
Business Amplification: Managing Innovation through Synthetic Users

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Abstract

This paper examines the potential of Synthetic Users (SyU) as a possible alternative or supplement to conventional human surveys in the area of innovative product or service development. Generative Artificial Intelligence (GenAI) can be an invaluable technology for companies and creative businesses during the "Eureka phase" and in testing, economic analysis, development, and manufacturing. GenAI can rapidly answer hundreds of questions without causing fatigue, creating rapid feedback and making it a cost-effective alternative to human testing (Aher et al., 2023). The deployment of SyU promises a more efficient business world, offering benefits such as predictive and cultural insights, and faster iteration, contributing to a deeper understanding of the emotional drivers behind user behaviours. SyU could be an innovative approach that blurs the boundaries between qualitative and quantitative investigation by allowing researchers to gain rich insights and leverage large-scale data, lowering biases in human interactions, observer-expectancy effects, emphasizing the importance of diverse data, objective questioning, and regular evaluation (Santurkar, S. et al., 2023). Finally, while conducting a survey again under identical conditions in the real world is not always feasible, in the synthetic realm it is

possible to improve the LLMs approach through a recent technique known as "self-refinement" (selfrefine.info), based on an iterative algorithm, punctuated by two moments, feedback and refinement, that result in higher quality output and a more structured process. (Maadan et al., 2023)

After reviewing the current state of the art, the article explores the potential of Large Language models (LLMs) to simulate human-like interactions and judgments through a real case. One company, Syntheticusers.com, based on GPT-4, has been selected to test the comparison between human participants and SyU in evaluating an immersive museum experience within a 5G-focused project led by the University of Turin.

Our results suggest that scientists study the right mix of humans and artificial intelligence, rather than focusing on whether artificial intelligence will replace humans.

Keywords – Artificial Intelligence, Large Language Models, Synthetic User, Immersive Reality, Innovation Management

Paper type – Practical Paper

1 Introduction

The rapid advancement of digital technologies has a profound impact on various aspects of society, including the cultural sector. Museums, as key cultural institutions, are actively embracing innovative technologies such as virtual and augmented reality (VAR), to attract visitors and enhance users' experience, fostering a more profound engagement with art, history, and culture.

Although VAR can potentially enhance the attractiveness of museums, in practice the public's interest in these technologies is not always as significant as we expect. It is important to emphasise that imagine and develop better use of these technologies to boost museum art exhibitions is not always a technological issue but also a humane one.

This paper investigates if SyU (SyU) could be a useful technique to identify customers' preferences and needs for a particular immersive reality experience, understanding how to design and develop an impactful and successful immersive experience for customers and museums.

In the following sections, after having thoroughly analyzed the literature review on SyU, an empirical study that combines simulated data and real-world observations has been run up to explore how synthetic entities interact with and respond to virtual experiences.

The research findings may contribute not only to a better understanding of the SyU potentiality in human behaviour comprehension but also to enhance, innovatively and effectively the immersive experiences in museums. Through an empirical study that combines simulated data and real-world observations to explore how synthetic entities interact with and respond to virtual experiences, the paper compares and contrasts the responses and behaviours of real and SyU,

shedding light on the unique strengths and limitations of each and leading to the creation of more immersive and interactive museum experience.

2 Literature Review on synthetic users through the lens of Generative Artificial Intelligence in survey research

At the end of 2022, ChatGPT took off, making Generative Artificial Intelligence (GenAI) massively and easily available to all users and changing the world with unimaginable challenges and opportunities in both business and education (Ooi et al., 2023). People have started to reimagine every single use case as a GenAI use case creating an incredible impact in many sectors: from the financial industry to the pharmaceutical one, from the creative industry to the educational sector (Alawida, et al., 2023), and affecting different working tasks in a transformative way. In this new framework, SyU emerged as a new way of understanding human behaviour.

SyU are computer-generated entities that mimic human behaviour and interactions and can be used in a variety of contexts, including research, testing or product development. They were early identified in a contribution related to query execution optimization time within a database (DB) (Lu et al., 1986). Some prominent companies (Ostler and Kalidas, 2023) define SyU as the ability of GenAI to reproduce answers to questions in a human way, potentially becoming a tool for use in questionnaires and market surveys, some researchers (Chelaru, 2023) emphasize the important relationship between the SyU and the training dataset in the accuracy of replicating human behaviour.

Due to significant contributions (Aher et al., 2023; Park et al., 2022; Argyle et al., 2022), the concept of SyU has evolved. Turing Experiment demonstrates that the GenAI can faithfully reproduce different aspects of human sample populations' behaviour (Aher et al., 2023). The concept of algorithmic fidelity reproduces the individuality and specificity of population subgroups through GenAI (Argyle et al., 2022). The use of *Social Simulacra* prototypes social computing environments and simulate credible human behaviour within immersive environments (Park et al., 2022).

In the social sciences, GenAI can generate responses and, thus, more nuanced and detailed human behavioural aspects thanks to the ability of Natural Processing Language (NLP) to capture word semantic meaning and relationships (Grossmann et al., 2023) using the embedding system technique (Park et al., 2022) and attention mechanism (Hämäläinen et al., 2023). In addition, some studies (Jansen et al., 2023) highlight the ability of LLMs to significantly improve NLP survey activities. Other research (Aher et al., 2023) confirms the contribution of GenAI--and the concept of virtual populations or *Silicon Samples* in the social sciences--by highlighting the ability to mimic U.S. population groups and reflect complex human behavioral and cultural facets.

The ability to generate responses with human attributes is well highlighted in Hämäläinen's Human-Machine Interaction studies (Hämäläinen et al., 2023), where GenAI provides answers reflecting likely subjective experiences on the requested topic, which are recognized as real by human evaluators. AI agents can linguistically articulate judgments that reflect possible "lived" experiences on requested topics, and thus be capable of reproducing an emotional judgment recognizable as human by their interlocutors. For Hämäläinen, AI Agents can be used in the design phase of experiments or the embryonic stage of research.

3 Research objective and significance

Following the initial literature review, this study aims to investigate, with a hands-on approach, the use of SyU to evaluate their impact in a real technological context to demonstrate if their application can represent an innovative tool for validating and investigating VR services before implementing them in the museum context. The use of SyU to test and improve services, such as Virtual Reality applications for museums, can represent an innovative, modern and effective approach to enhancing cultural and educational experiences.

Comparing the human and synthetic viewpoints, highlighting differences in engagement, perception and overall immersive experience quality, will provide valuable insights into the unique strengths and limitations of each perspective to inform the design and optimisation of immersive exhibits to maximise audience engagement. In fact, by examining artificial user responses, it is possible to identify areas of both proficiency and deficiency in the VR service and to propose enhancements that will improve the overall experience, providing practical guidance for cultural operators. With these premises, the paper's question research follows:

RQ1: Are synthetic users a useful technique to increase the engagement of the visitor through a virtual reality experience?

3.1 Conducting real-world observations testing an immersive museum environment as part of the 5G4C.A.P.10100 (Circuito. Auto. Pilota) project

5G4C.A.P.10100 (Circuito. Auto. Pilota)- funded by the Ministry of Enterprises and Made Italy, and with the University of Turin as the lead partner- is the project we used to test the value of SyUs. The goal of the project is to enable a new way of living the museum experience in an immersive, replicable, and adaptive mode, exploiting the potential of 5G technology.

A diffuse narrative will be created through the storytelling of the driver Ayrton Senna, organised at the Automobile Museum (MAUTO) in Turin to commemorate his legend on the 30th anniversary of his death, with content in synchronous and asynchronous modes. Immersive realities (AR/VR), Artificial Intelligence, the Internet of Things, and the 5G networks will be deployed to celebrate the life and

exploits of Ayrton Senna with 5G streaming connections from the Imola Autodrome, to deep dive the users into Ayrton Senna's real world wearing virtual reality visors to watch a stereoscopic 360 3D live broadcast, interspersed with content on the Brazilian driver pre-produced in Virtual Reality.

As part of the *5G4C.A.P.10100 (Circuito. Auto. Pilota)* project, the *Work Package 3.2 - Use case 5 "Project Dissemination and Scalability"* envisions the enhancement and scalability of the project will be achieved through the creation of a virtual reality platform that will support a pool of selected stakeholders to easily and intuitively create an immersive 3D environment navigable to develop events and exhibitions, regardless of content.

To carry out the activity, the Italian startup "Another Reality" was selected to provide a "technological kit" or immersive environment (museum template) that can be used both via a standalone VR headset and via the web, to enable visitors to feel truly immersed in an environment and to increase scalability and dissemination to those without a headset. The template refers to a museum environment to independently create events within navigable immersive spaces. Within the environment, it is possible to display images and presentations (.pdf format), videos (.mp4 format), and 3D models (.obj format) related to a specific museum environment and collections.

In the project context, a usability test was conducted on the "technological kit" to get feedback from five real users. These observations provide qualitative data on public behaviour and reactions to the current immersive experiences. After the testing session, a qualitative study was carried out to gather feedback from different perspectives and compare it with the results of the SyU's testing. Qualitative research - aimed at gaining a full understanding of people's opinions, perspectives, motivations and experiences on a particular issue - is based on the collection and analysis of non-numerical data, such as interviews, focus groups, participant observation and document analysis. The main objective of a qualitative investigation is to obtain a detailed and in-depth understanding of the phenomena under study, rather than generating numerical statistics. This approach is particularly useful when exploring complex or poorly understood issues, allowing researchers to capture the complexity and richness of human perspectives. The results of a qualitative investigation may be useful in generating new hypotheses, developing theories, or informing the design of interventions or policies based on the experiences and needs of the people involved.

To easily replicate the qualitative survey for SyU, five open-ended questions were posed to the five trial participants, a homogeneous target group between 25 and 35 years old, with university degrees and a passion for technology. The research objective of the five open questions is to evaluate the effectiveness of immersive museum experiences in terms of public engagement and audience captivation. Public engagement encompasses the level of interaction, involvement, and interest exhibited by participants, while audience captivation

refers to the ability of immersive experiences to capture and maintain the attention of visitors and effectively convey information. By examining factors such as content quality, interactivity, storytelling techniques, and sensory immersion, the research seeks to understand how these elements contribute to both engaging the public and captivating their attention within the museum setting. This holistic approach aims to uncover the mechanisms that drive effective audience engagement and captivation, providing valuable insights for designing immersive exhibits that resonate with visitors and enhance their overall museum experience.

*The insights that emerged from synthetic user interviews are outlined in **Annex 1** and **Annex 2**.*

3.2 Generation of synthetic users and collection of simulated data

The initial step has been the choice of the best GenAI platform for conducting experimentation, with advanced computational models used to generate SyU representing a wide range of potential museum visitors. Following a thorough benchmarking process, the *syntetichuser.com* platform was chosen due to its comprehensive features, user-friendly interface, track record with notable clients, and established scientific expertise. In addition to this, the psychometric model of Big Five Personality Traits (Synthetic Users Journal, 2023) integrated into the *syntetichuser.com* platform was highly appreciated. This model, originally developed in 1961 (Ernest Tupes and Raymond Christal, 1992), is used to describe human personality along five broad dimensions: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. These traits encompass a wide range of human behaviours and emotional patterns and provide insights into personality assessment and interpersonal dynamics. This psychometric approach, which offers a simple, concise, and methodologically tested way of classifying and predicting different personality traits from an extensive scientific literature, was integrated for the generation of SyU that mimic the behaviour and preferences of human beings, thus bringing greater confidence and conformity to real data in questionnaires and market research.

Initially, researchers proceeded with the selection of the "Custom script" interview modality. As the term suggests, this method allows the formulation of a customized script according to the researcher's qualitative investigation specifications. Researchers, possessing a deep understanding of their field, can input their desired questions individually, with each question occupying its line. This interview format is suited for individuals who have pre-established scripts and seek to conduct interviews based on these predetermined parameters, as opposed to those requiring assistance in generating interview content.

It was determined that 5 open-ended questions would be formulated, mirroring those administered to real participants who underwent the immersive museum visitation, generalizing them to a generic museum immersive visit

instead of focusing on the specific "technological kit" developed by the startup Another Reality and subjected to the testing & feedback session of real users.

After selecting the interview type and the question formulation, the subsequent step involves generating and refining SyU. These SyUs are characterized by a series of demographic, behavioural, and preference attributes, allowing for the simulation of public behaviour in response to different immersive experiences. This process begins by clicking the "generate SUs" button, which initiates the creation of Synthetic User Panels. These panels are equipped with a SyU editor, designed to facilitate the adjustment and customization of synthetic user profiles. Through the SyU editor, researchers can fine-tune and modify synthetic user attributes to align with the research objectives and experimental parameters.

To compare the answers provided by the same profile of customer personas, both real and synthetic, the same profile of synthetic respondents was defined: a homogeneous target group between 25 and 35 years old, with university degrees and a passion for technology.

*The description of the 5 synthetic customer personas generated by the syntheticuser.com platform is available in **Annex 1**.*

Upon completing the editing process, researchers proceed by activating the interviews through the "Run Interviews" function. This action initiates the interview process, wherein SyUs engage in structured interactions designed to elicit insights and responses relevant to the research inquiry.

*The insights that emerged from both human and synthetic user interviews are summarized in **Annex 1**.*

*For complete answers see **Annex 2**.*

3.3 Analysis and comparison of data

The data collected from the simulations and real-world observations have been analyzed and compared to identify any discrepancies or convergences between the responses of SyU and real visitors. This analysis helps to assess the accuracy and usefulness of simulated data in understanding public behaviour.

The examination involves a manual review of conversational flow, utilization of idiomatic expressions, and overall readability. Termed "glanceability," this process evaluates whether responses align with the relevance and appropriateness of the posed questions, mirroring the contextual responsiveness characteristic of real interviews. For this comparative study, initial emphasis is placed on assessing content overlap, with the potential for deeper exploration through synthetic interviews if deemed necessary. Right afterwards we performed a Context Analysis or rather the evaluation entails assessing the participant's responsiveness to the interview's provided context. This is achieved by gauging topic consistency and comparing the breadth of topics discussed initially in organic interviews with subsequent synthetic interviews.

The first remarkable evidence is that the responses provided by human users are considerably more concise and lacking in content compared to the elaborate responses provided by SyUs. Focusing on individual feedback, several points of convergence have emerged, alongside notable differences, attributed naturally to real experience versus simulation, which entails a series of considerations that will be assessed on a question-by-question basis.

1. Comparing the responses between humans and SyUs regarding what they liked most about museum virtual experiences reveals some commonalities as well as a few differences. Overall, both humans and SyUs value the immersive nature of VR tours for exploring museum exhibits. However, human users put more emphasis on sensory experiences, emotional involvement, and usability, while SyUs focus on accessibility and personalized learning. Discrepancies between the two groups highlight areas where human-centred design considerations may differ from purely functional or utilitarian perspectives.
2. When examining the feedback from both humans and SyUs regarding their least preferred aspects of virtual museum experiences, it became clear that both users converged on several key issues, such as the lack of physical presence, social interaction and technical limitations that affect the immersive nature of virtual museum experiences. However, there are also discrepancies, with human users emphasising personalisation, navigation, and graphical fidelity more, while SyUs focus on sensory engagement and the emotional impact of isolation. These differences highlight the importance of considering both user feedback and technical limitations when designing and improving virtual museum experiences.
3. Examining the feedback concerning the enhanced benefits of virtual tours over traditional visits underscores that both humans and SyUs agree on the accessibility, personalization, in-depth exploration, and educational value offered by virtual tours. However, there are discrepancies in emphasis, with human users focusing more on interactivity and graphical challenges, while SyU emphasizes preservation and convenience. Integrating these perspectives can inform the development of virtual tours that address a wide range of user needs and considerations.
4. Upon analyzing the data from both synthetic and human users regarding whether virtual tours enhance museum accessibility, various points of agreement and difference become evident. Overall, both human and Synthetic agree on the positive impact of virtual tours on accessibility, particularly for individuals with disabilities and those facing geographical constraints. However, there are discrepancies in perceptions regarding the fidelity of virtual experiences and the

challenges associated with device utilization. Integrating these perspectives can inform the development of virtual tours that maximize accessibility for diverse user demographics.

5. Lastly, comparing the responses from synthetic and human users regarding how to improve the museum experience in virtual reality reveals that overall both synthetic and human users converge on the importance of enhancing content and providing immersive experiences for a more engaging museum visit in virtual reality. However, there are discrepancies in addressing technical challenges, user guidance, and social interaction, reflecting differing perspectives on the current limitations and future potential of virtual museum experiences. Integrating these insights can inform the development of more effective and engaging virtual reality museum experiences.

4 Conclusions

Disparities observed between humans and SyUs underscore the divergence between human-centered design principles and synthetic purely functional or utilitarian viewpoints. These distinctions emphasize the critical need to incorporate both user feedback and technical constraints in the design and enhancement of virtual museum experiences. By integrating these multifaceted perspectives, developers can deploy virtual tours that effectively address a broad spectrum of user needs and considerations, thereby maximizing accessibility for diverse demographics. Integration of insights can guide the development of more compelling and immersive virtual reality museum experiences.

SyUs present several advantages over human participants in responding to qualitative research:

- Consistency: SyUs can provide responses consistently, free from variability or bias, thereby ensuring uniformity in data collection and analysis.
- Availability: SyUs are accessible at all times, allowing for flexible scheduling and immediate access for research purposes, unlike human participants who may have limited availability.
- Control: researchers have complete control over the characteristics and behaviours of SyUs, enabling standardized experimentation and comparison across various conditions.
- Effectiveness: utilizing SyUs can prove more cost and time-effective than recruiting and compensating human participants, particularly for large-scale studies or those requiring extensive interaction.
- Avoidance of social desirability bias: SyUs are unaffected by social desirability bias or rather answers that may be considered more socially acceptable than others-facilitating more candid and unbiased responses to sensitive topics.

Furthermore, it is also relevant to emphasize the ongoing dialogue opportunity with SyU, through the functionality of asking further questions, a capability not available with organic users after a questionnaire has been submitted. The importance of follow-up questions in interviews, particularly with SyU, cannot be overstated. Unlike organic interviews, the ability to ask follow-up questions allows for a deeper exploration of responses and the opportunity to address areas where answers may be too general. It is essential to be specific in questioning to elicit specific responses from users. This specificity is particularly relevant in avoiding SyU defaulting to broader considerations, such as policy concerns over personal budgeting. By prioritizing specificity in questioning, researchers can obtain more nuanced and informative insights from SyU.

In conclusion, the use of VR in museums poses unique challenges, including the need to cater to a diverse audience with varying levels of technology familiarity and physical and cognitive abilities. The integration of SyU in survey research offers promising avenues for enhancing the efficiency and depth of survey methodologies, propelled by advancements in Generative AI. Organizations and Institutions leveraging these technologies stand at the forefront of research innovation, harnessing the capabilities of GenAI to generate insightful, reliable, and diverse data. However, the successful adoption of these tools necessitates a careful consideration of their limitations, ensuring that the richness of human cognition and diversity is not overshadowed by the allure of technological efficiency.

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Annex 1

Qualitative summary of human and synthetic user response

A qualitative investigation is a research method that aims to gain a comprehensive understanding of people's opinions, perspectives, motivations, and experiences on a particular topic. This type of research is based on the collection and analysis of non-numerical data, such as interviews, focus groups, participant observations, and document analysis. The main objective of the qualitative survey was to understand the effectiveness of immersive museum experiences in terms of public engagement and audience

captivation, both from the point of view of real users and synthetic users with similar characteristics to the real sample.

Public engagement encompasses the level of interaction, involvement, and interest exhibited by participants, while audience captivation refers to the ability of immersive experiences to capture and maintain the attention of visitors and effectively convey information. By examining factors such as content quality, interactivity, storytelling techniques and sensory immersion, the research seeks to understand how these elements contribute to both engaging the public and captivating their attention within the museum setting. This holistic approach aims to uncover the mechanisms that drive effective audience engagement and captivation, providing valuable insights for designing immersive exhibits that resonate with visitors and enhance their overall museum experience.

Five questions were posed to the five trial participants, a homogeneous target group between 25 and 35 years old, with university degrees and a passion for technology: (i) *"What did you like most about the virtual experience?"*; (ii) *"What did you like least about the virtual experience?"*; (iii) *"What added value do you think a virtual tour can bring compared to a real visit?"*; (iv) *"Do you believe a virtual tour enhances museum accessibility?"*; (v) *"How could we improve the museum experience through virtual reality technology?"*.

The following is a qualitative summary of the **human user responses**

(i) *"What did you like most about museum virtual experience?"*:

- Immersiveness and interactivity: the ability to feel immersed in the virtual environment and interact with other avatars and virtual objects was particularly appreciated. Users find it engaging to manipulate virtual objects, modify their shapes and colors, and even explode objects to examine their components.
- Sensory experience: the visual immersion provided by the headset and the functionality of "object explosion" were distinctive elements that contributed to the enjoyment of the experience. This aspect was recognized as a potential resource for in-depth exploration of the 3D models present in the museum.
- Emotional sensations: some participants emphasized the feeling of immersion and disconnection from the real environment, indicating significant emotional involvement during the virtual experience.
- Usability and adaptability: appreciation was noted for the ease with which users adapted to the commands and dynamics of the virtual space, suggesting that the interface and user experience were intuitive and accessible.

(ii) *"What did you like least about museum virtual experience?"*:

- Lack of personalization and inadequate testing space: concerns were raised regarding the lack of personalization in the experience and the unsuitability of the physical testing space, which restricted movement and hindered full immersion.
- Perceived lack of added value: some participants felt that the virtual experience did not offer a significant value proposition compared to traditional museum visits.
- Need for improved user guidance and navigation: feedback highlighted the importance of more intuitive interaction and navigation features to prevent users from feeling lost in the various functionalities. Participants emphasized the importance of guided experiences to enhance user engagement and prevent aimless wandering.
- Perceived graphical elementary nature: concerns were raised about the perceived graphical simplicity of the experience, including aspects such as avatar design and spacing, which detracted from the sense of realism.

- (iii) "What added value do you think a virtual tour can bring compared to a real visit?"
- Accessibility and innovation: participants recognize the value of the global accessibility offered by virtual tours, allowing access to exhibitions and locations even in the absence of physical presence. Additionally, the inherent innovation of virtual tours makes the experience more appealing compared to a real visit.
 - Personalized experiences and engagement: participants highlighted the personalized experiences provided by virtual tours, fostering deeper engagement through storytelling, education, and the opportunity to immerse oneself in historical and cultural contexts.
 - Interactivity and depth: participants appreciate the ability to interact with virtual objects and explore functionalities such as the decomposition of 3D models (i.e. automobiles and the comparison of different engine components). This approach allows for a level of depth and exploration not always possible during a real visit.
 - Graphical challenges and untapped potential: some skepticism is raised regarding the graphical disparity between virtual tours and real visits, emphasizing the need for virtual tours to offer something more than what is provided by a real exhibition. Some suggest that interaction with virtual objects, such as object decomposition, could be a significant advantage.
- (iv) "Do you believe a virtual tour enhances museum accessibility?"
- Accessibility for individuals with disabilities and the elderly: there is unanimous acknowledgement that virtual tours augment accessibility for individuals with mobility impairments and older adults, facilitating museum visits without necessitating physical relocation or encountering travel-related obstacles.
 - Global accessibility: participants concur on the proposition that virtual tours afford universal access to museums, enabling individuals from any geographic locale to engage with collections and exhibitions devoid of geographical constraints.
 - Apprehensions regarding virtual versus real experiences: certain respondents express concerns regarding the efficacy of virtual tours in emulating or approximating the authenticity of a physical museum visit. They contend that the essence of the experience differs and assert that current technological capabilities do not adequately replicate a comprehensive museum visitation.
 - Challenges associated with device utilization: while the potential of virtual tours to facilitate home-based museum exploration is acknowledged, concerns are raised regarding the learning curve associated with device operation, posing a potential impediment for certain user demographics.
- (v) "How could we improve the museum experience in virtual reality?"
- Increase in content and immersive experiences: it is suggested to augment the number of contents, particularly those not available in the real exhibition, and to integrate immersive experiences such as 360-degree videos to provide a more comprehensive and engaging view of the museum environment.
 - Immersiveness and historical contextualization: the importance of immersing the user in the historical world has been emphasized, in order to provide a richer and more engaging context during the exploration of the virtual museum.
 - Enhancement of signage and instructions: the need to provide more signs, signals, and instructions within the virtual museum is highlighted to guide users during their visit and improve the experience of accessing the content.

- Technical challenges and perception of the virtual experience: some responses highlight the technical challenges related to graphics and virtual experience, suggesting that currently the technology is not yet capable of fully replacing the real museum experience. However, the value of virtual reality as an additional service to enrich the existing museum experience is acknowledged, but it has arisen the need to fully understand the role and added value that VR can offer, avoiding it becoming merely a superficial addition rather than an effective enhancement of the museum experience.
- In order to compare the answers provided by the same profile of customer personas, both real and synthetic, the same profile of synthetic respondents was defined: a homogeneous target group between 25 and 35 years old, with university degrees and a passion for technology.

Below a description of the five synthetic customer personas generated by the syntheticuser.com platform:

(1) Full name: Kazuki Nakamura

Age: 27

Location: Tokyo, Japan

Profession: Robotics Engineer

Type of technology interest: Robotics and Automation

Educational background: Engineering Degree

Lifestyle preferences: Traditional Japanese culture, martial arts

Personal development focus: Continuous learning and skill improvement

Technology adoption stage: Innovators



(2) Full name: Jasper van der Berg

Age: 33

Location: Amsterdam, Netherlands

Profession: UX Designer

Type of technology interest: User Experience Design

Educational background: Design Degree

Lifestyle preferences: Minimalist lifestyle, sustainability

Personal development focus: Creativity and innovation

Technology adoption stage: Late Majority



(3) Full name: Raphael da Silva

Age: 31

Location: São Paulo, Brazil

Profession: Blockchain Developer

Type of technology interest: Blockchain Technology

Educational background: Computer Science Degree

Lifestyle preferences: Entrepreneurship, startup ecosystem

Personal development focus: Networking and business development

Technology adoption stage: Early Adopter



(4) Full name: Ezra Thompson

Age: 28

Location: San Francisco, CA

Profession: Software Engineer

Type of technology interest: Artificial Intelligence



Educational background: Computer Science Degree
Lifestyle preferences: Active lifestyle, outdoor activities
Personal development focus: Leadership and management skills
Technology adoption stage: Early Adopter

(5) Full name: Sebastian Rodriguez

Age: 30

Location: Buenos Aires, Argentina

Profession: Data Scientist

Type of technology interest: Machine Learning

Educational background: Statistics Degree

Lifestyle preferences: Travel, exploring new cultures

Personal development focus: Technical skills enhancement

Technology adoption stage: Early Majority



The following is a qualitative summary of the **synthetic user responses**

(i) "What did you like most about museum virtual experience?":

- Immersive experience: users appreciate the depth and detail VR tours offer, allowing them to explore artifacts and exhibits they wouldn't otherwise have access to.
- Accessibility: VR tours break down geographical and financial barriers, making cultural education more inclusive.
- Personalized learning: the ability to tailor tours to individual interests and learning paces is highly valued.

(ii) "What did you like least about museum virtual experience?":

- Lack of physical presence: the absence of tactile experiences and the physical ambiance of museums diminishes the emotional impact of art.
- Social interaction: users miss the communal aspect of museum visits, noting that virtual tours can feel isolating.
- Technical limitations: issues such as low resolution, latency, and user interface clumsiness can detract from the immersive experience.
- Sensory engagement: the current technology does not fully replicate the multisensory experiences (e.g., smell, touch) available in traditional museum settings.
- Isolation: the solitary nature of VR tours can lead to feelings of isolation, missing the shared joy and discovery found in group visits.

(iii) "What added value do you think a virtual tour can bring compared to a real visit?":

- Accessibility: VR tours make museums accessible to a global audience, overcoming geographical and financial barriers.
- Personalization: users can customize their experience, focusing on specific interests or areas of study.
- In-depth exploration: VR allows for closer examination of artifacts and access to rare or fragile items not typically accessible in person.
- Educational value: enhanced learning through interactive elements, simulations, and multimedia content.
- Preservation: VR tours reduce physical foot traffic in museums, aiding in the preservation of artifacts and exhibits.
- Convenience: the ability to visit museums from the comfort of one's home caters to diverse lifestyles and schedules.

(iv) "Do you believe a virtual tour enhances museum accessibility?":

- Global access: VR tours eliminate geographical barriers, making museums accessible to a worldwide audience, including those unable to travel due to financial or physical constraints.
 - Disability accommodation: they offer an inclusive experience for individuals with disabilities, providing an alternative to navigating the physical challenges of traditional museum spaces.
 - Flexible learning: Virtual tours cater to diverse learning needs and preferences, allowing users to explore at their own pace and in their preferred language, enhancing educational accessibility.
 - Economic inclusivity: by reducing or eliminating the cost of travel and admission, VR tours make cultural education more economically accessible to a broader range of individuals.
- (v) "How could we improve the museum experience in virtual reality?":
- Engagement: interactive elements such as quizzes, simulations, and gamified learning experiences increase user engagement and make learning more enjoyable.
 - Personalized learning: Allowing users to interact with exhibits in a hands-on manner caters to individual learning styles and preferences, enhancing the educational value.
 - Deeper understanding: Interactivity facilitates a deeper exploration of artifacts, enabling users to examine details closely and understand the context better.
 - Social interaction: features that support social interaction, such as virtual group tours or live Q&A sessions with experts, can mitigate feelings of isolation and replicate the communal aspect of museum visits.

Surprising Insight

Despite the technological advancements and immersive potential of virtual reality museum tours, a notable and somewhat unexpected insight emerged: users deeply miss the physical and social aspects of traditional museum visits. This includes the tactile experience of interacting with exhibits, the ambient atmosphere of museum spaces, and the spontaneous social interactions with other visitors. This longing for physical presence and communal experiences highlights the intrinsic human desire for connection and shared cultural exploration, underscoring the challenge for VR technology to replicate these deeply valued aspects of museum visits.

Annex 2

Full answers generated by human and synthetic users

Human users

Anonymous human user 1

1 - What do you like most about virtual reality museum tour?

Feeling immersed in the virtual environment and the possibility of interacting with other avatars and virtual objects in the museum

2 - What did you like least about a virtual reality museum tour?

There was little content to explore, plus after a while I wanted to remove the visor

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

Besides allowing one to enjoy an exhibition even if one is not physically there, I believe that the innovativeness of a virtual tour makes the experience more attractive than a real visit

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely yes, allowing people with mobility problems and the elderly to take a tour without having to move and without having to spend resources to physically go to the museum

5 - How could the virtual tours in museums be improved?

Increasing the amount of content, particularly content not present in the actual exhibit, perhaps by integrating immersive experiences (e.g., 360 video)

Anonymous human user 2

1 - What do you like most about virtual reality museum tour?

The concept of immersivity itself, the possibility of being able to interact with objects within the virtual space: taking them, modifying their shape, colour, etc., and above all the possibility of being able to explode an object and thus analyse all its components

2 - What did you like least about a virtual reality museum tour?

Museum experience not personalised enough. Unsuitable physical rehearsal space that did not allow the possibility to move around the space completely freely

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

Global accessibility, customised experiences, involvement, storytelling, education. They give the opportunity to experience a deteriorated place or object to the fullest, immersing yourself in the history and age of that context

4 - Do you believe a virtual tour enhances museum accessibility?

Yes, they provide global accessibility

5 - How could the virtual tours in museums be improved?

making the user feel immersed in the relevant historical era (e.g. ancient Egyptian environment)

Anonymous human user 3

1 - What do you like most about virtual reality museum tour?

The immersiveness provided by the visor and the 'explosion' functionality of objects. Definitely to be exploited to explore e.g. 3D models of museum cars.

2 - What did you like least about a virtual reality museum tour?

I do not find real added value in it.

Going to a museum is not a concrete need to be fulfilled, but a very tourism-related experience.

As far as the immersive visit is concerned, what is needed is more intuitive interaction and navigability. Without the guidance of a collaborator, you get lost in the different functionalities.

What is needed is for the user to be accompanied to the experience and not left wandering around empty.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

Decomposition of 3D models of cars (e.g. the possibility of comparing two different engine components).

However, it should be extended to other experiences similar to the one tested, which was too limited.

The virtual component must bring an add on to the experience and not be limited to the creation of a digital twin

4 - Do you believe a virtual tour enhances museum accessibility?

No, if I want to see a work of art I look at the picture on the internet or get information from wikipedia.

5 - How could the virtual tours in museums be improved?

More signs, markings and instructions are needed to guide the user within the immersive space

Anonymous human user 4

1 - What do you like most about virtual reality museum tour?

The feeling of immersion and disconnection with the external environment

2 - What did you like least about a virtual reality museum tour?

I feel it is still very basic graphically, from the avatar to the spatial arrangement of the museum environment, so it does not give an effect of being immersed in another reality.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

I am still a bit sceptical because of the graphical difference that it does not make me feel in a real space. In my opinion it should VR tours should bring something more than what you can see in a real exhibition.

4 - Do you believe a virtual tour enhances museum accessibility?

The experience is different. I still don't think VR is technologically mature enough to replace or even be close to a real museum experience.

5 - How could the virtual tours in museums be improved?

I cannot evaluate the museum experience because I have not experienced it enough. What I can say about the actual experience is that there is still no level of graphics and experience that can replace the real one. So I see it as an additional service in a real museum, rather than a replacement.

Anonymous human user 5

1 - What do you like most about virtual reality museum tour?

The easiness with which I adapted to the commands to use the virtual space.

2 - What did you like least about a virtual reality museum tour?

I cannot yet imagine the application of this technological solution to business cases beyond the experimentation of the VR experience in a museum.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

The ability to interact with objects that would normally be behind protective glass can be a great advantage. Thinking more scientifically, the functionality of 'exploding' objects is fun and even educational.

4 - Do you believe a virtual tour enhances museum accessibility?

There is no doubt that VR makes art accessible from home. The problem I see is the learning curve for using the VR devices which, although short, may be difficult for some target groups to master in a reasonable amount of time.

5 - How could the virtual tours in museums be improved?

First of all, the museum environment needs to be better developed, otherwise it will be difficult for it to be appreciated.

Secondly, I think it is important to understand where VR contributes and where it is just another buzzword.

The technology has not yet penetrated enough for people to fully enjoy it in a few minutes of testing.

At the moment, it seems to me that rather than enhancing the museum experience, it is more like a children's game.

Synthetic users

Synthetic user 1: Kazuki Nakamura

1 - What do you like most about virtual reality museum tour?

The aspect I value most in a virtual reality museum tour is the immersive experience that bridges the gap between technology and traditional culture. Being deeply passionate about robotics and automation, I find that this blend of ancient artifacts and cutting-edge technology offers a unique perspective on how far human ingenuity has come and where it might head. For example, once I participated in a VR tour of an ancient Japanese castle, which wasn't just a mere observation of artifacts but a deep dive into the feudal era, showcasing the engineering marvels of that time juxtaposed with modern robotics principles. This kind of experience stimulates my continuous learning drive, offering insights into how technological advancements can preserve and breathe new life into our rich cultural heritage. It's a vivid reminder that innovation and tradition can coexist, each enriching the other in unexpected ways.

2 - What did you like least about virtual reality museum tour?

What I found least appealing about a virtual reality museum tour was the occasional sense of isolation and lack of physical interaction with the environment. Despite the technological advancements in virtual reality that provide an immersive visual and auditory experience, the physical aspect—such as the tactile feel of artifacts (understandably not directly, but through interactive displays) or the ambient environment of a traditional museum—remains absent. For instance, during a VR tour of a technology museum, while I was fascinated by the detailed visualizations of robot mechanics and could virtually "interact" with them, I missed the hands-on experience. The physical feedback, the resistance of materials, and even the spatial awareness one gains in a real-life setting were notably missing. This lack of sensory engagement can somewhat detach the experience from the reality it aims to represent, leaving a craving for the tangible aspects of learning and exploration.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

A virtual reality museum tour can offer unparalleled access and personalized experiences that extend far beyond the limitations of a physical visit. One significant added value is the ability to explore museums and exhibits from around the world without geographical constraints, breaking down the barriers that might prevent someone from engaging with distant cultures and histories. For someone like me, who values continuous learning and personal development, this accessibility is invaluable. It enables an exploration of a wide array of subjects from the comfort of one's home, making education and cultural appreciation more inclusive.

Moreover, VR tours can offer enhanced learning experiences through the integration of interactive elements, augmented information, and simulations that are not possible in the physical world. For instance, during a VR tour of an ancient civilization, I appreciated not just being able to see the artifacts but also interacting with simulations that illustrate how these items were used in daily life, providing a deeper understanding of the culture.

Additionally, VR tours can be customized to suit personal interests and learning paces, allowing for a more focused and engaging experience. This tailoring of the educational journey to individual preferences is something that traditional visits cannot easily accommodate, making VR tours a powerful tool for personal development and education in technology and beyond.

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely, I believe that virtual tours significantly enhance museum accessibility, democratizing access to cultural and educational resources. These tours can transcend

geographical, physical, and financial barriers that often restrict people from visiting museums. For instance, living in Tokyo, my opportunities to explore museums and cultural sites on other continents are limited by logistic constraints and costs. Virtual tours eliminate these obstacles, allowing me to immerse myself in global heritage from my own home.

Furthermore, virtual tours provide an inclusive environment for individuals with mobility challenges or other disabilities that might make traditional museum visits difficult or impossible. This aspect of accessibility aligns with my appreciation for how technology can enhance lives beyond its typical functional applications, making culture and education more inclusive.

Lastly, the convenience of accessing these tours online caters to a broader range of lifestyles and schedules. For someone with a demanding profession like mine, being able to explore and learn at my own pace during personal downtime, without the need to physically travel, significantly enriches my personal development journey. This form of accessibility not only broadens the audience for museums but also fosters a more inclusive culture of learning and curiosity.

5 - How could the virtual tours in museums be improved?

While virtual tours in museums offer a revolutionary way to access and enjoy cultural and historical content, there is room for enhancement to make these experiences even more valuable and immersive.

Firstly, integrating more interactive features could significantly improve engagement. For instance, allowing users to manipulate 3D models of artifacts or to participate in virtual reconstructions of historical events could provide deeper insights and a more hands-on learning experience. From my own experiences with robotics and automation, I see a vast potential for applying these technologies to create interactive simulations that could illustrate, for example, the mechanics behind ancient inventions or the construction process of historical architectures.

Secondly, enhancing the social aspect of these tours could replicate one of the enjoyments of physical museum visits - the shared experience. Incorporating options for live-guided tours with experts or enabling virtual group tours with friends or other enthusiasts could foster a sense of community and provide additional layers of information and perspectives.

Lastly, to address the sensory limitations previously mentioned, developing more advanced haptic feedback systems could bridge the gap between virtual and physical reality. Although it's challenging, incorporating tactile sensations or even olfactory stimuli could vastly enrich the virtual experience. Imagine feeling the simulated texture of an ancient scroll or the roughness of a dinosaur fossil, enhancing the educational value through a more holistic sensory engagement.

Improving virtual museum tours along these lines could not only make them more engaging and educational but also further break down the barriers between technology and traditional forms of learning and cultural exploration.

Synthetic user 2: Jasper van der Berg

1 - What do you like most about virtual reality museum tour?

The aspect I appreciate most about a virtual reality museum tour is the immersive experience it offers, allowing me to feel like I'm actually wandering through the museum halls from the comfort of my home. It's a unique blend of accessibility and experiential learning. What's even more fascinating is how it caters to my interest in UX design; observing how information is presented and interacted with in a 3D space provides me with insights and inspiration for my own work. For instance, I remember touring the Louvre virtually during the lockdown. The way the artwork was showcased and narrated was so

engaging that it pushed me to think about how to create more immersive experiences in my projects. The convenience of being able to dive deep into art and history without having to deal with the logistics of travel is remarkable. It exemplifies how technology can bridge gaps and make culture more accessible to everyone, aligning perfectly with my minimalist lifestyle by reducing physical clutter while enhancing my personal development in creativity and innovation.

2 - What did you like least about virtual reality museum tour?

While I find the convenience and immersive nature of virtual reality museum tours highly appealing, the aspect that I find least satisfying is the lack of physicality and the tactile experience. There's a certain depth of connection that comes from physically standing in front of an artwork, feeling the scale, and experiencing the subtle details with your own eyes, which virtual reality hasn't fully replicated yet. For example, during a virtual tour of the Van Gogh Museum, despite the stunning visuals and informative content, I couldn't help but miss the texture of the brush strokes and the physical presence of the paintings that evoke an emotional response when seen in person.

Additionally, the social component of museum visits is quite diminished in virtual reality. Part of the joy in visiting museums is the shared experience with friends or even strangers, discussing perceptions and interpretations of art, which is challenging to replicate in a virtual setting. This lack of social interaction and physical presence somewhat limits the complete appreciation of art, making the experience feel a bit isolated at times. It highlights a crucial area for innovation in how we can enhance the sensory and social aspects of virtual museum tours to make them more engaging and closer to the real thing.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

A virtual reality museum tour can offer several added values compared to a real visit, particularly in terms of accessibility, personalization, and educational depth.

Firstly, accessibility is a major advantage. Not everyone has the means or ability to travel to different parts of the world to visit museums. For me, living in Amsterdam, while I have access to some fantastic museums, experiencing institutions like the Smithsonian or the Met requires significant travel. Virtual reality tours open up these cultural treasures to a global audience, breaking down geographical and economic barriers to access.

Secondly, personalization is another significant advantage. Virtual tours can be tailored to match personal interests or educational needs, offering a more focused and relevant experience. For instance, if I'm particularly interested in a certain period of art history or a specific artist, a virtual reality tour could curate the content to highlight these interests, providing a depth of engagement that might be more challenging to achieve in a busy, physical museum setting.

Moreover, the educational value of VR tours can be enhanced through the integration of interactive elements and multimedia content, such as videos, audio descriptions, and 3D models. This can make learning more engaging and memorable. During a VR tour of an ancient history museum, I was impressed by the use of 3D reconstructions that allowed me to explore historical sites as they would have appeared in their prime. This added a layer of understanding and context that would be difficult to replicate through static displays or traditional guided tours.

Lastly, virtual tours can also allow visitors to experience exhibits and artifacts that are too fragile or valuable to be displayed publicly. This creates an opportunity for individuals to view and learn about items that they otherwise might never have had the chance to see.

Overall, while virtual tours can't fully replicate the experience of physically visiting a museum, they offer unique value in making art and culture more accessible, personalized, and educationally rich.

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely, I believe virtual tours significantly enhance museum accessibility, addressing several barriers that can prevent people from engaging with cultural and educational content.

For starters, geographical barriers are virtually eliminated with virtual tours. Not everyone has the luxury of living near world-class museums or the means to travel to them. I've friends scattered around the globe, some in remote areas, for whom traveling to cities like Amsterdam, Paris, or New York is a major endeavor. Virtual tours open up opportunities for these individuals to experience and appreciate global art and history that would otherwise remain out of reach.

Furthermore, virtual tours are a boon for individuals with physical disabilities. Traditional museum visits can be challenging, if not impossible, for those with mobility issues. Virtual reality offers a seamless and comfortable way to explore museums without the physical strain or the need for special accommodations. This inclusivity is a great stride forward in making culture and knowledge accessible to all.

Economic barriers are another consideration. The cost of museum admissions, along with travel expenses, can add up, making such educational outings a luxury for some families and individuals. Virtual tours, often offered for free or at a minimal cost, provide a cost-effective alternative for broadening one's horizons.

Moreover, for someone like me who leads a minimalist lifestyle, virtual tours align well with sustainable living. They reduce the carbon footprint associated with travel and the environmental impact of crowding at popular museum sites, offering a greener option for cultural exploration.

Lastly, the flexibility virtual tours offer in terms of timing and pacing is unparalleled. They can cater to different learning speeds and available time slots, making museum visits more adaptable to individual schedules and learning preferences.

In essence, virtual tours democratize access to cultural education, making it more inclusive and adaptable to diverse needs and circumstances. This is a development I wholeheartedly support, as it mirrors my own values of inclusivity, sustainability, and the democratization of knowledge and culture.

5 - How could the virtual tours in museums be improved?

Improving virtual museum tours could focus on enhancing realism, interactivity, and educational content to create more engaging and meaningful experiences.

One area for improvement is the quality of visual and auditory fidelity. High-resolution imagery and spatial audio can significantly enhance the immersive experience, making users feel as if they are truly inside the museum. During a virtual tour I once took, some artworks appeared blurry when zoomed in, which detracted from the experience. Incorporating 360-degree high-definition videos and more detailed 3D models of artifacts could resolve this issue, allowing users to appreciate the nuances of art and artifacts as closely as possible to the real thing.

Interactivity is another crucial aspect. Current tours often feel like a passive experience. Incorporating interactive elements such as clickable information points, quizzes, and even gamification elements can make the experience more engaging. For instance, virtual scavenger hunts or interactive timelines could add a playful learning aspect, making the tours more appealing especially to younger audiences or those with a keen interest in exploring content in a more dynamic way.

Personalization features could greatly improve user experience as well. Allowing users to customize their tour based on interests, time available, or even preferred languages can make the tours more relevant and engaging. Imagine being able to select a "sustainability

in art" themed tour that focuses on artists and works relevant to my interests in sustainability and minimalism.

Enhancing social interaction within the virtual environment could also enrich the experience. The ability to take a tour with friends or family members in a synchronized manner, even if they are in different locations, would replicate the social aspect of museum visits. Additionally, live Q&A sessions with museum curators or art experts could be scheduled within the virtual environment, adding a new dimension to the learning experience.

Lastly, accessibility features should be expanded to ensure that the tours are inclusive to all users. This includes offering closed captions for the hearing impaired, audio descriptions for the visually impaired, and ensuring the virtual tour platform is navigable for those with limited mobility or familiarity with technology.

By focusing on these areas, virtual museum tours can become more immersive, interactive, and accessible, offering a richer and more fulfilling experience that complements and, in some aspects, enhances the traditional museum visit.

Synthetic User 3: Raphael da Silva

1 - What do you like most about virtual reality museum tour?

What captivates me most about a virtual reality museum tour is the immersive experience it offers, allowing me to explore art and artifacts from around the globe without leaving my home in São Paulo. There was this time I took a VR tour of the Louvre, and I was astounded by the level of detail I could observe in the artworks. It felt as though I was standing right in front of the Mona Lisa, observing the nuances of Da Vinci's brushstrokes that I wouldn't appreciate as much in a traditional online gallery or through pictures in a book.

Moreover, the interactivity and the ability to control the pace of my exploration cater perfectly to my curiosity and desire for a deeper understanding of the subjects. I remember a specific instance during the tour when I spent a considerable amount of time examining Egyptian artifacts, reading about their history, and even virtually 'handling' them to see all sides. This wouldn't have been possible in a physical setting, especially considering the crowd management and the protective measures that limit how close you can get to the exhibits.

These experiences resonate with my inclination towards technology and how it can enhance our understanding and appreciation of culture and history. Virtual reality tours democratize access to education and culture, principles I passionately support, especially coming from a technology and entrepreneurship background where innovation and accessibility are key.

2 - What did you like least about virtual reality museum tour?

Despite my enthusiasm for the technology, one aspect that diminishes the allure of virtual reality museum tours is the lack of physical presence and the tactile experience of being in an actual museum space. There's a certain ambiance—the sounds, the scale of objects, and even the smell of aged artifacts or paint—that a VR headset just can't replicate. For instance, while exploring the VR tour of the Museu de Arte de São Paulo, I missed the bustling atmosphere, the murmur of awe from fellow visitors, and the grandeur of standing beneath the large, suspended artworks. These sensory experiences contribute significantly to the emotional impact of art.

Additionally, the social aspect is somewhat lacking. Even though VR tours can include multiplayer or shared experiences, it doesn't quite match the spontaneity of striking up a conversation with a stranger about a piece of art that caught both your attentions or the shared smiles and nods of appreciation that silently pass between art lovers in a gallery.

Lastly, while a VR tour can be incredibly detailed, there are times when the technology falls short, either through resolution limitations or latency issues, which can break the immersion. During one tour, experiencing a bit of lag while navigating through the rooms made me momentarily dizzy—a reminder of the technical limitations that still need to be addressed.

In essence, while VR museum tours are innovative and accessible, they're yet to fully capture the holistic experience of visiting a museum in person.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

Given my affinity for leveraging technology to enhance experiences, I see several areas where a virtual reality museum tour can provide added value over a traditional visit.

Firstly, customization and personalization of the experience stand out prominently. Unlike a real visit where exhibitions are static, a VR tour can adapt to my interests, allowing me to dive deep into specific art periods, artists, or themes without being constrained by the physical layout or current exhibitions of the museum. This personalized journey through art or history can be both engaging and educational, tailoring the information presented to match my background in technology and my curiosity without overwhelming or underwhelming me.

Another significant advantage is the ability to access rare and fragile artifacts up close. In real-life settings, these items are often kept behind glass or ropes to protect them. However, in a VR environment, I can virtually 'touch' and explore these items from all angles, sometimes even seeing beneath or inside them, offering insights that are impossible in a physical setting. For instance, being able to virtually dismantle and examine the mechanism inside an ancient clock or piece of technology from centuries ago is fascinating and aligns with my interests.

Furthermore, VR museum tours can transcend geographical and temporal boundaries, offering an invaluable educational tool. They make it possible to visit museums around the world without the constraints of travel costs and time, but they can also recreate historical sites or artifacts that have been lost or damaged over time. This feature was particularly striking when I explored a VR reconstruction of ancient civilizations, providing a sense of scale and detail that books or documentaries simply cannot match.

Lastly, VR tours can incorporate interactive elements that enhance learning and engagement. For example, gamification elements such as quizzes or puzzles related to the exhibits can make the experience more engaging, catering especially to users with a tech-savvy background. Interactive timelines, 3D reconstructions of historical events, or even simulated archaeological digs can transform a museum visit from a passive activity into an active learning experience.

In summary, the added value of VR museum tours lies in their ability to offer personalized, in-depth, and interactive experiences that transcend the limitations of physical space and time, aligning well with my interests in technology and personal development.

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely, I firmly believe that virtual tours significantly enhance museum accessibility, a conviction that's deeply aligned with my values around the democratization of knowledge and culture through technology. Virtual reality, in particular, dismantles many of the barriers that prevent people from accessing museum content, making it an essential tool in the advancement of cultural education and appreciation.

One of the most evident benefits is the elimination of geographical barriers. Not everyone has the financial means or physical ability to travel to major cities where most renowned museums are located. I've personally experienced the frustration of hearing

about a must-see exhibition halfway across the world with no means to visit. Through VR, these distant treasures become accessible, allowing anyone with internet access and VR equipment to embark on a cultural exploration from the comfort of their home.

Moreover, virtual tours can be a boon for individuals with physical disabilities or those who are unable to navigate the often sprawling, multi-level layouts of large museums. I recall a friend who uses a wheelchair expressing how transformative it was to explore an ancient castle through a VR tour, a place that would have been largely inaccessible to him in person. This inclusivity extends to people with sensory sensitivities as well, for whom the bustling environment of a popular museum can be overwhelming.

Additionally, VR tours can cater to a wide range of learning preferences and needs, providing personalized experiences that might not be feasible in a physical setting. For example, information can be presented in multiple languages, with adjustable pacing, and even in formats that cater to different learning disabilities. This level of customization ensures that a broader audience not only accesses but also engages deeply with the content.

Finally, considering the disruptive impact of global events like the COVID-19 pandemic on the accessibility of physical spaces, virtual tours have proven to be a resilient alternative for ensuring continuous access to cultural and educational resources during times when physical visits are not possible.

In essence, virtual tours embody the intersection of technology and culture in a way that enhances accessibility, making them an invaluable tool for ensuring that the treasures housed within museums can be shared with and appreciated by a global audience, regardless of physical or financial constraints.

5 - How could the virtual tours in museums be improved?

To enhance the effectiveness and appeal of virtual museum tours, integrating more interactive and personalized elements could significantly elevate the user experience, especially for someone with a profound interest in technology and a penchant for immersive storytelling. Here's a breakdown of potential improvements:

- **Increased Interactivity:** Imagine being able to interact with the exhibits in a more tangible way during a VR tour. Implementing features that allow users to manipulate objects, perhaps in a sandbox environment where they can experiment with ancient tools or machinery, would not only make the experience more engaging but also deepen the understanding of how these items were used historically.
- **Higher Resolution and Realism:** While current VR technologies offer a decent degree of realism, there's always room for improvement. Sharper images, more detailed textures, and enhanced lighting effects could make virtual visitors feel even closer to the real thing. During an online tour of a tech museum, I noticed the details on a vintage computer weren't clear, making it hard to appreciate the complexity of its design. Higher resolution visuals would have made a significant difference.
- **Personalized Guided Tours:** Leveraging AI to offer personalized guided tours based on the visitor's interests and previous interactions could enhance engagement. For instance, knowing my background in blockchain, a customized tour might focus more on exhibitions related to cryptography or the evolution of digital security, providing a richer and more relevant experience.
- **Social Interaction Features:** Incorporating options for live interaction with other visitors or even guided tours with real museum staff could replicate some of the social aspects of a physical museum visit. A memorable experience for me

was a live Q&A session with a curator during a virtual tour, which made the experience feel more personal and interactive.

- **Augmented Reality Integration:** Combining VR with AR could offer a blended experience where users can see how artifacts once looked and were used in their original contexts. For instance, pointing at a ruin could reconstruct it in its former glory within the virtual space, providing a direct link between past and present.
- **Enhanced Accessibility Options:** Optimizing VR tours for people with disabilities, including those with visual or hearing impairments, is crucial. Providing options for audio descriptions, sign language avatars, or text-to-speech for written content could make these tours more inclusive.
- **Feedback Mechanisms:** Incorporating user feedback loops can ensure continuous improvement. Post-tour surveys or in-experience rating options could provide valuable insights into which aspects users find most engaging or areas that need enhancement.

Implementing these improvements could significantly enrich the virtual museum tour experience, making it more immersive, educational, and enjoyable, thereby broadening its appeal and effectiveness as a tool for cultural and historical education.

Synthetic User 4: Ezra Thompson

1 - What do you like most about virtual reality museum tour?

I appreciate the layer of interactivity and engagement a virtual reality museum tour offers that goes beyond traditional visits. Being in the tech field, I've always been fascinated by how technology can enhance our experiences, and this is a prime example. In one instance, during a VR tour of an ancient history museum, I was able to virtually "handle" artifacts, zoom in on hieroglyphs, and even simulate the process of traditional crafts. It offered a level of detail and immersion that's simply not possible in a physical setting. This not only made the learning experience more engaging but also allowed me to explore at my own pace, diving deeper into areas of personal interest without the pressure of keeping up with a group or the physical limitations of a crowded space. It was an enriching experience that blended my love for technology, history, and interactive learning in a way that felt both innovative and personal.

2 - What did you like least about virtual reality museum tour?

The aspect I liked least about a virtual reality museum tour was the sense of isolation it created. Despite the immersive and interactive experience, I missed the social interaction and the shared excitement that comes with visiting museums in a group. In one particular experience, while deeply engaged in a VR tour of a space museum, I realized that although I was enjoying the content, I was missing out on the spontaneous discussions and varied interpretations that naturally arise when exploring with friends or even strangers. This sense of isolation was further accentuated by the physical disconnect; wearing a VR headset disconnected me from the immediate environment and people around me. It felt like a trade-off between immersive personal engagement and the communal, collaborative joy of discovery that enriches the museum-going experience. This highlighted for me the importance of balance between employing cutting-edge technology for enhanced learning and retaining the human, social aspect that makes such cultural experiences truly memorable.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

A virtual reality museum tour can significantly enrich the learning experience by providing access to places and artifacts otherwise inaccessible. For example, during a VR tour of an archaeological site, I was able to "visit" excavation sites that are off-limits to the

public due to their fragile nature. This access is invaluable for both education and personal enrichment, allowing for a deeper understanding of historical and cultural contexts.

Moreover, the ability to customize and interact with the environment in a VR tour adds a layer of personalization that a real visit might lack. Users can engage with exhibits in a way that caters to their learning style, whether it's through interactive timelines, detailed 3D models, or even simulations of historical events. This level of interaction ensures that the content is accessible and engaging for a wide range of users, from those with a casual interest to professionals in the field.

Another significant value is the democratization of access. Geographic and financial barriers often limit the ability to visit museums, especially those located in other countries. Through VR technology, users from around the world can explore global heritage from their own homes, bridging the gap between interest and access. This is particularly poignant for me, having friends in different parts of the world who share similar interests in technology and history but have limited access to such resources.

Lastly, VR tours can be a boon for preservation efforts. Physical foot traffic in museums and historical sites can lead to wear and tear over time. By providing an alternative means of exploration, VR can help mitigate this issue, ensuring that these cultural treasures are preserved for future generations.

In sum, the added value of a virtual reality museum tour lies in its ability to provide unparalleled access, customizable learning experiences, global reach, and support for cultural preservation.

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely, I believe that virtual tours greatly enhance museum accessibility on several fronts. Here are a few reasons why:

- **Global Reach:** Not everyone has the luxury to travel to different cities or countries to visit museums, be it due to financial constraints, physical limitations, or other commitments. Virtual tours break down these geographic barriers, allowing anyone with internet access to explore museums they might never have been able to visit in person. For instance, I have a friend in a wheelchair who has always wanted to visit the Louvre. Thanks to virtual tours, he was able to enjoy much of what the museum offers, something that would have been challenging in person due to the extensive walking required.
- **Inclusivity for Individuals with Disabilities:** Beyond geographic limitations, virtual tours make museums more accessible to people with disabilities. Traditional museum visits can be challenging for those with mobility issues, sensory processing disorders, or other disabilities. Virtual tours can be tailored to meet various accessibility needs, providing alternative ways to engage with content that might otherwise be difficult or impossible to access.
- **Flexible Learning for Diverse Audiences:** Everyone has different learning preferences and paces. In a physical museum setting, you're often restricted by time, crowds, or the availability of certain exhibits. Virtual tours allow for a more personalized experience, letting users spend as much time as they like on particular exhibits, access detailed information, and even explore content in different languages. This flexibility is especially beneficial for educational purposes, allowing students to explore in a way that best suits their learning style.
- **Cost-Effective Exploration:** Visiting museums, especially those in other countries, can be quite expensive when you factor in travel, accommodation, and entrance fees. Virtual tours often come at a fraction of the cost, or even for free, making cultural exploration more affordable. This has personally allowed

me to "visit" museums and historical sites around the world on a modest budget, broadening my understanding and appreciation of global cultures.

In summary, virtual tours significantly enhance museum accessibility by making cultural and educational content more inclusive and available to a broader audience worldwide. This democratization of access to knowledge and culture is something I highly value, seeing it as a vital step forward in making education and cultural enrichment more equitable.

5 - How could the virtual tours in museums be improved?

Improving virtual tours in museums could greatly enhance the user experience and accessibility, leveraging technology's full potential. Here are some suggestions for improvement based on personal observations and areas where I've felt enhancements could make a significant difference:

- **Increased Interactivity:** One area ripe for improvement is enhancing user interaction within the virtual environment. Integrating more interactive elements such as quizzes, gamified learning experiences, or interactive timelines could make the learning process more engaging. For instance, being able to virtually assemble parts of an ancient artifact or participate in a simulated archaeological dig would add depth to the educational experience.
- **Higher Quality Visuals:** While many virtual tours offer impressive visuals, there's always room for improvement, especially with rapidly advancing VR technology. Higher resolution images, 360-degree videos, and more detailed 3D models could provide a more immersive and visually appealing experience. I recall a tour where the resolution was somewhat lacking when zooming in on certain artifacts, which detracted from the experience of examining them closely.
- **Real-time Interactions:** Incorporating real-time interactions with educators or guides during the virtual tour could significantly enhance the learning experience. Live Q&A sessions, guided tours, or even interactive workshops within the VR environment could mimic the social aspects of a traditional museum visit, addressing the sense of isolation some users might feel.
- **Customizable Tour Paths:** Allowing users to customize their tour path based on their interests could make tours more engaging and personally relevant. Users could select specific topics or artifacts they're interested in and receive a tailored tour that focuses on these areas, making the experience more interactive and enjoyable.
- **Accessibility Features:** Enhancing accessibility features to cater to a wider audience, including those with disabilities, is crucial. This could include options for text-to-speech for visually impaired users, sign language avatars for the hearing impaired, or sensory-adjusted experiences for those with sensory processing sensitivities. Ensuring the platform and content are accessible to all potential users is essential for truly democratizing access to culture and education.
- **Integration of Augmented Reality (AR):** While VR offers an immersive experience, integrating AR features could allow users to see artifacts or historical figures in their own space, offering a different perspective and enhancing the learning experience. Imagine being able to see a life-sized dinosaur skeleton in your living room or examine a historical artifact up close on your desk.

Enhancing virtual museum tours along these lines could significantly improve their educational value, engagement level, and accessibility, making them an even more valuable resource for global audiences.

Synthetic User 5: Sebastian Rodriguez

1 - What do you like most about virtual reality museum tour?

I really appreciate the immersive experience that a virtual reality museum tour can provide, particularly when it comes to exploring places and artifacts I wouldn't otherwise have easy access to due to geographical or financial constraints. There was this one time I explored the Louvre virtually, and it was fascinating to get up close to the artworks, something that's often impossible in person due to the crowds. The ability to zoom in on details and view pieces from various angles without the obstruction of protective glass or barriers truly enriches the learning experience. It's also a plus when these tours include interactive elements, such as additional information pop-ups or audio guides that explain the historical context or significance of what I'm viewing. This not only enhances my understanding but also keeps me engaged throughout the tour. It's a great way to satisfy my curiosity and passion for technology and history without having to step out of my home.

2 - What did you like least about virtual reality museum tour?

While I enjoy the immersive aspect of virtual reality museum tours, I feel they sometimes lack the emotional connection and atmosphere that physically being in a museum provides. There's a certain ambiance and sense of awe when standing in front of a historical artifact or piece of art in real life that virtual tours struggle to replicate. For instance, the last time I took a virtual tour of the British Museum, despite the high-quality visuals and informative content, it couldn't fully capture the scale and texture of the artifacts. It felt somewhat sterile in comparison to the memories of walking through museum halls, where the surrounding architecture and the murmur of other visitors contribute to the overall experience. Additionally, technical issues such as lagging, low resolution, or user interface clumsiness can detract from the experience, pulling me out of the immersion and reminding me that I'm just wearing a headset in my living room, not actually exploring distant cultures and histories.

3 - What added value do you think a virtual reality museum tour can bring compared to a real visit?

Virtual reality museum tours offer several unique advantages compared to traditional visits. One significant value is accessibility. For example, I remember wanting to explore the Egyptian Antiquities section at the Louvre, but travel restrictions and budget constraints made it impossible at the time. The VR tour allowed me to virtually walk through the exhibit from my living room in Buenos Aires, making cultural education more inclusive for those who cannot afford to travel.

Furthermore, VR tours can provide a more detailed, personalized learning experience. During my virtual visit to the Smithsonian, I could spend as much time as I wanted examining the Apollo 11 command module, something that might be rushed in a real visit due to the crowds. Additionally, interactive features like clickable information points and narrated guides added layers of information that went beyond what's typically available on museum plaques. These features cater to my technical skills enhancement goals by allowing me to dive deep into the topics I'm most interested in.

Lastly, VR tours can include elements of time travel or reconstruction of lost or damaged artifacts and sites. Once, I participated in a VR tour that reconstructed the ancient city of Palmyra as it was before it suffered destruction. This type of experience is impossible to replicate in real life and provides invaluable insights into our world's

historical and cultural heritage, enriching my understanding and appreciation of different cultures in a way that only technology can enable.

4 - Do you believe a virtual tour enhances museum accessibility?

Absolutely, virtual tours significantly enhance museum accessibility, breaking down barriers that many individuals face. Reflecting on my own experiences, there have been instances where I deeply desired to visit world-renowned museums or exhibitions that were simply out of reach due to geographical distance or financial constraints. The option of a virtual tour opens up these cultural treasures to a global audience, making it possible for anyone with internet access to explore and learn from them.

Moreover, virtual tours can be a boon for individuals with mobility issues or disabilities that might make navigating the physical space of a museum challenging. It democratizes access to cultural education and appreciation, allowing everyone the opportunity to explore exhibits at their own pace, in their own time, without the need for physical travel or accommodation of physical limitations.

From a personal development perspective, these tours have allowed me to continue refining my technical skills and knowledge base by exploring technology-related exhibits worldwide, something that would have been significantly more challenging without virtual access. This inclusivity extends the educational reach of museums, potentially inspiring a broader range of individuals to engage with art, history, and science, regardless of their physical capability or socioeconomic status.

5 - How could the virtual tours in museums be improved?

Drawing from my experiences, there are several areas where virtual tours in museums could be enhanced to provide a more engaging and seamless experience. Firstly, integrating more interactive elements could significantly improve user engagement. For instance, incorporating gamification elements, such as quizzes or treasure hunts related to the artifacts or history being presented, could make learning more enjoyable and memorable.

The quality of the visual and audio content is crucial for immersion. I've encountered tours where the resolution was low or the audio guide was monotonous, detracting from the overall experience. Investing in high-quality, 360-degree visuals and employing narrators who can convey stories compellingly would make a significant difference. Additionally, offering content in multiple languages would make these tours more accessible to a global audience, aligning with my appreciation for exploring new cultures.

Another area for improvement is the customization of the tour experience. Allowing users to select specific areas of interest to create a personalized tour could cater to diverse audiences with varying preferences, whether it's ancient civilizations, Renaissance art, or modern technology. This customization could extend to the pacing of the tour, offering options for quick overviews or deep dives into subjects.

Lastly, to address the sense of isolation sometimes felt during virtual tours, implementing features that allow for social interaction, such as virtual tour groups or the ability to leave and view comments on exhibits, could foster a sense of community and shared experience. This would not only enhance the learning experience but also mimic the social aspect of visiting museums in person.

Improving these aspects could make virtual museum tours not just a convenient alternative to physical visits but a uniquely valuable and enjoyable way to explore and learn about our cultural heritage.