AR that features a voiceover of the artist explaining the creative process that went into their artwork can also allow visitors to feel more connected to the artist and understand the artwork at a deeper level.

"*I would have enjoyed knowing more about what the photographer did to do his work. [...] maybe some more personal comments about why he chose to take this photo this way. Like, what's his connection with the piece that he made?"* (P36)

3.3 Designing AR-Based Participatory Activities for Art Museums

In our interviews, we also asked participants to share their opinions on participatory activities on whether there is an interest in having them available in art museums. There were mixed views on the inclusion of participatory activities, and overall, it seems that several factors should be carefully considered prior to implementation, including:

- the **visitor** (e.g., their personality and age)
- the **type of visit** (e.g., solo or group visit)
- the **reason for the visit** (e.g., to connect with art emotionally, to socialize with friends or family, to enhance creativity)
- the **topic of the art exhibit**
- the **location** (e.g., small exhibit space or large art museum)

Before providing suggestions on how to design AR-based participatory activities, it is important to mention the potential benefits of including such activities, as well as the potential drawbacks to consider prior to implementation.

Potential Benefits

Participants who saw the potential added value of AR-based participatory activities considered them as an opportunity to interact more with the art featured in the exhibit in a fun and enjoyable way. Moreover, depending on the type of activity, it could provide a space for visitors to connect more with each other, as well as enhance their creativity and imagination. Overall, it seems that there is potential for such activities to enhance the art museum visit experience.

"It was really fun. I was able to interact with the images more." (P03)

"I liked it because it made me think more about the art. Like I had to look into it more to come up with the story or poetry or something, which adds more layers to it, which is cool." (P06)

Potential Limitations

While some could envision the benefits of AR-based participatory activities, others expressed concern over the possibility of distracting visitors from the focus of the exhibition – namely, the artists' work.

"*So recently, I went to the Van Gogh exhibition, that immersive one, with the lights and all. It was okay. Like, it wasn't the best experience that I had with like viewing art. […] I don't think Van Gogh would have liked it this way. And that's why it kind of took away from the experience. It's not really letting me the opportunity to appreciate his work in the way that he would like to have. […] I think as long as that was the actual intention of the artist, it's a good way to use it. But if it wasn't, then I think it should be used in the original purpose of the artist.*" (P29)

Moreover, some participants perceived the rise of AR and VR in museum spaces as potential "digital gimmickry" that is intended to attract audiences without consideration for the context.

"*I also don't want to see it going in the direction where it becomes less about art and more about AR. And then that just defeats the purpose. And nobody is bothered by who the photographer is, they just want to see the AR thing*." (P07)

Thus, when designing participatory activities, it is essential that they do not disrupt the artists' intended experience, but rather, that they supplement or complement the exhibition. This can be achieved by presenting the activities as optional experiences, as opposed to incorporating them as a necessary part of the exhibition. It is also recommended to consider the type of content featured in an exhibit to ensure that the activity appropriately matches the theme and context. For instance, designing a playful and interactive activity for an art exhibit centered on a somber topic may be considered inappropriate and would likely not help to highlight or enhance the artists' intended experience.

Suggestions for Designing AR-Based Participatory Activities

Participants shared their opinions and feedback on the two participatory activities that they experienced as part of the study (a creative activity and a competitive activity), as well as offered suggestions on the types of activities that they would be interested in if included as part of their art museum visit.

From our discussion, we identified the following themes for the types of activities:

1. Creative
2. Competitive
3. Collaborative

We will briefly describe each theme and provide examples of participatory activities that could be designed while leveraging AR technology.

1. **Creative Activity**

A **creative activity** allows visitors to interact with the artwork by reflecting upon the artwork and using it as inspiration to express their own ideas artistically. For instance, visitors could write poetry or short stories based on the artwork, or even create their own artistic piece in response to the artwork featured in the exhibit. This can be done individually or as a group, such that visitors share their own works of art with others in a designated place in the art museum. Alternatively, AR can be used as the medium for viewing these visitor-created artworks, by using a smartphone to scan the original artwork that inspired them and seeing the additional artwork displayed.

"I found it really cool, like the storytelling, because you could use your imagination and you could create anything that comes to your head. I thought it was very fun. It was kind of like charades." (P05)

2. Competitive Activity

A **competitive activity** allows visitors to interact with the artwork by competing against other visitors in challenges or quizzes. Using elements of gamification, such as points and leaderboards, visitors could be motivated to engage in friendly competition with others. For instance, the activity could be a scavenger hunt to locate certain objects throughout an art exhibit, or to successfully answer questions on a quiz based on what could be learned from the art exhibit. Due to the gamified nature of this activity, it may appeal more with younger audiences. AR can be used to provide clues or information for objects within an artwork.

"It lets the images kind of stay with you more, because you go over it to once, and you're like, 'Yeah, it's pretty, lovely.' But then like having the quiz makes you recall 'What did I see?' 'Which one was the one that had this information on it? Let me go back and look at it again.' It like sticks with you." (P04)

3. Collaborative Activity

A **collaborative activity** allows visitors to interact with the artwork by working alongside other visitors. For instance, visitors may be tasked with solving a riddle or puzzle based on the art exhibit. This could work well for visitors who are accompanied by family or

friends are looking for an opportunity to experience the artwork together. Similar to the competitive activity, AR can be used to provide clues or information for objects within an artwork.

"What if you had to get pieces of information from multiple photographs?" (P10)

3.4 The Future of Art Museums

When designing AR art exhibitions and AR-based participatory activities, it is helpful to gain perspective on why it is that visitors enjoy visiting art museums. So, we asked our participants what motivates them to visit art museums and what they would like to see more of in the future.

What Motivates People to Visit Art Museums?

Although participants expressed different motivations for visiting art museums, many responses overlapped, and five key themes emerged. The following table depicts the different types of visit motivations along with the number of participants.

Emotional Experience / Imagination	Social Activity	Learning Something New	Experiencing Different Art	Interest in Art / Exhibition / Artist
16	12	11	11	5

Table 1: Overview of different types of visit motivations expressed by participants.

As the results suggest, the majority of museum-goers are motivated by a desire for an **emotional experience**, in which they can use their imagination and feel connected to the artwork. Thus, designing AR exhibitions and creative participatory activities that tap into this motivation to feel moved and connected to the artwork could appeal to most visitors.

"*It makes you dream, too. It makes you want to go to places, do stuff."* (P01)

"A lot of artists in general have a different way of viewing life and a different way of understanding things. And that's what really drives me to art museums, generally." (P13)

"It's peaceful. It's quiet. And every art has its own unique way of expression. So, I like that. I mean, everything has a story." (P34)

Participants also consider visiting an art museum to be a **social activity** to be enjoyed with friends and family, so there is also an opportunity here for art museums to provide ways for visitors in pairs or groups to experience the exhibit together, such as through the offering of creative, competitive, or collaborative participatory activities.

"You want to share the experience. You want to talk about it afterwards." (P23)

"It's a place for people and not just art, and to enjoy it with each other." (P18)

What Do Visitors Want to See?

When asked what types of art exhibits they would like to see in the future, participants expressed an interest in the incorporation of more **digital technology**, such as AR, VR, and MR (8 out of 36), more **interactive and immersive exhibitions** (6 out of 36), and more **"behind-the-scenes"** footage or information (6 out of 36).

Indeed, art museums have already begun to offer more digital art experiences through AR and VR. With continued advancement in these technologies, this trend will likely continue and become more commonplace in art museum offerings.

"The technology that society's developing to make art even more engaging and stuff. Paintings are great and conventional, classical art is incredible, but humans are hungry, hungry creatures, and we just want more and more exciting art and I think AR, as a technology, really has the ability to create those sorts of new experiences." (P32)

While art is traditionally consumed using one's visual sense, there seems to be an emerging desire for more interactive and immersive exhibitions that allow visitors to tap into all of their senses, such as through sounds, smells, and even touch.

"I think something that could be really cool is like a sensory experience, where you could feel stuff that would give you shivers or smells, and touch, and, if there was wind and air and warmth and cold - just like a whole sensory experience." (P13)

There also seems to be a need for going beyond the surface-level of an artwork and diving deeper into the artist's creative process through "behind-the-scenes" footage and information. This not only provides more context into how an artwork was made; it also allows visitors to feel more connected to the artist and gain a greater appreciation for the artwork as a whole.

"I feel like we always go to museums, and we're just going to miss the small things like the nuances, the little things that an artist might have put thought into that really nobody except for maybe an art professor is going to notice. […] I want to know what's up with like, the dog in the corner, or something like that. Like random tidbits that are not necessarily the main subject of the artwork, but that still, it's like some subconscious choice went into it. And I feel like that would add dimension to it." (P10)

3.5 Conclusion

There is clearly an interest in AR exhibitions in art museums and they are not a trend that will be going away any time soon. They can be used to create more engaging, immersive, emotional, and educational experiences for visitors. However, AR is best incorporated in a meaningful way, and not for the sole purpose of increasing visitor engagement. Therefore, it is recommended that the design of AR be adapted to the specific topic or context of the art exhibit, and customized to align with the artists' intended vision. There are several different ways to leverage AR in art museums, whether in the design of an exhibition or as part of a participatory activity, and AR has the potential to provide novel opportunities that enhance the visit experience.

"*I think with AR, there's so much more possibilities where you can actually enhance the experience and add new content that you wouldn't be able to without AR."* (P17)

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Conclusion

The aim of this thesis was to investigate how participatory activities could positively enhance the art museum visit experience. More specifically, this thesis explored how AR technology and aspects of game design could be leveraged to develop AR-based participatory activities adapted to an art exhibition. First, a literature review was presented in Chapter 1 and provided an overview of the current state of research related to applications of AR and gamification in the art museum context and to identify the gaps in the literature. Second, an experiment was conducted and reported in Chapter 2 to evaluate the relative impact of a "gamified design" participatory activity versus a "gameful design" participatory activity on levels of engagement and learning. The role of perceived gamefulness and intrinsic motivation was explored, and implications for visitor intention to visit and recommend were considered. Third, a managerial article was presented in Chapter 3 to provide design recommendations for developing AR-based participatory activities for art museums. The recommendations are based on the results from the experiment and participants' feedback.

In this conclusion, an overview of the research questions, hypotheses, and study results will be presented, followed by the theoretical contributions of this research and the managerial implications of the findings. This section will conclude with the limitations of the experiment conducted and provide suggestions to guide future research.

Research Questions and Key Findings

The experiment conducted as part of this thesis aimed to answer three key research questions and proposed a set of hypotheses aligned with each. The following table (see *Table 1*) provides an overview of these research questions and hypotheses, as well as the study results. The level of support achieved for each of the hypotheses is indicated in the column labeled "Support." Overall, the research findings provide support for some of the hypotheses proposed with a 5% significance level, namely those related to *Perceived Gamefulness, Intrinsic Motivation,* and *Intention to Recommend AR-mediated Art*

Museums. However, there are some hypotheses which did not achieve support at the 5% significance level despite demonstrating a moderately positive association or relationship. This suggests that there may be a potential relationship between the constructs examined, but further research may be needed to determine their significance.

Research Question	Hypothesis	Support
RQ1a: What are the relative effects of gamified versus gameful design on intrinsic motivation and perceptions of autonomy, competence, and relatedness?	**H1a.** The gameful design condition will result in higher perceived intrinsic motivation compared to the gamified design condition.	No
	H1b. The gameful design condition will result in higher perceived autonomy compared to the gamified design condition.	No
	H1c. The gameful design condition will result in lower perceived competence compared to the gamified design condition.	No
	H1d. The gameful design condition will result in higher perceived relatedness compared to the gamified design condition.	No
RQ2: How does perception of gamefulness mediate the relationship between the type of participatory activity and the constructs of the Self-Determination Theory?	**H2.** The gameful design condition will result in higher perceived gamefulness compared to the gamified design condition.	No
	H3. Perceived gamefulness is positively associated with intrinsic motivation.	**Yes**
RQ1b: How do these constructs from the Self-Determination Theory contribute to experiential outcomes, such as engagement and learning, during an AR-mediated art museum visit?	**H4a.** Intrinsic motivation is positively associated with perceived engagement.	**Yes**
	H4b. Autonomy is positively associated with perceived engagement.	No
	H4c. Competence is positively associated with perceived engagement.	No
	H4d. Relatedness is positively associated with perceived engagement.	No
	H5a. Intrinsic motivation is positively associated with perceived learning.	No
	H5b. Autonomy is positively associated with perceived learning.	No
	H5c. Competence is positively associated with perceived learning.	No
	H5d. Relatedness is positively associated with perceived learning.	No
RQ3: What is the relationship between experiential outcomes and instrumental outcomes? Which type of participatory activity is associated with more positive instrumental outcomes?	**H6a.** Perceived engagement is positively associated with intention to visit AR-mediated art museums.	No
	H6b. Perceived learning is positively associated with intention to visit AR-mediated art museums.	No
	H7a. Perceived engagement is positively associated with intention to recommend AR-mediated art museums.	**Yes**
	H7b. Perceived learning is positively associated with intention to recommend AR-mediated art museums.	**Yes**
	H8. Intention to visit AR-mediated art museums is positively associated with intention to recommend AR-mediated art museums.	**Yes**

Table 1: Overview of research questions, hypotheses, and results.

Theoretical Contributions

The theoretical contributions for this study are four-fold. First, the explanatory value of the Self-Determination Theory (Ryan and Deci, 2000) was validated through this study as evidenced by the differential impact of the game-based learning activities on intrinsic motivation and psychological need satisfaction. These findings reinforce the continued relevance of applying SDT to empirical research focused on gamification, as well as extends the theory into a new context, namely an AR-mediated photography art exhibition.

Second, this study incorporated and further validated the role of perception of gamefulness (Högberg et al., 2019) as a mediating variable for intrinsic motivation, as evidenced in previous research. This may indicate that future research focused on gamification through the SDT framework can incorporate perception of gamefulness as a predictor of intrinsic motivation.

Third, the research model developed for this study incorporated the Framework for Design of Gamified Information Systems (Liu et al., 2017) alongside SDT, with findings that suggest intrinsic motivation plays a critical role in influencing experiential outcomes, such as engagement and learning, thus providing support for bridging both theories.

Lastly, this study applied the Mechanics-Dynamics-Aesthetics (MDA) framework (Hunicke et al., 2004) and Nicholson's (2015) RECIPE for meaningful gamification in the design of the Gameful Design condition with results indicating there was an impact on perceived autonomy, competence, and relatedness as hypothesized. This is encouraging as it further validates the value of the MDA framework, but also shows that the RECIPE framework can potentially serve as a set of guiding principles for designing applications of gamification to positively enhance intrinsic motivation through fulfilling the need for autonomy and relatedness, as successfully achieved in this study. Further, the RECIPE framework may also be valuable as a conceptual lens for evaluating applications of gamification on their ability to incorporate "gameful" qualities, such as reflection, exposition, choice, information, play, and engagement, and thus, foster intrinsic motivation.

Managerial Implications

This study demonstrates how AR technology could be used in the context of shared visitor experience in a photography art exhibition along with gameful design with mixed findings for practitioners. For museum curators and exhibitors, the results suggest that incorporating mobile AR that provides additional information about the artwork is beneficial for engaging museum visitors as it affords an interactive experience through a digital medium. However, while creating exhibitions that facilitate learning opportunities is important, the findings indicate that incorporating engaging elements is vital in encouraging visitors to visit and recommend AR-mediated art museums in the future.

Additionally, AR can be used to facilitate two-person game-based learning activities with successful outcomes for engagement and learning experience, as evidenced by the gamified design scavenger hunt activity in this study. However, considering the lower levels of perceived engagement and learning associated with the gameful design storytelling activity, it will be necessary to iteratively test the design of future activities that deviate from more conventional applications of gamification which feature points, leaderboards, and a competitive dynamic.

As for managers, it is recommended that art museums continue to explore the different ways that AR can be implemented, as a medium for viewing artwork or as a tool to achieve a goal or complete a task. Ideally, AR would be implemented during the design phases of the exhibitions as opposed to being added later in development. However, this study demonstrated the possibility of incorporating AR to supplement the shared visitor experience through participatory activities. The feasibility of conducting such activities will depend on the size of the museum and the nature of the exhibition, but nonetheless, it is worth considering as it has the potential benefit of increasing visitor engagement and providing a positive experience that can attract future visitors.

Limitations and Future Research

This study was limited in the following four key aspects. First, this study lacked a robust sample size. It would have been ideal to have more than 36 participants considering that this research study had been conducted with three conditions using a between-subjects experimental design. A more robust sample size would provide more confidence in the statistical significance of the results, as well as potentially provide evidence for hypothesized results that were not explained despite demonstrating medium-to-large effect sizes. Second, participants visited an art exhibition that was experimentally set up and located on a university campus, thus perhaps reducing the generalizability of the results. Third, there was only one pair of participants in the art exhibition at a given time, which may contrast with real-world experiences of visiting an art museum crowded with people. Therefore, it would be valuable for future studies to investigate how game-based learning activities can be facilitated with groups of participants, who may or may not know each other, in an actual art museum setting. And lastly, it is possible that the design of the two participatory activities did not sufficiently match in respect to their gameplay mechanics and level of interactivity, thus introducing some potential confounds that were not experimentally manipulated in the study. Therefore, it is recommended that future studies with the objective of comparing gamified and gameful design approaches establish more alignment between the two designs to control and examine influential factors more precisely. Future research should further investigate how AR technology can be incorporated in the design of game-based learning activities and how such activities can be applied to an art museum context.

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Appendix

HEC MONTRÉAL

Comité d'éthique de la recherche

June 01, 2022

To the attention of:
Constantinos K. Coursaris
HEC Montréal

Re: Ethics approval of your research project

Project No.: 2023-5055

Title of research project: The effects of augmented reality on the visitor experience in the context of an art museum

Funding source : CRSNG - CCS:R2579

Title of the grant : Envisioning and Enacting UX Evaluation of Augmented Reality: A Multimethod Approach

Your research project has been evaluated in accordance with ethical conduct for research involving human subjects by the Research Ethics Board (REB) of HEC Montréal.

A Certificate of Ethics Approval attesting that your research complies with HEC Montréal's *Policy on Ethical Conduct for Research Involving Humans* has been issued, effective June 01, 2022. This certificate is **valid until June 01, 2023.**

In the current context of the COVID-19 pandemic, you must ensure that you comply with the directives issued by the Government of Quebec, the Government of Canada and those of HEC Montréal in effect during the state of health emergency.

Please note that you are nonetheless required to renew your ethics approval before your certificate expires using Form *F7 – Annual Renewal*. You will receive an automatic reminder by email a few weeks before your certificate expires.

When your project is completed, you must complete Form *F9 – Termination of Project*. (or *F9a – Termination of Student Project if certification is under the supervisor's name).* **All students must complete an F9 form to obtain the "Attestation d'approbation complétée" that is required to submit their thesis/master's thesis/supervised project.**

If any major changes are made to your project before the certificate expires, you must complete Form *F8 – Project Modification*. .

Under the *Policy on Ethical Conduct for Research Involving Humans*, researchers are responsible for ensuring that their research projects maintain ethics approval for the entire duration of the research work, and for informing the REB of its completion. In addition, any significant changes to the project must be submitted to the REB for approval before they are implemented.

You may now begin the data collection for which you obtained this certificate.

We wish you every success in your research work.

REB of HEC Montréal

HEC MONTRÉAL

Comité d'éthique de la recherche

CERTIFICAT D'APPROBATION ÉTHIQUE

La présente atteste que le projet de recherche décrit ci-dessous a fait l'objet d'une évaluation en matière d'éthique de la recherche avec des êtres humains et qu'il satisfait aux exigences de notre politique en cette matière.

Projet # : 2023-5055

Titre du projet de recherche : The effects of augmented reality on the visitor experience in the context of an art museum

Chercheur principal :
Constantinos K. Coursaris,
Professeur agrégé, Département de T. I., (organization not found)

Cochercheurs :
Pierre-Majorique Léger; Lan Chi Maria Tran; Chantel Chandler; David Brieugne; Salima Tazi; François Courtemanche; Shang Lin Chen; Sylvain Sénécal

Date d'approbation du projet : June 01, 2022

Date d'entrée en vigueur du certificat : June 01, 2022

Date d'échéance du certificat : June 01, 2023

Maurice Lemelin
Président
CER de HEC Montréal

Signé le 2022-06-06 à 10:52